Authors: Tim Mair, Jacqui Matthews, Martin Nielsen
(Reviewed by T Mair, J Matthews, M Nielsen)

Chapter 1. Assessing the need for anthelmintic use

Table of Contents

Overview 3

Chapter 1.1. Internal equine parasites & disease 5

Overview of parasite species to consider in adult horses 5

Cyathostomins (small strongyles) 5

Tapeworms 6

Oxyuris equi (equine pinworm) 8

Strongylus vulgaris (large strongyle) 8

Gasterophilus intestinalis ('bot') 10

Dictyocaulus arnfieldi (lungworm) 10

Overview of additional parasite species to consider in foals and yearlings 10

Parascaris spp. (ascarids) 11

Strongyloides westeri (threadworm) 12

Chapter 1.2. Using monitoring tools effectively to determine the need for anthelmintic treatment 13

Faecal egg counts 13

Monitoring the level of strongyle egg shedding in adult horses 13

Monitoring for ascarid and strongyle egg excretion in foals and yearlings 15

Assessing the efficacy of anthelmintic treatment 17

Detecting tapeworm burdens 18

Small redworm ELISA in adult horses 18

Tapeworm antibody testing in adult horses 20

Considerations for foals and yearlings 21

Overview of tests for detecting other parasite species 21

Detecting *Strongylus vulgaris*: Larval culture and PCR 21

Detecting pinworms: The 'tape test' 22

Detecting ascarid burdens: Transabdominal ultrasonography 22

Chapter 1.3. A risk assessment-based approach to equine parasite control in adult horses 23

Appendices 26

Chapter 1.2.1. Guidance for use of faecal egg counts in horses 26

Chapter 1.2.2. Assessing diagnostic performance metrics 32

Authors: Tim Mair, Jacqui Matthews, Martin Nielsen
(Reviewed by T Mair, J Matthews, M Nielsen)

Overview

A primary aim of parasite (worm) control is to minimise the levels of infective parasites on pasture and, in so doing, mitigate the risk of parasite-associated disease in individual horses grazing that pasture. The control strategy implemented must be balanced against the need to slow the development and spread of anthelmintic resistance (AR), whilst simultaneously minimising the environmental impact of these drugs (see Chapter 7. Environmental considerations). This means that treatments need to be guided by knowledge of the life cycles and epidemiology of the key parasite species that affect horses and the use of monitoring tests. The objective is not to eliminate all parasites from all horses, but to maintain infection to a level that does not have a detrimental effect on any horse.

When designing a control programme, a risk assessment approach should be undertaken, considering factors such as:

- **C**linical history – horse age, previous history of parasitic disease (in the individual and on the premises) and overall health of the horses
- **A**ge profile
- **N**umber of horses on the premises and stocking density
- **T**est results – including faecal egg counts (FEC), faecal egg count reduction tests (FECRT), tapeworm ELISA, small redworm (cyathostomin) ELISA
- **E**nvironment – pasture management, open/closed herd, quarantine procedures, time of year to inform the overall risk
- **R**isk profile.

In this way, an evidence-based decision can be made as to which horses require, and, importantly, which horses do not require anthelmintic treatment. The approach should aim to provide a full herd analysis, so that potential levels of infection intensity can be categorised in terms of parasite species present and the likelihood of there being moderate to high burdens in individuals. In order to design appropriate parasite control programmes, prescribers should understand the main parasite challenges faced by different equine species and age groups. Gaining an appropriate clinical history, age

profile information, an overview of pasture management approaches and efficacy of anthelmintics used on the premises will help to determine the potential risk of clinical disease occurring and inform appropriate action to take.

In the UK, most equine anthelmintics are legally classed as POM-VPS medicines, and can be prescribed for routine use by veterinary surgeons, pharmacists and suitably qualified persons (SQPs). However, only veterinary surgeons can prescribe medicines under the cascade, if the use of certain unlicensed specific anthelmintics is considered appropriate. For non-routine use, for example in horses affected by confirmed or suspected parasite-associated disease, consultation with a veterinary surgeon is required since diagnosis (and subsequent treatment choices) can only be undertaken by a veterinary surgeon.

Authors: Tim Mair, Jacqui Matthews, Martin Nielsen
(Reviewed by T Mair, J Matthews, M Nielsen)

Chapter 1.1. Internal equine parasites & disease

Overview of parasite species to consider in adult horses

Equine parasites are ubiquitous. The most prevalent parasites belong to the Strongylidae nematode family, which comprises the sub-families, Cyathostominae (cyathostomins, small strongyles) and Strongylinae (large strongyles). Other parasites that commonly affect equids are the ascarids, *Parascaris* spp. (primarily found in foals and youngstock), the pinworm, *Oxyuris equi* (a persistent issue in some equine populations) and cestodes (tapeworms), most commonly *Anoplocephala perfoliata*, which can sometimes cause clinical disease. In horses over 1 year of age, the most common and clinically important parasites are the cyathostomins (small redworms or small strongyles) and tapeworms.

Cyathostomins (small strongyles)

Virtually all grazing horses are exposed to cyathostomins (Figure 1), with many horses encountering infection all of their lives. Cyathostomins have a period of larval development in the large intestinal wall. Thousands of larvae can accumulate, especially in younger horses (i.e. <5 years-old), and these play an important role in the clinical condition of acute larval cyathostominosis.

Figure 1. Cyathostomins excreted in faeces.

Horse history and potential for clinical disease

- Most adult horses control infection well and have low burdens of cyathostomins.
- Horses more likely to have lowest burdens are adult horses that graze pasture with good hygiene practices (e.g. dung removed more than once per week and low stocking density) or those with limited access to pasture.
- Young horses (1-5 years), and, possibly, geriatric horses and horses with pituitary pars intermedia dysfunction (PPID) ("Cushing's disease"), may be more at risk of having higher cyathostomin burdens.
- In a small number of horses (depending on risk factors such as level of infection on pasture, age, concurrent disease, season) cyathostomins can cause a life-threatening disease (weight loss, diarrhoea and colic) known as acute larval cyathostominosis.

Resistance

Anthelmintic resistance is common in cyathostomins, with reports of resistance to all classes of anthelmintics authorised for treatment of cyathostomins (benzimidazoles, tetrahydropyrimidines and macrocyclic lactones). This issue of resistance is one of the key reasons why parasite control programmes need to be based on risk assessment and testing to identify which horses require treatment.

Tapeworms

Anoplocephala perfoliata is the most common equine tapeworm (Figure 2). Infection occurs when horses ingest infected oribatid mites whilst grazing. Infection has been associated with various forms of colic. Tapeworms produce erosions of the intestinal mucosa at the site of attachment, and when present in relatively high numbers, can result in disturbances of motility ("spasmodic colic" / "gas colic") or cause

Figure 2. Equine tapeworm in situ.

