ASSESSING THE AWARENESS OF ONCHOCERCA CERVICALIS AMONGST EQUINE VETERINARY SURGEONS IN THE UK

by

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being an Honours Research Project submitted in partial fulfilment of the requirements for the BSc (Honours) Degree in Bioveterinary Science

2020
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“There’s something about the outside of a horse that is good for the inside of a man.”
– Winston Churchill
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<th>Description</th>
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<td><em>Onchocerca cervicalis</em></td>
</tr>
<tr>
<td>OV</td>
<td><em>Onchocerca volvulus</em></td>
</tr>
<tr>
<td>MF</td>
<td>Microfilariae</td>
</tr>
<tr>
<td>FEC</td>
<td>Faecal egg count</td>
</tr>
<tr>
<td>EC</td>
<td>Encysted cyathostomes</td>
</tr>
<tr>
<td>AR</td>
<td>Anthelmintic resistance</td>
</tr>
<tr>
<td>BTV</td>
<td>Bluetongue virus</td>
</tr>
<tr>
<td>AHSV</td>
<td>African horse sickness virus</td>
</tr>
<tr>
<td>ML</td>
<td>Macrocyclic lactone</td>
</tr>
<tr>
<td>IBH</td>
<td>Equine insect bite hypersensitivity</td>
</tr>
<tr>
<td>SF</td>
<td>Staphylococcal folliculitis</td>
</tr>
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<td>ERP</td>
<td>Egg reappearance periods</td>
</tr>
<tr>
<td>KS</td>
<td>Knowledge score</td>
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I would also like to thank my family and friends for their constant support during my time at Harper Adams University, and Joe Gallimore who I could not have done any of this without.
Assessing the awareness of *Onchocerca cervicalis* amongst equine veterinary surgeons in the UK
S.E. Mansell and M. Behnke
*BSc (Hons) Bioveterinary Science*

**Introduction:** *Onchocerca cervicalis* (OC) is a filarial nematode which affects equids worldwide. In the UK, the parasite is transmitted by *Culicoides nubeculosus* which acts as the intermediate host (Mellor, 1975). The clinical syndrome, onchocerciasis, most commonly manifests as a dermatosis characterised by pruritus and dermatitis, particularly around the ventral abdomen and thorax, and closely resembles insect bite hypersensitivity (IBH). Onchocerciasis is controlled by ivermectin and moxidectin (Rashmir-Raven, 2018), the most commonly administered anthelmintics in UK horses (Allison et al., 2011); therefore the condition is presumed to be rare and of minor importance. Recent research and discussion of OC in British Literature was lacking and therefore it was unknown to what extent UK based equine vets were aware of the parasite. Establishing this was important as OC prevalence could increase in the near future, particularly if ivermectin/moxidectin use declines. This study also aimed to determine approximate numbers of UK horses affected with unresponsive cases of dermatoses including IBH which are differential diagnosis for onchocerciasis and to assess whether ivermectin/moxidectin use is declining in the UK equine industry.

**Materials and Methods:** An online survey was distributed to UK practising equine veterinary surgeons. A total of 88 responses were obtained over a three-month period, providing a 10.2% margin of error at the 95% confidence interval. Statistical analysis was carried out using Excel and Genstat 19th edition.

**Results:** The majority (78.41%) of respondents were aware of OC. Six had previously diagnosed a case, however only one of these was confirmed using diagnostic testing. ‘Aware respondents’ knowledge of OC was generally low, with 49.27% answering less than two of the four knowledge questions correctly. A median of 25% of IBH cases respondents saw annually were unresponsive to standard treatment and the majority (83.72%) of respondents did not consider onchocerciasis as a differential in these cases. The median level of annual ivermectin or moxidectin use by respondents clients was 81-90%. The majority (60.23%) of respondents thought ivermectin/moxidectin use in the UK equine industry would decline over the next ten years; recent developments in parasitology testing, increased uptake of faecal egg count tests and increased understanding of anthelmintic resistance amongst horse owners being the main reasons provided for this.

**Conclusions:** Results indicated there could currently be horses in the UK suffering from onchocerciasis not receiving appropriate diagnosis and treatment due to a lack of awareness and knowledge amongst UK equine vets. It was also found that onchocerciasis prevalence could increase in the near future due to reduced ivermectin and moxidectin use; this demonstrated the need to increase OC awareness and knowledge in the profession. This investigation also highlighted the need to conduct research into determining UK OC prevalence and to develop less invasive diagnostic tests for the parasite.

**References:**


Chapter One: Introduction

Due to the effects of climate change and globalisation, an increase in the emergence and re-emergence of vector-borne and vector transmitted diseases has been seen in recent years, including the arboviruses Bluetongue virus (BTV) and African horse sickness virus (AHSV) (MacLachlan and Guthrie, 2010). Reduced drug efficacy, including antimicrobial resistance and anthelmintic resistance (AR), also increases the chances of re-emerging infectious diseases, causing the resurfacing of previously controllable pathogens. This emergence and re-emergence of disease poses a significant threat to both animal and human health (Conraths et al., 2011). One pathogen which may re-emerge in the UK is Onchocerca cervicalis (OC).

