Review Article

Common helminth infections of donkeys and their control in temperate regions

J. B. Matthews* and F. A. Burden†

Disease Control, Moredun Research Institute, Edinburgh; and †The Donkey Sanctuary, Sidmouth, Devon, UK.
*Corresponding author email: jacqui.matthews@moredun.ac.uk

Keywords: horse; donkey; helminths; anthelmintic resistance

Summary

Roundworms and flatworms that affect donkeys can cause disease. All common helminth parasites that affect horses also infect donkeys, so animals that co-graze can act as a source of infection for either species. Of the gastrointestinal nematodes, those belonging to the cyathostomin (small strongyle) group are the most problematic in UK donkeys. Most grazing animals are exposed to these parasites and some animals will be infected all of their lives. Control is threatened by anthelmintic resistance: resistance to all 3 available anthelmintic classes has now been recorded in UK donkeys. The lungworm, Dicyocaulus anfieldi, is also problematic, particularly when donkeys co-graze with horses. Mature horses are not permissive hosts to the full life cycle of this parasite, but develop clinical signs on infection. In contrast, donkeys are permissive hosts without displaying overt clinical signs and act as a source of infection to co-grazing horses. Donkeys are also susceptible to the fluke, Fasciola hepatica. This flatworm can be transmitted, via snails and the environment, from ruminants. As with cyathostomins, anthelmintic resistance is increasing in fluke populations in the UK. A number of the anthelmintic products available for horses do not have a licence for use in donkeys, and this complicates the design of parasite control programmes. As no equine anthelmintic classes appear to be near market, it is important that the efficacy of currently effective drugs is maintained. It is important that strategies are used that attempt to preserve anthelmintic efficacy. These strategies should be based on the concept that the proportion of worms in a population not exposed to anthelmintic at each treatment act as a source of ‘refugia’. The latter is an important factor in the rate at which resistance develops. Thus, it is imperative that parasite control programmes take into account the need to balance therapy to control helminth-associated disease with the requirement to preserve anthelmintic effectiveness.

Introduction

Perhaps one of the biggest challenges when managing helminths in donkeys is that of clinical assessment. Donkeys with significant helminth burdens may appear healthy and it is rare to observe the type of clinical signs (diarrhoea, weight loss, colic or poor condition) that are more common in horses. Morrow et al. (2011) determined that, of 1444 donkeys that presented at post mortem, 16% harboured helminth infections that were considered to be of a moderate to high cyathostomin or mixed species burden. The importance of parasites as a significant cause of morbidity and mortality in otherwise healthy donkeys is as yet undetermined; however, extrapolation of data from horses would suggest that management of helminths in donkeys is of general importance to their wellbeing and to that of co-grazing animals.

Nematodes that commonly affect donkeys

Cyathostomins

In donkey populations in which all animals are administered anthelmintics on a regular basis, most harbour low burdens of parasitic nematode infections and do not exhibit overt signs of disease. As in horses and ponies, the most common parasitic nematodes are the cyathostomin species. The life cycle of these nematodes is the same as in other equids, with a period of larval encystment in the large intestinal wall playing an important role in the epidemiology and pathogenicity of infection. In some donkeys, encysted larvae build up in large numbers and can emerge synchronously to cause larval cyathostomiasis. The latter is associated with one, or all, of the following: sudden onset weight loss, colic and, rarely in donkeys, diarrhoea. The case fatality rate of larval cyathostomiasis in donkeys is not known, although, in this species, it would appear to be lower than observed in other equids, which, in some reports, approaches 50% (Giles et al. 1985). Encysted larvae can persist for many months and, during autumn/winter in the UK, the larvae can comprise the majority of the cyathostomin burden. This being the case, donkeys can harbour considerable levels of infection but the parasites (encysted larvae) are not detectable by routine faecal egg count (FEC) analysis.

The impact of cyathostomin infections on working donkeys is unclear; some studies indicate that they have a negative effect on body condition score and are associated with the presence of anaemia (Matthee et al. 2002). Other studies show no correlation between FEC and body condition score (Getachew 2006; Burden et al. 2010). Donkeys do appear to remain ‘healthy’ when high levels of cyathostomin infection are present, as long as they are not nutritionally compromised or overworked (Getachew 2006; Burden et al. 2010). A recent randomised blinded control study carried out in Morocco by Crane et al. (2011) showed significant increases in body condition score in those equids that received anthelmintic treatment when compared to those that were administered a placebo; however, no significant change in bodyweight was noted. Further research is needed in this area, particularly in light of the significant expenditure required to maintain the mass deworming programmes that are commonly a mainstay of charities working with equids in the developing world.