Photo credit: Austin Davis Biologics Ltd.

blockage (ileo-caecal impactions) or other types of obstruction, including caeco-caecal and caeco-colic intussusceptions.

Horse history and potential for clinical disease

- There is limited evidence of age-dependent or acquired immunity; mature horses are just as likely to harbour tapeworms as younger horses.
- Most horses tend to have relatively few tapeworms, which are unlikely to cause clinical signs.

Resistance

There are indications of emerging anthelmintic resistance in *A. perfoliata* in some regions of the world (Nielsen, 2023). Although there are no confirmed reports of resistance to praziquantel and pyrantel embonate in tapeworms in the UK, there is anecdotal evidence of treatment failure of both of these actives against *A. perfoliata*, so approaches to controlling tapeworm should be targeted and not interval-treatment based.

Parasite species that are currently of less importance in the UK but can cause significant clinical problems, include *Oxyuris equi*, which can cause tail rubbing and perianal pruritus and *Strongylus vulgaris*, which is associated with non-strangulating intestinal infarctions.

***Oxyuris equi* (equine pinworm)**

The equine pinworm (Figure 3) deserves specific consideration when clinical signs of infection are observed. Treatment of a pinworm infection should be approached on a case-by-case basis (see Chapter 9.1. Pinworms).

Figure 3. Equine pinworm excreted in faeces.

Horse history and potential for clinical disease

- Pinworms can infect horses at any age.
- The majority of horses are not clinically affected by pinworm, but this parasite can cause tail rubbing in a subset of infected individuals.

Resistance

Anthelmintic resistance in pinworms has been evaluated for fenbendazole, pyrantel, ivermectin and moxidectin and has been reported for the macrocyclic lactones (see Chapter 9.1. Pinworms). Therefore, oral administration with either fenbendazole or pyrantel may be the most sensible anthelmintic choice.

Strongylus vulgaris (large strongyle)

The large strongyles consist of several parasite species, including three belonging to the *Strongylus* genus. Of these, *Strongylus vulgaris* is considered to be the most pathogenic of all equine helminth parasites (Drudge, 1979). The larval stages in the cranial mesenteric arteries that supply blood to the intestines can result in non-strangulating intestinal infarction, which can manifest as colic or peritonitis. This parasite has generally become rare in managed horse populations, and surveys conducted in the UK

have indicated very low prevalence levels (Tzelos *et al.*, 2017). However, in countries like Denmark and Sweden, where strict administration of prescription-only legislations has led to a sharp reduction of anthelmintic treatment intensity, *S. vulgaris* has been documented to have re-emerged (Nielsen *et al.*, 2012a; Tyden *et al.*, 2019) and is now identified as a cause of significant clinical disease again (Nielsen *et al.*, 2016a; Pihl *et al.*, 2018).

Following restrictive use of anthelmintics within the UK, there is a plausible possibility that *S. vulgaris* and other large strongyles could also re-emerge here. Since *Strongylus* spp. parasites all excrete similar strongylid eggs, which are indistinguishable from those of the small strongyles (cyathostomins), other tests are necessary to monitor for the presence of these parasites (see Chapter 1.2. Using monitoring tools effectively to determine the need for anthelmintic treatment).

Horse history and potential for clinical disease

- Decades of routine administration of anthelmintics at regular intervals have reduced the prevalence of *S. vulgaris* such that control of this parasite is no longer the focus of our current UK parasite control programmes.
- Large strongyles can infect any horse, however, the risk of clinical disease from *S. vulgaris* has become uncommon in managed horse populations in the UK.

Resistance

To date, this parasite has not been reported to be resistant to any anthelmintic classes anywhere in the world.

Gasterophilus spp. ('bots')

While several *Gasterophilus* species can infect horse, *G. intestinalis* is by far the most common and bot larvae are found commonly in the stomach of equids. Eggs are laid by adult flies on the animal's hair coat and are then ingested during grooming. Less commonly larvae have been found around the mouth and nasal cavity. After a period of development in the equine host, larvae are excreted in the faeces, after which they go through further development to adult flies in the environment. Horses of any age can be affected but the clinical impact of these parasites is minimal.

Dictyocaulus arnfieldi (lungworm)

Infection by the lungworm, *Dictyocaulus arnfieldi*, is rare in horses. Donkeys are the primary hosts and usual reservoir of this parasite (Lyons *et al.*, 1985; Solomon *et al.*, 2012), but horses can become infected when sharing pastures with infected donkeys (Nielsen and Anderson, 1981), although horse-horse transmission has occasionally been documented (Clayton and Duncan, 1981; Slocombe 1985; Boyle and Houston, 2006). Lungworm infection is rarely patent in adult horses but infection is often pathogenic and can cause mucopurulent bronchitis, manifested as a chronic cough and nasal discharge (Slocombe, 1985; Boyle and Houston, 2006). Lungworm is considered to be a common / "normal" parasite of donkeys since it reaches patency and rarely causes clinical disease in this species (Rickards and Thiemann, 2019) (see Chapter 10. Donkeys and hybrids).

Since patent infections occur uncommonly in horses, faecal analysis to identify eggs or first stage larvae is usually negative. Diagnosis of lungworm infection in a horse requires veterinary investigation using techniques such as bronchoscopy and tracheal aspirate analysis (see Chapter 10. Donkeys and hybrids).

Overview of additional parasite species to consider in foals and yearlings

In foals and yearlings, the most common and clinically important parasites are the cyathostomins and *Parascaris* species, however other parasite species of concern for

adult horses should also be considered, such as tapeworms. Foals and young horses are more susceptible than adults to being infected by nematode parasites. In addition, these age groups are more vulnerable to parasite-associated diseases, so control programmes for youngstock need to be the most rigorous and excellent paddock management is especially important for pastures being grazed by broodmares and foals or yearlings. For these reasons foals and yearlings should be considered separately when using the risk assessment-based approach, defined below, which is specifically aimed at adult horses (see Chapter 11. Foals, weanlings, yearlings and youngstock).

***Parascaris* spp. (ascarids)**

The most important parasites of foals are nematodes of the genus, *Parascaris* spp. (ascarids). This large roundworm is very common on stud farms (Figure 4). Infection can cause poor condition and respiratory disease and, on rare occasions, intestinal impaction, which carries a poor prognosis. The eggs shed in the faeces are very resilient and can persist in the environment over the winter to infect the following season's crop of foals, so excellent pasture hygiene is essential on paddocks grazed by foals, and foals should not be grazed on the same pastures year on year. All three classes of anthelmintic (benzimidazoles, tetrahydropyrimidines and macrocyclic lactones) are authorised for the treatment of *Parascaris* spp. infections, however, anthelmintic resistance is an issue in these parasites. Care needs to be taken when treating foals with large adult ascarid burdens as some anthelmintics (for example, macrocyclic lactones and pyrantel salts) have a paralytic effect on the parasites, which can cause colic due to sudden acute intestinal impaction.