Onchocerca cervicalis, commonly known as equine neck threadworm, is a filarial nematode which causes the condition equine onchocerciasis, which will hereafter be referred to as onchocerciasis. The parasite has an indirect lifecycle with Culicoides midges, specifically Culicoides nubeculosus acting as the intermediate host (IH) in the UK (Mellor, 1975). Other Culicoides spp, Simulium spp and mosquitoes act as IH where the climate is suitable (Marques and Scrofeneker, 2004). Zoonotic potential has been reported in case studies (Beaver et al., 1974; Burr et al., 1998), however a risk to public health is unlikely. Onchocerca gutturosa and Onchocerca reticulata also infect horses, however OC is regarded as the predominant cause of onchocerciasis (Nielsen et al., 2014). A number of other Onchocerca parasites are pathogenic in other species, including Onchocerca volvulus (OV), the causative agent of river blindness in sub-Saharan Africa (Vlaminck et al., 2015).

Research on OC in British horses is lacking, with the last notable study published in 1973 (Mellor, 1973a). Therefore, current levels of OC awareness and knowledge amongst UK equine veterinary surgeons are unknown. This study aims to determine these levels and provide an insight into the potential current and future prevalence of OC in the UK through the use of an online survey.
Chapter Two: Literature review

2.1 *Onchocerca cervicalis*

2.1.1 Life Cycle

Adult OC reside in the funicular portion of the nuchal ligament, which supports the horse’s head and neck from the withers (Aroch *et al.*, 2008). Adult females are long, often measuring 30-50cm, and usually coiled up within nodules (Gray, 1995). Unlike the majority of nematodes, OC females are viviparous and give birth to larvae which are termed microfilariae (MF). Figure 2.1 summarises the lifecycle of OC.

![Lifecyle of Onchocerca cervicalis](Source: Adapted from: Gray, 1995; Mellor, 1975; Nielsen *et al.*, 2014; Hendrix and Robinson, 2017)

2.1.2 Pathogenesis and clinical signs

In onchocerciasis, the MF act as the aetiologic agent. Historically adult OC were associated with fistulous withers and poll evil (Thompson, 1947), however, the presence of OC in healthy horses created debate regarding its pathogenic role in these conditions (Dagnaw *et al.*, 2016); it is now hypothesised that bacterial species including *Brucella abortus* are more likely involved (Mair and Divers, 2009). Mellor (1973b) concluded that adult OC had no significant pathological effects.
Dermal MF cause severe pruritis and subsequent skin lesions where they congregate. This is most commonly along the ventral midline and thorax, although the face, neck and withers may also be affected (Ginn et al., 2007). Skin lesions include alopecia, scaling, crusting and leukoderma; as the condition progresses, ulceration and lichenification may also occur (Figure 2.2) (Rashmir-Raven, 2018). It is hypothesised these clinical signs occur due to individual type I and type III hypersensitivity reactions to MF (Schmidt et al., 1985) as many horses have dermal MF without exhibiting clinical signs (Mellor, 1973b). There are, therefore, welfare implications associated with onchocerciasis as pruritis can significantly impair a horse’s quality of life and subsequent self-trauma can cause secondary infections (Knottenbelt, 2009a).

Figure 2.2: Skin lesions along the ventral midline due to onchocerciasis

Older horses are more susceptible to OC infection; Schmidt et al. (1982) and Lyons et al. (2000) both found prevalence increased with age in horses from the United States. In particular, Lyons et al. (2000) found a significant difference in prevalence between 5-15 and 16-30 year olds (p<0.001); however only horses aged above five were examined, which places limitations on the conclusions that can be drawn. In addition, the results from these two studies cannot be directly compared due to different diagnostic methods; Schmidt et al. (1982) used the presence of OC in the nuchal ligament alone whereas Lyons et al. (2000) also used the presence of lesions.

Microfilariae occasionally migrate to the eyes and can produce symptoms including conjunctivitis, recurrent uveitis and keratitis (Hughes, 2010). Recurrent uveitis is reported to be the most common cause of equine blindness (Deeg, 2008). However, there is debate regarding the pathogenic role of OC in these conditions (Dagnaw et al., 2016), as MF are present in the eyes of horses without ocular lesions. Moran and James (1987) found ocular MF in 34% of horses positive for dermal MF however not all displayed ocular changes; additionally, ocular changes were found in horses with only dermal MF and also in horses negative for OC. However, as horses examined in this study were 15-20 years old, dermal and ocular MF prevalence is likely higher than in a sample representative of all ages.