Like other equids, individual donkeys vary in susceptibility to cyathostomins. Generally, in well managed populations, within a group, the majority control their level of infection relatively well. This is manifest as a negative or low FEC. Often, a few
Parascaris equorum

Horses and ponies acquire immunity to this small intestinal nematode relatively quickly with age and exposure; patent infections (as detected by the observation of round, thick-shelled eggs in faeces) are usually only seen in horse/pony foals. In donkeys, however, mature animals harbour patent infections (Getachew et al. 2010b). Hence, otherwise healthy, mature donkeys may be important sources of pasture contamination and, when compromised through overwork, ill health or poor nutrition, may be at risk of disease. The life cycle of P. equorum is migratory and infection is in the form of an environmentally resistant egg containing a second stage larva. Time from infection to detection of eggs in faeces is approximately 10 weeks. The parasite is relatively common, especially on large operations where animals graze permanent pastures and can cause clinical problems when infection intensity is high. Because the migratory pattern is hepato-tracheal, respiratory signs are observed in animals under high levels of challenge. Other signs include failure to thrive, whole adult worms in faeces and, in cases where infection intensity is high, direct effects on the intestine. The latter effect is rare but holds a poor prognosis. There have been a number of reports of treatment failure of anthelmintics (primarily, ivermectin) against P. equorum in horse foals (von Samson-Himmelstjerna 2012) and the authors have experienced treatment failure against P. equorum with ivermectin, moxidectin and pyrantel embonate when used in donkeys. Therefore, anthelmintic resistance in this nematode species should be considered when designing control programmes.

Oxyuris equi

Oxyuris equi (pinworm) is relatively common in horses and ponies, but not as common as the cyathostomins (Bucknell et al. 1995; Upjohn et al. 2010). Oxyuris equi are primarily considered a nuisance or irritant, but in some animals persistent infection can lead to damage around the perineum and tail head. The nematodes are found in the terminal portion of the large intestine. Female worms are found in higher numbers than males and when gravid, pass out of the rectum to lay eggs, which stick to the skin. These are observed as yellow, crusty masses and eggs containing L3 become infective in 4–5 days. Time from infection to the release of eggs is in the region of 5 months. Adult pinworms cause perineal irritation in horses leading to rubbing with broken hairs and bare patches on the perineum and tail head. Donkeys do not, however, appear to demonstrate this behaviour as frequently (F.A. Burden, unpublished observations). Identification of infection in donkeys is often by the observation of adult worms passed in faeces. Faecal examination may not reveal infection and samples should be collected from around the perineal region. Anthelmintics that have demonstrated efficacy against larval and adult O. equi in horses include ivermectin, moxidectin and fenbendazole, although not all brands have a licence for this activity. Pyrantel has demonstrated efficacy against adult stages only. No published studies are available describing efficacy of these products against O. equi in donkeys. Recently, there have been a number of unpublished reports of reduced
anthelmintic efficacy against *O. equi* in horses (Reinemeyer 2012) and the authors have experienced a lack of response to treatment with both ivermectin and pyrantel in donkeys. It is important that good hygiene is practiced to reduce the levels of infective eggs in the environment. Thorough cleaning with a strong disinfectant after removal of all bedding will reduce the risk of infection from the environment. Although there are no published studies detailing efficacy of disinfectants against *O. equi*, extrapolation from studies on human pinworms would indicate that better levels of personal hygiene lead to a lower risk of infection to individuals (Mazhilene 1991; Wang et al. 2010).