Figure 4. Ascarids excreted in faeces

Horse history and potential for clinical disease

- Adult horses appear to develop immunity to *Parascaris* spp. and significant burdens are rare in this age category.
- It is important to consider the age of the foal as the parasitic nematodes that predominate change over the first year of life. In the **first 6-7 months**, *Parascaris* spp. often predominate.
- **After the first 6-7 months**, immunity reduces the level of ascarid infection, and cyathostomin and tapeworm infections start to increase.
- **Recently weaned foals and yearlings** should be turned out onto grazing with the **lowest possible levels of parasite contamination** because animals of this age group are at risk of developing parasite-associated disease.

Resistance

Worldwide, there is evidence of macrocyclic lactone resistance in ascarid populations and resistance to the benzimidazole and tetrahydropyrimidine classes is increasing (Nielsen, 2022). To date, there is limited UK-specific information on the prevalence of anthelmintic resistance in ascarid populations.

Strongyloides westeri (threadworm)

Strongyloides westeri is occasionally associated with diarrhoea in young foals, but disease due to this parasite is relatively rare. There is no evidence either way to suggest that treatment of mares near the end of gestation prevents lactogenic transmission of this nematode species, so specific advice cannot be provided on this practice at this time.

Authors: Martin Nielsen, Tim Mair
(Reviewed by T Mair, J Matthews, M Nielsen)

Chapter 1.2. Using monitoring tools effectively to determine the need for anthelmintic treatment

In healthy adult horses, the majority of parasitic helminths are commonly present in, and eggs excreted by, a minority of the horse population. Consequently, often, only a small number of individual horses contribute to the bulk of pasture contamination; this is important to consider when instituting programmes that minimise selection pressure for anthelmintic resistance.

Faecal egg counts

Faecal egg counts (FECs) are used to:

- Evaluate treatment efficacy with the faecal egg count reduction test (FECRT)
- Estimate the level of strongylid egg shedding contributed by each horse in a given herd
- Monitor ascarid egg excretion in foals and yearlings.

Guidelines for FECRT testing are provided in Chapter 4. Testing for anthelmintic resistance. Specific guidelines for the choice of FEC technique and relevant performance metrics to consider are also provided elsewhere (see Chapter 1.2.1. Guidance for use of faecal egg count methods in horses and Chapter 1.2.2. Assessing diagnostic performance metrics).

Monitoring the level of strongyle egg shedding in adult horses

Egg counts typically follow an over dispersed distribution within groups of horses, with most horses shedding low or moderate levels and a minority of the horses being high strongylid egg shedders (Stratford *et al.*, 2011; Nielsen *et al.*, 2018). This is often described as the 20/80 rule (see Chapter 6. Reducing the dependence on anthelmintics, section on cyathostomin overdispersion), since around 20% of the horses in a given herd excrete around 80% of the total egg output (Kaplan and Nielsen, 2010). Furthermore, research has documented that mature horses have a strong tendency to consistently maintain the same level of strongylid egg shedding over time (Nielsen *et al.*, 2006; Scheuerle *et al.*, 2016). Therefore, FEC testing is recommended to identify high strongyle egg shedders within a group and treat them appropriately. Since

all strongylid eggs are similar in appearance, it is not possible to morphologically differentiate cyathostomin eggs from those of large strongyles based on coprological examination. To monitor for the presence of the large strongyle parasite, *Strongylus vulgaris*, other tests are necessary.

In terms of treating horses to reduce strongyle egg shedding, regular FEC tests can be used to identify which horses are consistently shedding high numbers of eggs and those which are not. Depending on the estimated level of strongyle transmission, based on the climatic conditions, the duration of the grazing season, age profile and paddock management, FEC tests are recommended one to four times a year in grazing horses to assess the degree of pasture contamination arising from individuals and to determine which horses require treatment. FECs can be determined year-round; although there may be fluctuations in egg count levels between seasons, with lower levels of shedding in the UK in autumn and winter (for example, Wood *et al*., 2013), there are no fluctuations in test performance across seasons. The usefulness of determining FECs in the winter is dependent on the management of the horses (for example, access to grazing), as parasite transmission occurs while grazing and at temperatures above 6˚C. It should be kept in mind that anthelmintic treatments aimed at reducing strongylid egg shedding in a herd of horses are only meaningful if the horses are turned out on pasture under climatic conditions allowing parasite transmission.

How often should FECs be performed?

- FEC tests are recommended 1-4 times per year in grazing horses
- A risk assessment will inform the frequency to apply FEC tests
- Often a good starting point for adult horses is two FEC tests per year during the grazing season; more tests could be performed in certain circumstances (for example, in horses grazing pastures all year round or horses at high risk).

Anthelmintic applications should be targeted at those horses that have moderate or high FECs, whereas horses with repeatedly low FECs require fewer treatments. Treatment cut-offs of 200-500 eggs per gram (EPG) can lead to reductions in overall faecal egg output of 95% (Kaplan and Nielsen, 2010). Therefore, choosing a threshold in this range is recommended when using the commonly applied McMaster FEC method.

Prescribers should determine which threshold to choose (within the range of 500 EPG or below) using a risk-based approach (see Chapter 1.3. A risk assessment-based approach to equine parasite control in adult horses).

It should be emphasised that FECs are highly useful and reliable monitoring tools for three purposes: 1) Evaluating anthelmintic treatment efficacy, 2) Determining the strongylid egg shedding status and pasture contaminative potential of individual horses, and 3) Monitoring the presence of ascarid parasites in foals and yearlings. However, the magnitude of the strongylid FEC does not correlate with the size of the parasite burden or reflect the risk of clinical disease. This means that the FEC cannot be used to evaluate possible parasite involvement in a horse with clinical manifestations, which should be assessed and managed by a veterinary surgeon. Also, FECs do not indicate a risk of disease or adverse reactions to anthelmintic treatment. Finally, consideration should be given to the FEC methods used – see Chapter 1.2.1. Guidance for the use of faecal egg counts in horses for more information.

Using faecal egg counts for strongylid parasites:

- FEC tests can be used to estimate the level of strongyle eggs that individual horses excrete and can be used to inform anthelmintic treatments to reduce egg shedding and subsequent pasture contamination.
- FECs do not provide information on the level of infection within individual horses, as larval stages and male parasites do not produce eggs, and FECs do not correlate with adult helminth burdens.
- *S. vulgaris* produces a strongyle-type egg, morphologically indistinguishable from eggs produced by other strongyle parasites, such as cyathostomins so different tests need to be used to identify the presence of large strongyles.
- In most adult horse populations, usually <20% individuals contribute >80% of the eggs to the contaminating output at any one time.