Some studies have reported seasonal variation in MF concentration. Foil et al. (1987) found dermal MF density in ponies in Louisiana was highest in spring, corresponding to seasonal fluctuations in Culicoides variipennis population density, an OC IH in the United States. In comparison, Mellor (1973a) reported no significant change in dermal MF concentration in 31 English horses from June to December, however found that MF appeared to migrate from the deeper dermal layers to just under the epidermis during the summer months; it was suggested this may be an adaption during the biting season to enable ingestion by Culicoides. Similarly, Foil et al. (1987) found MF present in all dermal layers throughout most of the year, but in winter MF were not present in superficial layers; it was suggested this may be due to greater MF production in spring.
2.1.3 Epidemiology

*Onchocerca cervicalis* has worldwide distribution; demonstrated by research from various parts of the globe. The parasite has been most well documented in the United States, however, recent research is lacking and infection rates vary between studies, depending on geographical location, date and diagnostic methods used (Table 2.1).

Table 2.1 *Onchocerca cervicalis* infection rates in the United States

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of horses examined</th>
<th>Infection rate</th>
<th>Diagnostic methods</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeastern US (Kentucky)</td>
<td>157</td>
<td>24%</td>
<td>Nuchal ligament examination</td>
<td>(Lyons et al., 2000)</td>
</tr>
<tr>
<td>Southeastern US (Louisiana)</td>
<td>232</td>
<td>22.4%</td>
<td>Skin samples from the withers or neck</td>
<td>(Collins, 1973)</td>
</tr>
<tr>
<td>Southeastern and midwestern US</td>
<td>664</td>
<td>51.4%</td>
<td>Skin samples</td>
<td>(Cummings and James, 1985)</td>
</tr>
<tr>
<td>Midwestern US</td>
<td>83</td>
<td>37%</td>
<td>Nuchal ligament examination</td>
<td>(Schmidt et al., 1982)</td>
</tr>
<tr>
<td>Midwestern US</td>
<td>52</td>
<td>76.9%</td>
<td>Umbilical skin samples and nuchal ligament examination</td>
<td>(Rabalais et al., 1974)</td>
</tr>
</tbody>
</table>

Lyons *et al.* (2000) and Collins (1973) researched in similar geographical areas and found similar infection rates. However, these studies cannot be directly compared due to the different diagnostic methods used; nuchal ligament examination investigates adult OC presence whereas skin samples detect dermal MF. A horse may be infected with OC without detectable dermal MF, particularly if ivermectin or moxidectin has been administered; this will be discussed further in Section 2.1.5. The age of horses examined in Rabalais *et al.* (1974) was not reported, however they were sourced from a small abattoir and therefore likely older, whereas in Schmidt *et al.* (1982) horses of all ages were represented; this could explain the variation in these two infection rates. Similarly, the high infection rate found by Cummings and James (1985) could be because most of the horses examined were approximately 15 years old.

Results from studies investigating OC infection rates across the globe are summarised in Table 2.2, as with studies conducted in the US, recent research is lacking.

Table 2.2 *Onchocerca cervicalis* infection rates across the globe

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of horses examined</th>
<th>Infection rate</th>
<th>Diagnostic methods</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>383</td>
<td>11.8%</td>
<td>Umbilical skin samples</td>
<td>(Polley, 1984)</td>
</tr>
<tr>
<td>Brazil</td>
<td>1200</td>
<td>16.6%</td>
<td>Umbilical skin samples and nuchal ligament examination</td>
<td>(Marques and Scroferneker, 2004)</td>
</tr>
<tr>
<td>Argentina</td>
<td>257</td>
<td>18.7%</td>
<td>Skin samples from the ventral midline</td>
<td>(Mancebo <em>et al.</em>, 1997)</td>
</tr>
<tr>
<td>France</td>
<td>368</td>
<td>1%</td>
<td>Umbilical skin samples and nuchal ligament examination</td>
<td>(Collobert <em>et al.</em>, 1995)</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>99</td>
<td>8%</td>
<td>Umbilical skin samples</td>
<td>Lutz <em>et al.</em>, 1975</td>
</tr>
</tbody>
</table>
There is a significant lack of research on OC prevalence in British horses. The most recent extensive study was carried out by Mellor (1973a) who examined 903 carcasses from three abattoirs in south-east England using skin snips from the ventral midline. The nuchal ligaments from 209 of these carcasses were also dissected to investigate the presence of adult OC. Thirty-three carcasses from one abattoir were examined in more detail with snips taken from multiple areas including the umbilicus, chin, breast, eyelids and legs. Infection rates of 22.7%, 13.9% and 12.9% were found for the three abattoirs respectively. It was assumed the higher rate at the first abattoir was due to a higher average age of horses examined from these premises. However, the results from this study cannot be generalised to the whole of the UK; furthermore, this research is now dated and infection rates have likely changed. In addition to lack of research, there appears to be little discussion of OC in recent British literature. This creates the questions of whether UK equine vets are aware of OC as a potential cause of skin disease and whether vets are being taught about OC at university.

2.1.4 Diagnosis
The standard method for OC diagnosis is microscopic examination of skin samples, an approach which the majority of studies cited above utilised, exceptions being Schmidt et al. (1982) and Lyons et al. (2000). Mellor (1973a) found no significant difference between infection rates in horses where the nuchal ligament was examined alongside skin snips and where snips were used alone, showing dermal MF presence provided a good indication of infection. However, the sensitivity of this method is likely highly variable depending on a number of factors including MF distribution, number of skin samples taken and whether ivermectin or moxidectin has been recently administered, as is the case in OV diagnosis (Bottomley et al., 2016).