**Dictyocaulus arnfieldi**

This is relatively common in donkeys, which, in contrast to mature horses, are permissive of the entire life cycle. However, the availability of MLs has reduced the number of donkeys infected with *D. arnfieldi*: in a recent study, only 4% of animals entering the UK Donkey Sanctuary for the first time were positive on coprological examination (F.A. Burden, unpublished data). Adult worms are found in the respiratory passages and eggs are coughed up and swallowed and passed out in the faeces. Note that this is different to lungworms of other host species in which first stage larvae (L1) are usually detected in faecal samples. *D. arnfieldi* eggs hatch quickly, so diagnostic analysis should include examination for eggs by standard FEC methods, particularly if samples are fresh and have been stored anaerobically, as well as by Baermannisation (Rode and Jørgensen 1989) for L1. Donkeys do not often exhibit clinical signs of infection, yet may excrete large numbers of eggs in their faeces. Donkeys most at risk of developing disease related to high infection intensity are those that are geriatric and/or immunocompromised. The administration of corticosteroids or pars pituitary intermedia dysfunction appear to be correlated with higher lungworm burdens (F.A. Burden, unpublished data) and the screening of such donkeys for *D. arnfieldi* infection is recommended. Co-grazing horses are more likely to develop clinical signs (for example, coughing), so care must be taken to control for lungworms in resident donkeys. Mules appear to be able to support the full life cycle (Solomon et al. 2012), although less commonly than observed in donkeys, and, so, may be more susceptible to disease. Most broad spectrum anthelmintics have a label claim for lungworm in donkeys (please refer to http://www.noahcompendium.co.uk/Compendium/Overview).

**Common cestodes that affect donkeys**

*Anoplocephala perfoliata*

This parasite has an indirect life cycle involving an oribatid mite. Information on this parasite in donkeys is scant. A PubMed search of publicly available databases reveals that few papers detail the prevalence of ‘cestode infections’ in donkeys. In one, ‘cestodes’, including *A. perfoliata* (the commonest tapeworm found in horses in the UK), were identified in 8% of working donkeys examined in Ethiopia (Getachew et al. 2010a) and, in another in Burkina Faso (Vercruysse et al. 1986), the presence of *Anoplocephala magna* was reported in varying numbers. Proudman and Ellis (1995) identified infection rates of *A. perfoliata* of 27% by coprology and 40% by antigen specific antibody ELISA in a group of donkeys studied in the Welsh borders. Serology also indicated a 34% infection rate in donkeys in Ethiopia (Getachew et al. 2012). A low prevalence (3%) of infection has been identified by coprology in donkeys entering the UK Donkey Sanctuary (F.A. Burden, unpublished data). In this case, most tapeworm egg-positive donkeys originated from Ireland or Wales.

In horses, a number of studies have described the effects of *A. perfoliata* at the attachment site, the ileo-caecal junction (Proudman and Trees 1999); however, nothing is reported about the clinical effect on donkeys. A post mortem survey (n = 1617) at the UK Donkey Sanctuary indicated a 0.5% prevalence of tapeworm infection, with only one tapeworm-associated clinical case reported over a 5-year period (F.A. Burden, unpublished data). *A. perfoliata* infection is thought to occur all year round; however, recent studies in horses in Germany indicated a peak in late summer/autumn (Roelfstra et al. 2006). Specific treatment with a product with licensed efficacy against *A. perfoliata* is recommended at this time of year. Praziquantel is not licensed for use in donkeys in the UK.

**Common trematodes that affect donkeys**

*Fasciola hepatica*

*Fasciola hepatica* affects mainly cattle and sheep, but can infect all grazing animals. It is common in the wetter, western areas of UK and in Ireland, but infection is spreading geographically, probably associated with changes in climate and the difficulty of controlling this parasite due to increasing resistance to the commonly used anthelmintic, triclabendazole (Fairweather 2011). The adult fluke is found in the bile ducts and overt clinical signs are not usually observed in infected donkeys; however, thickened bile ducts and raised levels of liver enzymes in serum may occasionally be noted in heavily infected animals (Collins 1961). Little is known of the overall prevalence of *F. hepatica* in donkeys in the UK; a recent coprological survey (n = 735) of new relinquishments to the UK Donkey Sanctuary indicated an infection prevalence of 4%, the majority of positive animals originating from Wales and Ireland (F.A. Burden, unpublished data). Another study at the UK Donkey Sanctuary indicated that, of 60 post mortem examinations performed on donkeys transferred from Ireland, *F. hepatica* was identified in 17% of livers examined and, of 200 faecal samples assessed, 8.5% were positive for *F. hepatica* eggs (Trawford and Tremlett 1996). In the latter study, it was noted that there was little reaction to the flukes in the liver. A recent study in working donkeys in Ethiopia indicated that *Fasciola* spp. (*F. hepatica* and *F. gigantica*) were common in donkeys of all ages; prevalence rates identified at post mortem (n = 112) and coprologically (n = 803) were in the region of 40–45% (Getachew et al. 2010b). In this study, infection intensity was significantly higher in donkeys that were aged 8 years or older. For these reasons, where *Fasciola* spp. are known to be present in other hosts, control programmes must address the exclusion of snail habitats (by fencing or drainage), which will help break the life cycle. No products are licensed specifically for use against flukes in donkeys: in the UK, triclabendazole and other flukicides can be used under the “Cascade” (http://www.noah.co.uk/issues/briefingdoc/24-cascade.htm). The latter is a legal flexibility that allows a rational balance between the legislative requirement for veterinary surgeons to prescribe and use authorised medicines where available and the need for professional freedom to prescribe other products where they are not and is intended to increase the choice of medicines.
Anthelmintic use in donkeys