Monitoring for ascarid and strongyle egg excretion in foals and yearlings

The equine roundworm, *Parascaris* spp., commonly occurs in foals and youngstock. As opposed to the strongylids and tapeworms, infection with this parasite is largely restricted by age. This means that the parasite is highly relevant to test for in some age

groups, but highly unlikely to be encountered in others. There does not appear to be a strong effect of seasonality on ascarid transmission (Ripley *et al.,* 2023).

In foals **up to 4 months of age**, targeted treatments informed by FEC testing are **not** recommended because the predominant parasite in this age group, *Parascaris* spp. has a long prepatent period. Waiting for ascarid egg excretion to inform treatment could therefore lead to clinical disease. Instead, to target *Parascaris* spp., all foals should be treated with an effective anthelmintic at 2-3 months of age (see Chapter 11. Foals, weanlings, yearlings and youngstock).

For foals **older than 4 months old**, FEC analysis is important because it will provide information about the predominant parasite category present (i.e. *Parascaris* spp. or cyathostomins), which each need to be targeted with a particular anthelmintic (see Chapter 11. Foals, weanlings, yearlings and youngstock). Faecal egg count analysis will provide valuable information on the levels of egg excretion onto pasture. Ascarid FECs tend to peak in foals of about 4-5 months of age, after which they decline and eventually become negative (Fabiani *et al*., 2016). While ascarid worm burdens also tend to peak at this age, there is no correlation between ascarid egg counts and worm counts in individuals (Nielsen *et al*., 2010). Between 4 and 9 months of age, FEC testing is recommended at a frequency of every 8 weeks to determine the predominant parasite type present to inform anthelmintic choice.

The most meaningful use of FECs is to monitor the transition from ascarid-dominated parasite burdens to strongyles and tapeworms at 5-8 months of age. This is due to the often-contrasting anthelmintic resistance profiles between ascarids and strongyles, where products that perform well against ascarids often do not work well against strongyles, and vice versa (Nielsen, 2022).

Recently weaned foals and yearlings are more likely to be high egg shedders, so routine monitoring (ideally every 2-3 months) using FEC tests is paramount. In the UK, however, many foals will have been recently weaned by the autumn/early winter when a cyathostomin larvicidal treatment may be considered. Inhibited larval development appears to be less prominent in foals and yearlings (Nielsen and Lyons, 2017), although clinical cases of larval cyathostominosis have been described in yearlings (Byrne *et al*.,

2025). This means that there may be no basis for recommending that **all** foals and yearlings should routinely receive a larvicidal treatment in the autumn/winter. Therefore, the advisor who is in regular contact with the stud and has extensive knowledge of the management practices applied would be best placed to advise on whether a larvicidal treatment is required, based on a risk assessment. In addition, there can be a second wave of ascarid infection in some yearlings, and a FEC should be used inform on the presence of this species.

The sensitivity and specificity of ascarid FECs have been reported to be 72% and 94%, respectively, while the positive and negative predictive values were 95% and 66%, respectively (Nielsen *et al.*, 2010). This means that a positive FEC is highly likely to reflect a current patent infection, while a negative count could be a false negative.

Faecal egg counts in foals and yearlings:

- The most meaningful use of FEC analysis is in foals older than 4 months to provide information on levels of egg excretion onto pasture and monitor the predominant parasite types present to inform treatment.
- Ascarid FECs tend to peak in foals of about 4-5 months of age.
- When foals are 4-9 months old, FEC testing is recommended at a frequency of every 8 weeks to monitor the transition from ascarid-dominated parasite burdens and inform anthelmintic choice.
- Routine monitoring (ideally every 2-3 months) of FEC shedding is recommended for older foals and yearlings.

Assessing the efficacy of anthelmintic treatment

The FEC test is also invaluable in assessing the effectiveness of anthelmintics. It is advisable to conduct FECRTs once a year to monitor drug effectiveness patterns on individual premises. The information helps guide which anthelmintics to avoid using as the use of an ineffective anthelmintic in the face of pre-existing resistant parasites will promote expansion of the resistant sub-population of parasites (see Chapter 4. Testing for anthelmintic resistance). For foals and yearlings, FECRTs should be performed once a year to assess the effectiveness of the anthelmintics used against both cyathostomins and *Parascaris* spp.

It is important to **report all cases where there is a suspected lack of efficacy** (see Chapter 5. Reporting lack of efficacy).

Detecting tapeworm burdens

Standard McMaster FEC techniques have very poor sensitivity for detection of tapeworm eggs. Two studies showed sensitivities of less than 10% for these techniques, which means that 90% of infections are likely to go undetected (Nielsen, 2016a). A modified egg counting technique, involving a larger sample and extra washing steps, often referred to as the 'Proudman's technique' has been validated and shown to have good sensitivity (92%) and specificity (98%) for the detection of tapeworm burdens of 20 worms and above (Proudman and Edwards, 1992). This technique can be considered for detecting individual horses with tapeworm burdens exceeding 20 worms, but risks not accounting for the presence of immature or sterile adult tapeworms, which can be present in high proportions in some cases (Meana *et al.*, 2005; Rehbein *et al.*, 2013).

Small redworm ELISA in adult horses

A serum ELISA test for the detection of antibodies to adult and larval stages of cyathostomins in horses is available commercially in the UK (Small Redworm Blood Test).

The Small Redworm Blood Test is a qualitative test capable of detecting presence or absence of total cyathostomin burdens (i.e. larval and adult stages combined) exceeding a threshold in the 1,000-10,000 total helminth count range (Lightbody *et al.*, 2024) – please also refer to Chapter 1.3. A risk assessment-based approach to equine parasite control in adult horses. The test does not quantify the helminth burden, and it does not differentiate between larval and adult stages. Diagnostic sensitivity has been shown to be above 90%, while the specificity ranges from 75 to 85%, depending on the chosen threshold. In other words, the test is highly sensitive, but does operate with a 15-25% false-**positive** rate.

It should be emphasised that this test was designed to detect infection with **all cyathostomin stages** in the host and does not specifically reflect the levels of

encysted larval stages. Thus, a positive test result cannot be interpreted as an indicator of a need for specific treatment of encysted larvae (larvicidal treatment), whereas a negative test result can be interpreted as strong evidence of a low cyathostomin burden, which is unlikely to require treatment. Application of the test in low-risk populations, following the test's guidelines, has the potential to substantially reduce anthelmintic treatments compared with blanket dosing. For example, in an EU-based sport horse cohort (n = 981), 62% of horses had serum scores corresponding to very low cyathostomin burdens below 1,000 worms, 19% between 1,000 and 10,000 worms, and only 19% above 10,000 worms (Matthews *et al.*, 2024). However, given that the test does not specifically reflect encysted larval burdens, it is not recommended for evaluation of clinical cases under suspicion of acute larval cyathostominosis.