Advances made in OV diagnosis could be applied to OC diagnosis in the future. Biochemical assays have been developed with more reliable sensitivity than skin microscopy (Vlaminck et al., 2015). Golden et al. (2013) developed a lateral flow test to detect antibodies for OV for use with finger prick blood and found it to have 89.1% sensitivity; the test has since been marketed for use (Vlaminck et al., 2015). More recently, Shirey et al. (2018) developed a urine-based lateral flow test for detection of a biomarker for adult OV with reported sensitivity of 85%. This research presents opportunities to utilise more sensitive, practical and non-invasive diagnostic tests for OC.

2.1.5 Treatment and management
Currently, there is no treatment effective in eliminating adult OC (Plummer et al., 2014), however, oral ivermectin is widely used to kill dermal MF (Van Vleet and Valentine, 2007). Pollitt et al. (1986) studied the efficacy of oral ivermectin paste in 12 horses with onchocerciasis and found an evident regression of lesions and MF absent from all skin biopsies one-week post treatment.

Initially, clinical signs may appear or increase in severity following ivermectin use. Herd and Donham (1983) found ventral oedema developed in 10% of horses 24 hours post treatment and that this persisted for up to 72 hours. It has been reported these seemingly adverse reactions are due to an inflammatory response to dead or dying MF. An in vitro study by Coley and Wes Leid (1982) showed adult OC could significantly depress normal haemolytic complement activity in equine serum and hence suppress inflammatory responses. They suggested inflammatory and pathological changes following MF death could be due to the parasites inability to sustain normal depression of complement activity, leading to an influx of inflammatory cells.

Moxidectin is also effective in removing MF; this was unintentionally demonstrated by Bello and Laningham (1994) whilst investigating the action of moxidectin oral gel against gastrointestinal parasites. Moxidectin appears not to initiate the same post-treatment reactions seen with ivermectin. Mancebo et al. (1997) compared the efficacy of 2% moxidectin oral gel and 2% ivermectin oral paste and found skin snips from the ventral midline were negative for MF in all horses by 21 days post-treatment; it was hence concluded that both anthelmintics were 100% effective in removing MF. This study also
found that unlike ivermectin, moxidectin did not produce any post-treatment dermal reactions; this disputes the above hypothesis regarding inflammatory responses to dead or dying MF.

Both ivermectin and moxidectin belong to the macrocyclic lactone (ML) group of anthelmintics. These are routinely used in equine parasite control programmes as they are highly effective against bot flies (Gasterophilus spp) and important gastrointestinal nematodes including Strongylus vulgaris (Prichard et al., 2012). In particular, moxidectin is regarded as the most effective treatment against encysted larval stage cyathostomes (EC), which have developed resistance to other anthelmintics including fenbendazole, praziquantel and ivermectin (Matthews, 2014). Cyathostomes are the most prevalent endoparasite in UK horses and mass emergence of EC in spring can cause pronounced disease and fatality in some cases (Rendle, 2014a); therefore maintaining moxidectin efficacy is essential to equine health and welfare.

Due to the widespread use of ML’s in the UK equine industry, many horse owners are inadvertently controlling OC and therefore it is presumed that onchocerciasis is rare and of minor importance (Coles et al., 2012). This again poses the question of whether equine vets are aware of the parasite. However, interval treatment use of ML’s is reducing, with an increasing number of owners using targeted treatment informed by faecal egg count (FEC) tests (Tzelos et al., 2019). This will be discussed further in Section 2.4.

2.2 Culicoides spp.

2.2.1 Presence and activity patterns of Culicoides spp. in the UK

Culicoides midges are most active at dawn and dusk (Mellor, 1974) and in warm and humid environments, favouring areas with standing water where they typically breed (Whittmann and Baylis, 2000). Harrup et al. (2013) used traps to investigate Culicoides habitats in South East England and found C. nubeculosus was most prevalent in areas with marginal vegetation surrounding open water. Sanders et al. (2012) reported temperatures above 21°C inhibit Culicoides activity, this corresponds with the observation by Sanders et al. (2011) that Culicoides abundance in England was greater in spring and autumn compared to mid-summer. The Culicoides activity season in the UK appears to have lengthened in recent decades, likely due to rises in average temperature and precipitation (Sanders et al., 2019). This indicates that Culicoides abundance in the UK may increase in the future and therefore OC prevalence could also increase.

2.2.2 The role of Culicoides nubeculosus in the transmission of Onchocerca cervicalis

C. nubeculosus preferentially lands and feeds on the horse’s ventral midline. Mellor (1974) studied C. nubeculosus landing activity on eight bait horses over 16 days and found 85% landed within six inches of the ventral midline. The authors hypothesised that the sparse covering of hair in this area made it easier for C. nubeculosus to penetrate the skin. They also proposed MF migration to the ventral midline is an adaptation to accommodate the vector’s feeding habits. Similar relationships have been described with other parasites and their vectors. For example, McCall and Trees (1993) investigated Onchocerca lienalis transmission in Welsh cattle and found that 93% of Simulium ornatum landed on the cattle’s belly. Onchocerca lienalis MF are highly concentrated in this area (Trees et al., 1987).