Few products have specific label indications for donkeys and medicines are often administered based on dose rates optimised for use in horses. Donkeys are adapted to living in arid areas and thrive on poor quality fodder and, because of physiological differences associated with these adaptations, donkeys differ from horses and ponies in how they distribute, metabolise and excrete xenobiotics. This has implications for water compartment partitioning which affects drug distribution (Grosenbaugh et al. 2011). All 3 modern anthelmintic classes (Table 1) available for administration to horses have been shown to be effective in donkeys when administered at doses determined for the former (Maalan and Reinecke 1979; Taylor and Craig 1993; Crane et al. 2011); however, a number of products are not licensed for use in donkeys and care must be taken to acknowledge the appropriate label claim for each active ingredient or brand. Early studies with moxidectin indicated shorter strongyelid egg reappearance periods in donkeys than was observed at the time in horses (Matthee et al. 2002). Indeed, the first report of moxidectin resistance in cyathostomins was observed in donkeys (Trawford et al. 2005). This anthelmintic is not licensed for donkeys and this presents difficulties for cyathostomin control when treatments for encysted larvae are required. In the UK, only a 5-day course of fenbendazole has licensed efficacy against cyathostomin encysted larvae, but there is widespread resistance in these nematodes to this anthelmintic type.

Helminth control in donkeys

Donkeys have different nutritional requirements and natural behaviour compared to other equids. When donkeys are kept in temperate climates, they can become obese if allowed free grazing access. Thus, grazing is often restricted for much of the year, with donkeys commonly grazed at 0.1–0.2 ha/animal. Such stocking densities mean that larval contamination can become high on land that is not effectively managed. Although donkeys are selective grazers that will not, by choice, graze areas soiled by dung, when enclosed on small areas, they graze close to or inside dunging areas, with resultant exposure to high levels of parasite challenge. To restrict grazing, they are often enclosed using electric fencing to encourage strip grazing; although of benefit to weight control, this can lead to abnormal dunging behaviour, with lack of establishment of natural latrine areas away from grazing and so parasite challenge may be high. In these cases, good pasture hygiene is paramount; dung should be lifted at least twice per week and consideration should be given to methods of pasture restriction that enable animals to establish latrine areas. Studies at the UK Donkey Sanctuary have shown substantially reduced strongyle FEC in donkeys grazing pastures where dung was lifted mechanically or manually twice a week compared to pastures with no dung removal at all (Fig 2). Management of manure is important; it should be composted with temperatures reaching a minimum of 50–70°C maintained for over 8 h (Hébert et al. 2010). Generally, compost heaps require turning and maintenance at these levels for a minimum of 3 weeks to ensure destruction of helminth eggs throughout the heap. If possible, alternative means of disposal should be sought or manure heaps sited so that they are not accessible and run-off will not contaminate grazing land.

† High levels of resistance to this anthelmintic reported in cyathostomins, worldwide.