Small redworm ELISA:

- An antibody-based test (Small Redworm Blood Test) is available to detect the presence or absence of total cyathostomin burdens.
- This test is not appropriate for use in horses deemed to be at high risk of cyathostomin infection.
- A low/negative test result, alongside serial FEC results and other risk assessment factors, may be used to demonstrate low risk of cyathostomin burden and may support decisions on whether or not anthelmintic treatment is necessary (see Table 1).
- In addition, at this time, CANTER does not make recommendations for the use of this test routinely and/or in isolation to determine whether to administer anthelmintics in horses.
- This test may only be offered by veterinary surgeons who should consider the clinical guidelines for the profession, such as the BEVA Anthelmintic Toolkit (ProtectMEtoo).
- CANTER recognises that this recommendation regarding the use of the test may change as confidence and understanding around the merits of applying the test increase and could be included in future updates to the guidelines.

Tapeworm antibody testing in adult horses

ELISA tests have been validated and made commercially available in the UK for measuring tapeworm-specific IgG(T) antibody in serum (Proudman and Trees, 1996) or saliva samples from horses (Lightbody *et al.*, 2016) to tapeworm antigens. These tests can also generate information about the level of tapeworm exposure in herds of horses, as they are measuring the presence of antibodies and not necessarily actual infection. This can be a useful aid in determining the need for tapeworm-directed treatments to a specific group. The saliva test has been validated using samples from horses for which tapeworm burdens were enumerated, and demonstrated 83% sensitivity and 85% specificity at the 1+ tapeworm threshold, with 100% sensitivity for detecting 20 or more tapeworms (Lightbody *et al.,* 2016). These metrics indicate that the test can reliably detect current tapeworm burdens in horses. The serum test has similar performance, but tapeworm-specific antibodies in saliva are reported to reduce at a faster rate following effective anthelmintic treatment than in serum (Matthews *et al*., 2024).

The saliva test has been demonstrated to be useful for screening of horses in a targeted treatment approach, where only the horses testing positive received a tapeworm treatment, resulting in an 86% reduction in anti-tapeworm anthelmintic use compared with blanket annual treatments (Lightbody *et al*., 2018).

Horses grazing pastures in groups where antibody tests have demonstrated high tapeworm exposure or where there has been tapeworm-related disease should be considered at higher risk of tapeworm-related disease and be tested in spring and autumn, followed by treatment if results indicate a moderate/high burden. Any suspicions of current clinical disease should be referred to a veterinary surgeon. Horses considered at low risk of tapeworm-related disease (low antibody levels in previous tests in the herd or no previous history of tapeworm-related disease on the premises) can be tested once a year in spring or autumn. Horses considered at medium risk of tapeworm-related disease (i.e. a group of horses that co-graze and have had clinical disease in the past) should be tested once per year for surveillance purposes, and testing frequency adjusted accordingly. The need for testing twice per year in medium-risk horses is determined by risk factors or changes to the horse's environment, management and/or health status. Analysis of the commercial dataset

for the tapeworm saliva test demonstrated that, of 164,002 UK samples submitted between 2015 and 2022, inclusive, 68.2% of horses had saliva scores that fell below the treatment threshold, corresponding to a potential saving of 111,927 anthelmintic treatments in this period compared to a programme not informed by monitoring test results (Matthews *et al.*, 2024). Thus, it is relevant to use this test to identify horses potentially in need of treatment and avoid unnecessary use of anthelmintic products in those that do not need treatment.

Detecting tapeworm burdens

- Standard nematode egg counting methods, such as the McMaster technique, have poor sensitivity for detecting tapeworm eggs, but other coprological methodologies can be used.
- Measurement of IgG(T) by ELISA in serum or saliva to tapeworm antigens can be performed to indicate the need to treat for tapeworm.

Considerations for foals and yearlings

Foals can be tested for tapeworm infections from 6 months-old onwards and, ideally, treatment should be targeted based on regular monitoring test results, as levels of infection can vary between yards or farms.

In recently weaned foals and yearlings, testing for tapeworms can be performed twice a year to indicate levels of infection at a population level, as well as to indicate individuals that require treatment to reduce shedding of tapeworm eggs onto paddocks.

Overview of tests for detecting other parasite species

Detecting *Strongylus vulgaris*: Larval culture and PCR

Since all *Strongylus* spp. parasites release a similar type of strongylid egg, which is indistinguishable from those of the small strongyles (cyathostomins), other tests are necessary to monitor for the presence of these parasites.

Larval culture is a low-technology technique where eggs are hatched and larvae cultured (2-week faecal culture) to the third larval stage, where they can be

morphologically identified under the microscope. When conducted by trained personnel, this technique has been shown to perform with a sensitivity and specificity of 73% and 84%, respectively, for detecting *S. vulgaris* infection (Nielsen *et al.*, 2010). While the positive predictive value is high (96%), the negative predictive value is substantially lower (37%). In other words, a positive test result is highly likely to be true, whereas a negative result can often be a false-negative.

An alternative to the larval culture is a faecal PCR detecting *S. vulgaris* (Nielsen *et al.*, 2008), which is being offered by several national laboratories in Europe. However, PCR testing and larval culture are both limited to detecting the patent phase of infection. A larval culture service is now commercially available in the UK.

Given the low negative predictive value of individual larval culture tests, the most reliable *S. vulgaris* infection status information is achieved when all herd members are tested, including those with 0 strongylid EPG. Like other strongylids, the parasite is transmitted during the grazing season, and testing should be planned accordingly, i.e. either prior to spring turnout, and/or in the autumn towards the end of the season.

Detecting pinworms: The 'tape test'

Pinworms can be detected using the tape test applied to the skin surrounding the anus, which is where the female worms deposit their eggs. Several studies have demonstrated that the tape test can also be used for evaluating treatment efficacy (See Chapter 9.1. Pinworms).

Detecting ascarid burdens: Transabdominal ultrasonography

As an alternative to FEC monitoring, transabdominal ultrasonography can be a useful tool for visualising and semi-quantifying small intestinal ascarid burdens with good agreement between ultrasound findings and ascarid worm counts (Nielsen *et al.*, 2016b). A scoring system for assessing the number of worms present has been developed and validated and can be used to assess the potential risk of a verminous impaction in the small intestine following anthelmintic treatment.