2.2.3 Other diseases transmitted by Culicoides nubeculosus

Research has shown C. nubeculosus to be a biological vector of BTV. Jennings and Mellor (1988) found this midge became infected after feeding on a viraemic sheep and could transfer BTV across a membrane after eight days incubation. However, this study used serotypes three and four and, therefore, it cannot be said whether C. nubeculosus can transmit serotype eight which was responsible for the 2006-2008 outbreak in northern Europe (Pioz et al., 2012). In comparison, Mellor and Boorman (1980) found C. nubeculosus was incapable of supporting BTV multiplication under normal conditions, however when simultaneously infected with BTV and OC MF a number of midges became...
infectious. This suggests BTV transmission is enhanced when *C. nubeculosus* concurrently ingests MF. *C. nubeculosus* is also a potential vector of AHSV. Whilst the midges oral susceptibility rate for AHSV is less than 1% at standard temperatures (Mellor *et al.*, 2000), both Wittmann (2000) and Mellor (1998) found that at above 30°C this increased, suggesting *C. nubeculosus* could act as a vector. This research highlights the importance of monitoring *C. nubeculosus* distribution and activity and also shows a future increase in UK OC prevalence may be indicative of an increased threat of these important diseases.

2.3 Skin conditions in the UK equine population

Skin disorders are the most frequent general disease syndrome recorded in UK horses (Slater, 2018). However, many of these conditions resemble one another, presenting a challenge to veterinarians in the diagnostic process (Sloet van Oldruitenborgh-Oosterbaan and Grinwis, 2016). Knottenbelt (2009b) stated nothing should be excluded as a differential diagnosis when investigating equine dermatoses. Effective treatment often requires identification of the causative agent through laboratory testing (Atkins, 2013), presenting costs which owners may be unwilling or unable to pay. Numerous equine dermatoses can act as differentials for onchocerciasis (Ginn *et al.*, 2007); for the purposes of this study, four disorders which closely resemble onchocerciasis will be discussed.

2.3.1 Equine insect bite hypersensitivity

Equine insect bite hypersensitivity (IBH), commonly known as sweet itch, is perhaps the most likely differential diagnosis for onchocerciasis (Nielsen *et al.*, 2014). Caused by an allergic reaction to *Culicoides* saliva, (Wilson *et al.*, 2001), IBH manifests as a pruritic dermatitis leading to self-trauma and lesions similar in appearance to onchocerciasis, particularly around the crest and tail (Figure 2.3) (Gray, 1995). This enables differentiation from onchocerciasis where the crest and tail are less commonly affected (Ginn *et al.*, 2007). In addition, IBH is seasonal, commonly reoccurring in affected horses every summer; onchocerciasis is generally non-seasonal, although clinical signs may increase in severity during *Culicoides* activity seasons (Dagnaw *et al.*, 2016). Ginn *et al.* (2007) reported that since both conditions are caused by *Culicoides*, it is probable IBH and onchocerciasis can occur simultaneously. Prevalence rates for IBH in the UK vary; with Slater (2018) and Ireland *et al.* (2013) finding 2.5% and 7.8% respectively. One potential weakness in this research is that owner reported incidence, rather than vet reported, was used. Ireland *et al.* (2011) found that in geriatric horses, owner reported prevalence was lower than prevalence based on veterinary examination for a wide range of diseases; specifically, only one horse was reported by its owner to suffer from IBH, although 12 exhibited clinical signs on examination. As both onchocerciasis and other hypersensitivities produce similar clinical signs to IBH, intra-dermal or serum allergen testing can be used to confirm diagnosis (Fadok, 2013). This would be a more accurate way of determining prevalence rather than using clinical signs.

![Figure 2.3: Skin lesions due to insect bite hypersensitivity](Source: BHS, 2007)
Standard IBH treatment and management includes reducing exposure to *Culicoides* and the use of insect repellents, antihistamines and glucocorticoids (Lloyd *et al.*, 2003). There is a lack of research available on the proportion of cases which are unresponsive to these methods, however Whittle (2011) reported that IBH was considered ‘notoriously difficult to manage’.

### 2.3.2 Lice infestations

Louse infestation can be caused by either the chewing louse (*Werneckiella equi equi*) or the sucking louse (*Haematopinus asini*). Signs are usually a result of self-trauma from pruritis and include alopecia, scaling and crusts (Figure 2.4) (Wilson, 2014). The condition is more common in winter (Littlewood, 1999); Gawler *et al.* (2005) examined horse hides at an abattoir in south west England and found chewing louse prevalence was highest in December at approximately 20%. Treatment includes the use of insecticides in shampoo, spray or pour-on preparations (Scott and Miller, 2003). Castilla-Castaño *et al.* (2017) and Mencke *et al.* (2005) measured the efficacy of two different insecticidal based preparations and both found all horses were lice-free by 56 days post treatment, however sample sizes in these studies were relatively small, seven and 38 respectively, which reduces the validity of these findings.