### Table 1: Anthelmintics available for use in treating helminth infections in donkeys in the UK

<table>
<thead>
<tr>
<th>Anthelmintic class</th>
<th>Active ingredient</th>
<th>Indication</th>
<th>Dose rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macrocyclic lactones</td>
<td>Vermectin</td>
<td>GI nematodes, Dictyocaulus arnfieldi</td>
<td>0.2 mg/kg bwt per os</td>
</tr>
<tr>
<td>Benzimidazoles</td>
<td>Moxidectin*</td>
<td>GI nematodes, D. arnfieldi</td>
<td>0.4 mg/kg bwt per os</td>
</tr>
<tr>
<td></td>
<td>Fenbendazole†</td>
<td>As above + encysted cyathostomin larvae</td>
<td>7.5 mg/kg bwt per os</td>
</tr>
<tr>
<td></td>
<td>Triclabendazole†</td>
<td>Immature and mature Fasciola hepatica</td>
<td>7.5 mg/kg bwt per os</td>
</tr>
<tr>
<td>Tetrahydropyrimidines</td>
<td>Pyrantel embonate</td>
<td>Gastrointestinal nematodes, Anoplocephala perfoliata</td>
<td>18 mg/kg bwt</td>
</tr>
<tr>
<td>Pyrazinoisoquinolines</td>
<td>Praziquantel*</td>
<td>Mature F. hepatica</td>
<td>19 mg/kg bwt</td>
</tr>
<tr>
<td>Salicylanilides</td>
<td>Closantel†</td>
<td>A. perfoliata and other tapeworms</td>
<td>38 mg/kg bwt</td>
</tr>
</tbody>
</table>

Fig 2: The average number of strongyle eggs/g/group calculated in 3 groups of donkeys grazing land with different pasture management protocols over a grazing season. Automated (blue line) or manual (pink line) collections of faeces were carried out twice per week throughout the grazing season for 2 of the groups. For the remaining group (green), faeces were not lifted from pasture. Data courtesy of Dr M.L. Denwood and Professor S. Love, University of Glasgow, 2011. FWEC, faecal worm egg count.
Grazing with livestock other than equids is to be encouraged; sheep and cattle may act as biological vacuum cleaners, with few parasite species being shared between the different host types. In areas with high fluke prevalence and where the environment may support snails, fluke infection status of sheep should be assessed before allowing them to graze donkey pasture. It is not advisable to graze sheep with donkeys that are unaccustomed to them, as donkeys may exhibit aggressive behaviour towards unknown livestock (Burden and Crawford 2006); sheep are best employed to graze after donkeys before a period of pasture rest. Ideally, grazing should be allowed at least 6 months to reduce parasite populations (Kuzmina et al. 2006).

Individual donkeys differ in susceptibility to strongyle infections; this is likely to result in over-dispersed patterns of faecal egg excretion, which, at the appropriate time of year, provides an opportunity for control via targeted therapy (Sangster 2003). In horses and ponies, ‘high egg shedders’ generally maintain higher lifelong FEC patterns, despite similar exposure levels (Becher et al. 2010). Temporal data indicating such patterns in donkeys are lacking. As indicated above, the clear effect of age on strongyle egg output, in part explained by the acquisition of immunity in horses (von Samson-Himmelstjerna et al. 2009), does not appear to be as clear cut in donkeys. Despite recommendations being described for targeted therapy in equids over 20 years ago (Duncan and Love 1991), there has been relatively poor implementation of this strategy in the field. The principal objective is to decrease selection pressure for anthelmintic resistance, whilst maintaining health by reducing infection intensity (Stratford et al. 2011). Variation in environmental conditions, pasture management and herd dynamics mean that no one protocol can be applied uniformly; an understanding of the target helminth species, appropriate diagnostic tests (and their limitations), along with a knowledge of anthelmintic sensitivity provide the concepts on which to base best practice control. When low faecal egg shedding is unexplained, helminth eggs in their faeces are thought to provide ‘refugia’, which serve to dilute eggs laid by worms that have survived in anthelmintic treated animals. As parasite refugium is considered to be the most influential factor in the development of anthelmintic resistance and the rate at which it increases (van Wyk 2001), repeated, simultaneous treatments of all animals, irrespective of FEC, are not recommended.

Faecal egg count should be used regularly to target helminth adulticial treatments and can be performed ‘in-house’ as they require little specialised equipment or particularly advanced skills. Alternatively, a number of laboratories offer a commercial FEC service. The McMaster (or modified McMaster) test, based on a flotation/dilution principle, is the most commonly used technique. A centrifugal-flotation technique is more sensitive, particularly at low egg numbers (Bello and Allen 2009). Faecal samples should be collected as fresh as possible and placed into sealable bags, excluding as much air as possible to reduce egg development. Samples collected in this way can be refrigerated in airlight containers for up to 120 h without a significant change in nematode egg numbers (Nielsen et al. 2010). FEC do not provide a gauge of total nematode burdens; especially during autumn and winter in the UK when cyathostomin encysted larval levels can be high. For this reason, FEC are of most use in targeted therapy strategies during the grazing season when they can be used to identify the relative contribution that individuals make to pasture contamination (Matthews 2010). All co-grazers should be tested simultaneously after the effective refractory period of the previously administered anthelmintic has elapsed. Individuals with a FEC in excess of a set threshold should be treated with a licensed anthelmintic, ideally, shown previously to be effective, at a dose rate of 100–110% bodyweight estimated by weight tape or scale. The most frequently cited FEC cut-off for determining treatment is 200–500 eggs/g (Matthews 2008). Subsequently, FEC may be performed at 2–3 monthly intervals depending on the product used. Since FEC do not detect cyathostomin encysted larvae, larvicidal treatments can be administered when considered most appropriate (for example, late autumn or winter in the UK).