Chapter 1.3. A risk assessment-based approach to equine parasite control in adult horses

The risk assessment outcome should provide an appraisal of the parasite transmission potential within a group so that the implemented programme is tailormade to suit the estimated level of risk of developing parasite-associated disease. A risk assessment-based approach should also be applied to horses kept individually, such as those horses not in a herd or sharing pastures with other horses.

A "traffic lights" system approach to assist prescribers in their decision-making process for assessing the need for anthelmintic treatment is outlined in Table 1 below. The value of monitoring tools is exemplified in this approach so that the level of risk can be quantified alongside what is known of the population's structure and its prior pasture and parasite management approaches. The risk assessment table is generated to focus on adult horse populations in the UK, where the tests described are available.

The level of risk within each category would decrease/increase depending on the criteria that are relevant to the group or individuals being assessed. For example, if the assessment indicates agreement with most criteria in low-risk categories, then the risk is lower, or if the assessment indicates agreement with most criteria in the high-risk category, then the relative risk is high. The Parasite Risk Table is a horse owner-facing material developed by CANTER to facilitate discussions between prescribers and horse owners about their horse's parasite risk profile. A free online risk assessment tool is also available (https://www.whatsyourwormrisk.com).

Authors: Tim Mair, Jacqui Matthews, Martin Nielsen
(Reviewed by T Mair, J Matthews, M Nielsen)

Table 1. Criteria in different risk categories as applied to parasite control in horses.

A "traffic lights" system – purple (high risk), orange (medium risk) and amber (low risk) – approach will assist prescribers in their decision-making process for assessing the need for anthelmintic treatment. The CANTER Parasite Risk Profile Table primarily relates to gastrointestinal parasite species of importance and/or clinical significance in adult horses, which are cyathostomins and tapeworm. The approach to parasite control is different in foals and yearlings because different parasite species are likely to present, so this age group are treated separately to adult horses.

Risk factor*		Factors indicating potential for parasite transmission LOW	Factors indicating potential for parasite transmission MEDIUM	Factors indicating potential for parasite transmission HIGH
		Risk category: Amber	**Risk category: Orange**	**Risk category: Purple**
C	**C**linical history	No history of parasite-associated (gastrointestinal) disease in the last 24 months	History of suspected subclinical parasite-associated (gastrointestinal) disease, such as weight loss and ill-thrift, in the last 24 months	History of confirmed parasite-associated (gastrointestinal) disease in the last 24 months
A	**A**ge profile	Age profile – 5-20 years old, no concurrent parasite-associated disease or PPID[1]	Age profile – 5-20 years old, concurrent suspected parasite-associated disease or PPID[1]	Age profile – <5 years old, >20 years old +/- concurrent parasite-associated disease or PPID[1]
N	**N**umber of horses	Low stocking density (>2 acres per horse)	Moderate stocking density (1-2 acres per horse)	High stocking density (<1 acre per horse)
T	**T**est results	Tested for strongyle faecal egg shedding and results indicate consistently low egg shedding (<200 eggs per gram)	Tested for strongyle faecal egg shedding and results indicate moderate egg shedding (200-500 eggs per gram)	Tested for strongyle faecal egg shedding and results indicate high egg shedding (>500 eggs per gram)
		Tested for tapeworm antibody (saliva or serum): low proportion of animals (<20%) above test low score threshold (-0.09, saliva; 2.7, serum) or individual horse kept alone that has score below low score threshold	Tested for tapeworm antibody (saliva or serum): moderate proportion (20-50%) of herd above test low score threshold (-0.09, saliva; 2.7, serum) or individual horse kept alone that intermittently has score above the low score threshold	Tested for tapeworm antibody (saliva or serum): high proportion (>50%) of herd above test low score threshold (-0.09, saliva; 2.7, serum) or individual horse kept alone that consistently has score above the test low score threshold
		A low small redworm antibody test result can provide confidence of low risk of cyathostomin burden and can be used alongside serial FECs	A high small redworm antibody test result does not necessarily indicate a significant cyathostomin burden and should not be used to document these risk categories	A high small redworm antibody test result does not necessarily indicate a significant cyathostomin burden and should not be used to document these risk categories

[1] PPID = Pituitary pars intermedia dysfunction

		Demonstrated efficacy of all anthelmintics by faecal egg count reduction test	Demonstrated efficacy of all anthelmintics by faecal egg count reduction test	Demonstrated lack of efficacy or anthelmintic resistance by faecal egg count reduction test
E	**E**nvironment	Closed herd or individual horse not kept in a herd. Horses that have restricted time at grazing (e.g., sport horses, racehorses, or other horses stabled for the majority of the time)	Occasional newcomers into herd	Frequent movements in and out of herd
		Good pasture management, including dung removal at least once per week	Moderate pasture management, for example dung removal less than once per week	Poor pasture management, for example very infrequent or no dung removal
		Effective quarantine procedures	Quarantine procedures inconsistent	Quarantine procedures non existent
R	**R**isk profile	Estimate the risk based on the number of factors that apply in each category.		

Author: Martin Nielsen, Jacqueline B Matthews

(Reviewed by T Mair, J Matthews, M Nielsen)

Appendices

Chapter 1.2.1. Guidance for use of faecal egg counts in horses

Introduction

In horses, faecal egg counts (FECs) are of value for three main purposes. They are important for:

- testing the effectiveness (efficacy) of the wormers (anthelmintics) used
- monitoring the level of strongyle egg shedding in the dung of horses
- checking for ascarid (large roundworm) and other parasite eggs excreted by foals, weanlings, and yearlings.

It should be noted that FECs do not provide any useful information about the possible involvement of parasites in cases of disease or suspected disease. Nor do they predict the risk of disease in individuals. One reason is that there is no correlation between FEC and worm counts, so a higher FEC does **not** necessarily mean more worms. Furthermore, parasitic disease is often caused by parasite larvae, which, being immature, do not yet produce eggs.

In general, FEC techniques are useful for three parasite egg types: threadworms (*Strongyloides westeri*), strongyles and ascarids. Most methods commonly used in the UK do not reliably detect tapeworm, pinworm, fluke or lungworm eggs. However, other tests for these are available.

Collection and storage of samples

Sample collection, storage and handling methods can all affect FEC test results. Once eggs hatch, FEC are not accurate so samples should be collected from freshly voided dung or, at most, within 12 hours (Nielsen *et al.*, 2010).

As nematode egg hatching requires an aerobic environment and does not occur below 6°C, samples should be placed in bags or containers without air and, ideally, kept below this temperature, especially if stored more than a few hours. Samples can be

stored below 6°C for up to five days before egg counts start to decline substantially, but should be processed as soon as possible after collection (Nielsen *et al.,* 2010).