![Figure 2.4 Puritus related lesions due to louse infestation](Source: Phillips, 2020)

### 2.3.3 Bacterial skin infections

Common bacterial skin infections (pyodermas) in horses include dermatophirosis (rain scald) and staphylococcal folliculitis (SF) (Knottenbelt, 2012). SF is perhaps the most likely differential for onchocerciasis as this condition is typically pruritic and alopecia and crusts may develop (Figure 2.5) (Rendle, 2014b). However unlike onchocerciasis, lesions typically develop in the lumbar region, particularly where the saddle has been, rather than the ventral midline (White and Yu, 2006). Like IBH, SF can occur alongside onchocerciasis due to secondary infection of lesions (Knottenbelt, 2009a). Topical antiseptics such as chlorhexidine are usually applied for seven to ten days as first-line treatment (Atkins, 2013). If systemic treatment is required, sulphonamides are usually given; this is often effective, however antimicrobial resistance may be present (Rendle, 2014b). Confirming diagnosis of SF and other pyodermas through bacterial culture and susceptibility testing is of increasing importance to ensure correct and responsible antimicrobial use (Weese and Yu, 2013).
2.3.4 Seasonal contact dermatitis

Contact dermatitis (Figure 2.6) may result from type IV hypersensitivity reactions following contact with a particular chemical, substance or vegetation that a horse is allergic to (Knottenbelt, 2009a). These hypersensitivities can be seasonal depending on the allergens involved; for example an allergy to fly repellent would only emerge in the summer months. Clinical signs include varying pruritis, alopecia, scaling, crusts, urticaria and the affected area often indicates the nature of the allergen (Scott and Miller, 2003). As with IBH, intra-dermal and serum testing can be used to identify hypersensitivities to common allergens and thus enable differentiation from other skin conditions (Fadok, 2013). In addition to allergen avoidance, antihistamines and corticosteroids may be used to control the hypersensitivity (Paterson, 2003), however there is a lack of research on the efficacy of these treatments.

2.4 Anthelmintic use and anthelmintic resistance in UK equines

During the second half of the 20th century, interval treatment use of broad-spectrum anthelmintics was extensively utilised to control helminth infection in horses (Tzelos et al., 2019). This widespread use selected for the development of AR, thus presenting major health and welfare threats to the equine population (Matthews, 2014). A number of approaches have been adopted in recent years to help reduce anthelmintic use and hence prevent further resistance development. One of these is FEC tests, which can be used to assess parasite burden and inform whether treatment is required (Nielsen and Reinemeyer, 2018).

Research shows that in light of growing concern regarding AR, routine anthelmintic use in the UK equine industry is declining and owners are utilising FEC tests more. An online questionnaire by Tzelos et al. (2019) found 60.9% of a sample of UK horse owners and yard managers used FEC tests to inform them whether they needed to administer anthelmintics and that 54.9% of these had moved away from interval treatment in the previous one-to-five years. Likewise, Stratford et al. (2014) found FEC tests had been
used on 62% of equestrian premises in Scotland and that their use reduced annual anthelmintic treatment frequency. This decline in anthelmintic use may increase the prevalence of onchocerciasis in the future due to OC no longer being inadvertently controlled. Rashmir-Raven (2018) stated recent use of FEC targeted worming appears to have increased the incidence of onchocerciasis.

2.4.1 Use of macrocyclic lactones in the UK equine population
Research has found that ML’s are the most common anthelmintics administered in UK horses. Allison et al. (2011) conducted an online survey of horse owners who were predominantly ‘leisure riders’ and found ML’s were the most commonly used anthelmintics, with 73% stating they had administered either ivermectin or moxidectin in the previous 12 months. Similarly, Ireland et al. (2013) found 74% of horse owners reported either ivermectin, moxidectin or their combination products with praziquantel as the last anthelmintic they had used. Tzelos et al. (2019) found that 77.5% and 67.6% of respondents respectively reported either ivermectin or moxidectin products had been used on their premises in the previous 12 months; in comparison, only 61.2% reported other classes of anthelmintic had been used.

2.4.2 Developing resistance to macrocyclic lactones
There is evidence for developing resistance to ivermectin and moxidectin in equine nematodes. Daniels and Proudman (2016) evaluated the efficacy of both anthelmintics in UK leisure horses using egg reappearance periods (ERP). For both ivermectin and moxidectin, ERP following treatment were shorter than those published when the drugs were first marketed, indicating reduced efficacy. Tzelos et al. (2017) found moxidectin was highly effective when investigating the efficacy of a combination product in 261 horses from eight yards across the UK, with FEC reduction tests showing a 99.9-100% reduction two weeks post-treatment. However, the authors also found shorter ERP than published values, and morphological identification of larvae from egg culture found only EC present. These findings suggest moxidectin is still effective, but shorter ERP may be an early indicator of AR. If EC develop resistance to moxidectin, there will be no anthelmintic effective against them; this highlights the importance of reducing moxidectin use. A potential limitation in both of the above studies was that anthelmintic dosing and faecal sampling were carried out by owners or yard managers. Therefore, the chance of early ERP resulting from incorrect weight estimation and dosing was higher compared to if this had been done by the researchers.