A total reduction in administration of some anthelmintic classes (for example MLs) could potentially lead to the increased prevalence of parasite species or stages (for example Strongylus spp. or P. equorum). Following a decade of targeted treatment application in Denmark, it was initially noted that the prevalence of S. vulgaris had remained similar to that observed in Sweden, where such treatment regimes had not been instituted to the same degree (Nielsen 2009). In a further Danish study in which larval culture analysis was performed to identify strongylid nematodes in faecal samples from farms that instituted targeted treatments based on FEC analysis compared to those that treated without using FEC, S. vulgaris prevalence was significantly higher where targeted therapy had been applied (Nielsen et al. 2012). Donkeys newly relinquished and resident at the UK Donkey Sanctuary have been rarely found to harbour large strongyles (<0.1% of donkeys at post mortem over a 5-year period: F.A. Burden, unpublished data). However, further research is required and baseline prevalence data are essential to assess the impact of changes in parasite management regimes over time.

In terms of quarantine, the UK Donkey Sanctuary screens all relinquishments for strongyles, P. equorum (regardless of age), liver fluke and lungworm coprologically. Coprological assessment is also carried out for tapeworm. Although sensitivity is low (Meana et al. 1998), unless there is a specific concern, tapeworm serology is not carried out as the available ELISA (Diagnostec, http://www.liv.ac.uk/diagnostec/) has not been validated for donkey serum (IgG1). Donkeys or mules whose test results indicate a patent infection with P. equorum, liver fluke, lungworm or tapeworm are treated appropriately and follow-up FEC are analysed 14–21 days post treatment to gauge efficacy of treatment. Donkeys with positive strongyle FEC may be treated above 300 eggs/g dependent upon the clinical picture. If there is concern that a newly acquired donkey or mule entering a group harbours lungworm or P. equorum that may not have reached patenty, ivermectin is administered immediately and the animal quarantined from grazing for 48 h.

Assessing anthelmintic efficacy

Anthelmintic resistance may be suspected following a FEC reduction test, a reduction in the expected effective refractory period after anthelmintic treatment, or by clinical signs of disease where appropriate dosing is thought to have occurred. The FEC reduction test compares FEC before (Day 0) and 10–14 days after anthelmintic treatment. It is simple to
Accuracy can be affected by inherent variability in FEC within and between donkeys, and it can be difficult to interpret data derived from populations where there are large proportions of animals that have low or zero FEC (Matthews 2011). Pre- and posttreatment samples should be handled and processed similarly. Performing the test on a large proportion of the population will provide the most accurate representation of sensitivity. Different FEC reduction percentage cut-offs are recommended for different classes of anthelmintic; recent recommendations state these as 90% for benzimidazoles and tetracyclines and 95% for MLs (Kaplan and Nielsen 2010). These threshold percentages take into account variation in efficacy when the anthelmintics were initially tested for licensing. A population mean FEC reduction above these cut-offs represents acceptable efficacy, whilst a lower mean FEC reduction is indicative of resistance. Ideally, in cases of suspected resistance, the test should be repeated: a second observed lower efficacy confirms resistance, whereas a mean FEC reduction above the accepted threshold indicates possible under-dosing or administration error in the first test. It is important to consider the number of animals tested, the age distribution of the population and average pretreatment FEC to determine whether the result is likely to be truly representative of the entire population. Higher levels of sensitivity (i.e. tests with detection limits of <50 eggs/g) will more accurately determine anthelmintic sensitivity, especially when there are a high proportion of low FEC in the test population. It is important to investigate all suspected cases of resistance. In the UK, confirmed anthelmintic resistance should be reported to the Veterinary Medicines Directorate as a ‘Suspected Adverse Reaction’ (http://www.vmd.defra.gov.uk/adverseactionreporting/).

Authors’ declaration of interests
No conflicts of interest have been declared.

References