Strongyle eggs are not evenly distributed in equine faeces (Lester and Matthews, 2014); this clumping effect has a significant impact on the level of precision in FEC analysis, such that, if only a small amount of material is collected from one area of the dung, it increases the variability of the results. Thus, samples should be taken from at least three dung balls for testing. When samples are processed, they should be well mixed (ideally, homogenised) at the laboratory if sub-samples are taken for counting; this will improve precision of testing (Matthews and Lester, 2015).

The key points are summarised in Box 1, below.

Box 1. Sample collection for FEC testing

- Take five small pinches from at least three dung balls from a fresh dung pile to submit for testing. The sample should be *at least* 5 grams to optimise the value of the test; owners should be made aware of this if they usually provide lower amounts.
- All air must be excluded from the container when the sample is transported.
- Samples should be collected on the day they are submitted (or posted) to the laboratory and should be clearly labelled with the horse's name and date of collection to enable the testing laboratory to determine whether the sample may have expired.
- Care must be taken during warm weather as higher temperatures (> 40˚C) will affect egg counts within a day.

Once samples arrive at the laboratory, it is important to handle them to minimise sources of variation that can occur at this point. These are summarised in Box 2.

Box 2. Points to consider for samples once at the laboratory

- Samples are only suitable for analysis within five days of collection and providing air has been expelled satisfactorily during this time.

- Other measures of sample quality should be assessed, such as dryness, evidence of mould/fungal growth, before deeming a sample suitable for testing.
- Samples should be analysed immediately upon arrival or refrigerated, if necessary.
- When samples are processed, they should be well mixed (ideally, homogenised) if sub-samples are taken for counting; this will improve precision of testing.

Faecal egg count methods and performance metrics

Since the FEC is a quantitative measure, there are performance metrics that can be used to assess how a specific test performs.

The **multiplication factor** is used to convert the number of eggs counted under the microscope into the number of eggs per gram (EPG) of faeces reported. The multiplication factor is determined by the egg counting technique protocol and is not a measure of diagnostic or analytical sensitivity.

Box 3. Explanation of the use of multiplication factors in equine faecal egg count tests

The multiplication factor is the number used to convert the number of eggs counted under the microscope to the standardised 'eggs per gram' of faeces. This is defined by the FEC protocol, and depends on the total volume of faecal suspension prepared, the mass of faeces processed, and the volume of suspension examined under the microscope. The formula for calculating the multiplication factor can be described as follows:

$$\left(\frac{total\ volume\ of\ suspension\ [mL]}{mass\ of\ faeces\ processed\ [g]}\right) \times volume\ of\ subsample\ analyzed\ [mL]$$

As an example, an often-used McMaster technique suspends 4 g faeces in 56 mL flotation medium, achieving a total suspension volume of 60 mL. If both grids are counted on a classic two-chambered McMaster slide, the volume of the subsample analysed is 0.3 mL. The multiplication factor can be calculated as (60/4)/0.3 = 50.

Common errors when applying the McMaster method

The McMaster technique is based on the flotation/dilution principle and assumes that eggs are randomly distributed in the solution if the sample has been well mixed before dispensing the filtrate into the slide for counting. If the suspension sits in a given flotation solution for an extended period (>2 mins) before loading onto the slide, eggs will float towards the surface and will no longer be randomly distributed. Not mixing the faecal suspension and removing only the surface layer will place relatively more eggs into the slide, resulting in an overestimation of the EPG count and an inaccurate result. Therefore, the faecal suspension should always be (re)mixed before it is loaded onto the slide. It is important to regularly confirm the specific gravity of the flotation solution. This can be done by measuring 10 ml of solution and weighing it. If the specific gravity is 1.25, 10 ml should weigh 12.5 g.

End-users should request information on diagnostic sensitivity, accuracy and precision from providers of FEC to ensure the test being applied aligns with the reason for the assessment being required. For example, failure to use a technique with the appropriate performance metrics could lead to inappropriate treatment decisions due to misclassification of egg shedding level, treatment efficacy or presence/absence of ascarids.

The use of faecal egg counts in practice

Several FEC methodologies are available for counting nematode eggs in dung. The most widely used standard quantitative technique in the UK is the McMaster method (Gordon and Whitlock, 1939). This method, and related modifications (Henriksen and Aagaard, 1976; MAFF, 1986), are relatively easy to perform and are used in many laboratories across the world. Techniques performing with low diagnostic accuracy will return a lower range of counts than the typical McMaster technique.

It is widely recommended to monitor horses >6 months-old for strongyle egg shedding levels to inform anthelmintic treatment decisions to reduce worm transmission via the environment. Here, the primary purpose is to identify high strongyle (or ascarid) egg shedders, which most available FEC techniques (including the commonly used

McMaster technique) should be capable of. It should be kept in mind that FECs are **not** indicative of the number of worms present, so they should be interpreted only as an estimate of parasite egg shedding capacity.

It should be noted that expected levels of FECs will vary between age groups and between parasite categories. Table 2 Table summarises the expected distribution of faecal egg shedding levels in different age groups for strongyle and *Parascaris* spp. eggs.

Table 2. Low, moderate, and high faecal egg count levels (in eggs per gram, EPG) for different age groups for strongyles and ascarids, respectively, showing the proportions (as percentages) to expect in each age category. The table refers to parasite faecal egg counts as typically determined using the McMaster method.

	Strongyles			**Ascarids**		
	Low	Moderate	High	Low	Moderate	High
Foals: EPG	0-500	500-1000	>1000	0-500	500-1500	>1500
Proportion of animals	70-90%	5-20%	0-10%	70-90%	5-20%	0-10%
Yearlings: EPG	0-500	500-1500	>1500	0-200	200-500	>500
Proportion of animals	20-50%	20-50%	20-50%	90-100%	0-5%	0-5%
Adults: EPG	0-200	200-500	>500	0	0-100	>100
Proportion of animals	70-90%	5-20%	0-10%	95-100%	0-1%	0-1%

Ascarids are primarily parasites of foals and youngstock, and generally have different anthelmintic resistance profiles compared to strongyle parasites, so may require different treatment considerations. If ascarid monitoring is the purpose, choose a technique with a good diagnostic sensitivity for ascarids. As monitoring for ascarids is primarily a qualitative exercise (i.e. to determine presence/absence of eggs), quantitative performance metrics are of less relevance.

When assessing anthelmintic treatment efficacy, the recommendation is to choose a method with a low multiplication factor, which will make it easier to determine the per cent reduction of FECs following deworming with good statistical power. This is important when assessing anthelmintic efficacy in adult equines as EPG levels are

usually relatively low and group sizes are often small (<10) when trying to assess levels of FEC reduction post-treatment in practice. High precision is required to reliably distinguish a true reduction in anthelmintic treatment efficacy from random variation of pre- and post-treatment FECs. The same FEC methodology and sampling/transfer processes should be used for both pre- and post- treatment FECs.