In light of the increasing level of ML resistance in other nematodes, there is a strong possibility OC may also be developing resistance to these products; in addition to reduced anthelmintic use, this may also increase UK onchocerciasis prevalence in the future.

2.5 Conclusion and research gap
After reviewing the literature, it is evident there is lack of research available on OC in the UK and that available research is dated. Because of this, there may currently be limited awareness and knowledge of the parasite in the UK equine veterinary profession. There is also no survey-based research available on OC which presents a gap for all research of this nature. Furthermore, there is limited data available on the proportion of cases of onchocerciasis differentials such as IBH which are unresponsive to standard treatment and management. This study aims to begin to fill in these research gaps by assessing the awareness and knowledgebase of OC amongst practising UK equine vets using an online questionnaire. The survey will also aim to determine an approximate number of horses in the UK affected by unresponsive cases of onchocerciasis differentials including IBH and assess whether ML use is declining in the equine industry. It is hoped the findings will raise awareness of OC in the equine veterinary profession and assist in shaping future research in this area.
Chapter Three: Methodology

3.1 Aims and Objectives
1. To determine current levels of OC awareness and knowledge amongst UK equine veterinary surgeons.

2. To determine an approximate number of horses in the UK affected with skin conditions including IBH that do not respond to standard treatment and management.

3. To determine whether use of ivermectin and moxidectin is declining in the UK equine industry.

3.2 Questionnaire design
A questionnaire-based study was used because in order to accurately assess the research aims, a large number of responses from equine vets across the UK were required and therefore using focus groups or interviews would not have been feasible. The questionnaire was designed using Jisc Online Surveys. This software was freely available to use and allowed completion on multiple types of devices, thus making the questionnaire more accessible and easier to complete. A copy of the distributed questionnaire is included in Appendix 1.

The survey consisted of 18 questions. Closed questions with a single choice answer, collecting quantitative data, were used most frequently; these enable direct comparison of answers and therefore were used for questions directly relating to the research aims (Saunders et al., 2019). The majority of closed questions included an ‘unsure’ option to prevent inaccurate responses and to help ensure respondents completed all of the questions (Blair et al., 2014). Open questions were also included to collect a ‘fuller’ range of responses, particularly surrounding diagnosed cases of OC and opinions on ivermectin and moxidectin use; these questions generated qualitative data.

The survey was split across four sections. The first included demographic questions which collected information about the age of respondents, when and where they qualified and where they currently practised. These questions were included to enable identification of potential associations between these factors and awareness and knowledge levels. The second section assessed awareness and knowledge of OC, asking questions about the parasites lifecycle and if vets had ever diagnosed a case. These questions were essential for answering the first research objective. The third section was used to establish the number of cases of unresponsive IBH, lice infestations, bacterial skin infections and seasonal contact dermatitis respondents saw and whether they considered OC as a differential for these conditions. The final section assessed respondents opinions on levels of client FEC use, levels of client ivermectin/moxidectin use and the future use of these products in the UK equine industry; these questions were necessary for answering the third research objective.

Before distribution, the questionnaire was piloted by an equine vet to assess the ease of completion, clarity and relevance of the questions to the research aims (Brace, 2013). Following the pilot, Question 12 was added to expand the assessment of OC knowledge and Question 14b was converted from an open to a closed question to make the survey less time consuming for respondents to complete (Saunders et al., 2019).
3.3 Questionnaire distribution
Following piloting and amendment, the survey was launched using the Jisc Online Survey platform on the 2nd December 2019. A volunteer sampling method was used as the questionnaire was circulated and publicised to equine vets who then decided if they would participate (Saunders et al., 2019). Online distribution was considered the most practical method, particularly as a large number of responses were required (Lefever et al., 2007). Using Equation 1 (Appendix 2) (Survey Monkey, not dated) and a target population of 1800 vets registered with the British Equine Veterinary Association, it was calculated that 317 responses were required to obtain a 95% confidence interval with 5% margin of errors.

The questionnaire was promoted through social media platforms and on a number of websites including the Harper Adams University website. The survey link was also blind copy emailed to 277 UK equine and mixed veterinary practices and a letter calling for participation was published in the Veterinary Record on the 17th January 2020. The survey closed on the 29th February 2020 with 88 responses, providing a 10.2% margin of error at the 95% confidence level.

3.4 Data analysis
The data collected was exported into Excel and first analysed using frequency distributions and measures of central tendency. Respondents who were aware of OC were given a ‘knowledge score’ based on their answers to questions 9-12 which was used for analysis. Data collected on skin conditions was processed to determine the percentage of cases of each condition that each vet saw which were unresponsive. Where respondents left a column blank, or did not see any cases of the condition, they were removed from that particular dataset. Statistical analysis was carried out using Genstat 19th edition. Standard errors followed by binomial comparison tests (95% confidence limit) were used to investigate if there were significant differences between the proportions of correct responses for questions 9-12. Chi-square analysis was planned to investigate associations between demographic factors and awareness/knowledge of OC. However, the small sample size resulted in expected frequencies less than five and therefore chi-square was not appropriate. Instead, contingency table permutation tests or Fisher’s Exact tests were carried out using a significance level of 0.05. There were sufficient expected frequencies to use chi-square analysis to investigate potential associations between questions in the final section of the survey. Qualitative data obtained from open questions, including questions 18a and 14bi, was coded using a content analysis approach to allow inferences to be made.