Author: Martin Nielsen
(Reviewed by T Mair, J Matthews, M Nielsen)

Chapter 1.2.2. Assessing diagnostic performance metrics

Diagnostic performance of faecal egg counting techniques can be assessed through a number of different metrics, of which some are more relevant than others. These are briefly outlined in the following section. In general, diagnostic tests can be evaluated for their qualitative and quantitative performance. Not all tests are quantitative in nature, but all tests (both quantitative and qualitative) can be evaluated for their qualitative diagnostic performance.

Qualitative performance

A qualitative test detects the presence or absence of a given condition but does not quantify the intensity or level of egg shedding. Classic qualitative performance diagnostic parameters are sensitivity and specificity, but other metrics include the positive and negative predictive values and the positive and negative likelihood ratios. These are defined below.

- Sensitivity: The probability of the test detecting a true positive.
- Specificity: The probability of the test detecting a true negative.
- Positive predictive value: The probability of a positive test result being a true positive.
- Negative predictive value: The probability of a negative test result being a true negative.
- Positive likelihood ratio: The probability that a test would detect a true positive divided by the probability that the same test would return a false positive result.
- Negative likelihood ratio: The probability that a test would detect a true negative divided by the probability that the same test would return a false negative result.

Of the metrics above, it should be recognised that estimation of the first four (sensitivity, specificity, and predictive values) all depend on the prevalence and abundance of the target organism (in this case, parasite eggs in the faeces) in the validation dataset. Different studies will yield different performance estimates. The likelihood ratios, however, are more robust to being affected by prevalence and

abundance, and are, thus, better suited for comparison between studies. However, these are rarely evaluated in veterinary parasitology.

It should be strongly emphasised that the **multiplication factor** of a given egg counting technique is not a diagnostic performance metric. Rather, it has not been determined in a study evaluating test performance, and it is merely a constant derived from the egg counting protocol. The multiplication factor, therefore, cannot be equated to "the technical sensitivity", "the analytical sensitivity", or "the detection limit" of a given egg counting technique.

The relevance of these qualitative diagnostic metrics depends on the target organism. For tapeworms and ascarids, for example, results are interpreted qualitatively, which means that these metrics are highly relevant. Examples are provided in Table 3. However, for strongyle egg counts, qualitative metrics are less relevant for a couple of reasons: 1) strongyles are ubiquitous, so even FEC-negative horses should be expected to harbour these parasites, and 2) diagnostic sensitivity becomes a matter of the ability to detect low positive counts, which may have limited implications for parasite control. It should be kept in mind that the purpose of a strongyle faecal egg count is never to detect parasite infection. Instead, the main purposes of a strongyle FEC is to 1) evaluate treatment efficacy, and 2) identify high strongyle shedders for a targeted treatment approach aimed at lowering pasture infectivity.

Table 3. Examples of sensitivity and specificity estimates for detection of *Anoplocephala perfoliata* and *Parascaris* spp. eggs in faecal samples.

Parasite	Technique	Sensitivity	Specificity	Reference
Anoplocephala perfoliata	McMaster	7.14%	100%	Hreinsdóttir et al., 2019
	Proudman	61%	98%	Proudman and Edwards, 1992
	Proudman	46%	100%	Kjær et al.,2007
Parascaris spp.	Stoll	72%	94%	Nielsen et al., 2010

Quantitative performance

Since FECs are quantitative measurements, it makes sense to consider the quantitative performance of FEC techniques. It should be emphasised that there is no linear

correlation between FECs and host nematode burdens (Nielsen *et al.*, 2010). The two relevant quantitative performance metrics are accuracy and precision, which are defined below.

- Accuracy: A measure of how close a test is measuring to the true value.
- Precision: A measure of how close repeated measures on the same samples are to each other.

It is important to understand that accuracy and precision are two different measures and that the two terms, therefore, cannot be used interchangeably. A technique can perform with low accuracy and high precision, or vice versa.

Of the two metrics, precision is more important than accuracy when it comes to evaluating FEC techniques. Accuracy can be deemed less important for the reasons outlined below.

- The true FEC value is never known, and the exercise of spiking egg-free samples with known quantities of eggs can only be regarded as a simulation of a true sample at best (Nielsen, 2021). Thus, accuracy can never be truly estimated.
- Accuracy will not affect the evaluation of anthelmintic treatment efficacy, since this is expressed as a per cent reduction from the pre-treatment FEC levels.

However, some techniques can be performed with such low accuracy levels that recommended treatment thresholds might have to be lowered because the magnitude of counts can be substantially lower than with other techniques.

Precision, however, is very important because it is a measure of repeatability of the test. This is both important for classification purposes (i.e. Is a FEC above or below a given threshold?) and for anthelmintic efficacy evaluation (i.e. Is an observed reduction a true reduction or just random variation?). Several studies have shown that good precision levels for strongylid FEC techniques are coefficients of variation (CVs) at around 20% or below (Noel *et al.*, 2017; Cain *et al.*, 2020). Evaluation of the precision of FEC techniques has become “the norm” in recent years, and it is reasonable for veterinary surgeons or other end-users (e.g. horse owners) to request information about this performance metric from providers of such services.

Depending on the purpose for performing the FEC, different performance metrics may be particularly relevant when considering which technique to use. Table 4 provides a guideline for values considered as low and high performance relating to the aforementioned metrics when assessing different FEC methods. It is important to note that the performance of these techniques is dependent on the level of personnel training (Cain *et al.*, 2021), so it is also imperative to consider training protocols and quality assurance procedures for these tests.

Table 4. Guideline metrics for high and low performing parasite faecal egg counting techniques

Metric	High performance	Low performance
Multiplication factor	<10	>50
Accuracy	>70%	<20%
Precision	Coefficient of variation <20%	Coefficient of variation >50%
Diagnostic sensitivity	>75%	<50%

The choice of faecal egg counting technique should depend on the purpose of the FEC. Table 5 summarises which performance metrics to consider when using the FEC test to monitor for worm egg shedding, to evaluate the efficacy of anthelmintic treatment and, in the case of foals and yearlings, when assessing samples for *Parascaris* spp. eggs.

Table 5. Use of faecal egg counts in horses and relevant performance metrics are worth considering when choosing the technique

Application	Aim	Relevant performance metric
Monitoring for strongyle egg shedding	Reliably detect high strongyle egg shedders	Accuracy
Evaluation of treatment efficacy and egg reappearance periods[a]	Reliably measure faecal egg count reduction	Precision, multiplication factor
Monitoring for ascarid eggs	Reliably detect ascarid eggs in faeces	Diagnostic sensitivity

[a] The same technique should be used for determining pre- and post-treatment counts.