3.5 Limitations
The low response rate (4.89%) was the main limitation in this study; however, low response rates are typical of online questionnaires targeted towards vets, this will be discussed further in Section 5.4. Phoning equine veterinary practices and asking more industry bodies to help distribute the questionnaire may have increased the number of responses. A flaw in the questionnaire design not picked up during the pilot was that the University of Surrey was not included as an option for ‘place of qualification’, this may have limited the number of responses. As online surveys rely on the willingness of respondents to participate (Lefever et al., 2007), the survey sample may not accurately represent the target population. In addition, although respondents were asked not to refer to literature to answer the questions, they may still have done so; this places constrictions on the validity of the questionnaire, particularly in relation to the first research objective.
3.6 Ethical considerations
Online surveys challenge traditional research ethics principles including consent, confidentiality and autonomy (Buchanan and Hvizdak, 2009). In particular, an oral explanation of the study cannot be provided and it is more difficult for respondents to ask the researcher questions prior to completing, making informed consent more difficult to obtain (Varnhagen et al., 2005).

Prior to data collection, a research ethics application was submitted to Harper Adams University. The data collected was handled according to the Market Research Society Code of Conduct and hence remained confidential. In order to gain informed consent, a statement was included at the start of the questionnaire (Appendix 1), informing participants of the following:

- The research subject and purpose of data collection
- Confidentially and anonymity of both themselves and the companies they represented
- Their right to withdraw at any time prior to the completion of the survey
- The approximate time the survey would take to complete
- That by participating in the survey, they were giving consent to data collection
- Where the data may be used and published
- Contact details of the researcher should there have been any queries.
Chapter Four: Results

4.1 Respondent demographics

Table 4.1 summarizes the demographics of equine vets who completed the questionnaire. The majority of respondents (77.01%) had been qualified less than 20 years. Seventy-five percent were aged between 25 and 45 and none were over 65. The Royal Veterinary College was the most common university of qualification. Of those who qualified abroad, three had qualified in South Africa, three in Australia, two in Spain, one in the Republic of Ireland and one in Austria.

Table 4.1 Respondent demographics

<table>
<thead>
<tr>
<th>Demography</th>
<th>Number of respondents</th>
<th>Percentage of respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of years qualified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5</td>
<td>17</td>
<td>19.54</td>
</tr>
<tr>
<td>5-9</td>
<td>21</td>
<td>24.14</td>
</tr>
<tr>
<td>10-14</td>
<td>16</td>
<td>18.39</td>
</tr>
<tr>
<td>15-19</td>
<td>13</td>
<td>14.94</td>
</tr>
<tr>
<td>20-24</td>
<td>8</td>
<td>9.20</td>
</tr>
<tr>
<td>25-29</td>
<td>3</td>
<td>3.45</td>
</tr>
<tr>
<td>30-34</td>
<td>2</td>
<td>2.30</td>
</tr>
<tr>
<td>35-39</td>
<td>6</td>
<td>6.90</td>
</tr>
<tr>
<td>&gt;40</td>
<td>1</td>
<td>1.15</td>
</tr>
<tr>
<td>Age category</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>5</td>
<td>5.68</td>
</tr>
<tr>
<td>25-35</td>
<td>37</td>
<td>42.05</td>
</tr>
<tr>
<td>36-45</td>
<td>29</td>
<td>32.95</td>
</tr>
<tr>
<td>46-55</td>
<td>8</td>
<td>9.09</td>
</tr>
<tr>
<td>56-65</td>
<td>9</td>
<td>10.23</td>
</tr>
<tr>
<td>Where qualified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bristol</td>
<td>10</td>
<td>11.36</td>
</tr>
<tr>
<td>Cambridge</td>
<td>11</td>
<td>12.50</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>7</td>
<td>7.95</td>
</tr>
<tr>
<td>Glasgow</td>
<td>10</td>
<td>11.36</td>
</tr>
<tr>
<td>Liverpool</td>
<td>13</td>
<td>14.77</td>
</tr>
<tr>
<td>Nottingham</td>
<td>2</td>
<td>2.27</td>
</tr>
<tr>
<td>Royal Veterinary College</td>
<td>25</td>
<td>28.41</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>11.36</td>
</tr>
</tbody>
</table>
Figure 4.1 displays the locations where respondents practised. One respondent provided an invalid postcode and hence their practice could not be shown. Postcodes were grouped into regions for analysis (Table 4.2), the postcodes included in each region are provided in Appendix 3. The majority (86.2%) of respondents practised in England, with the South East and North being the most common regions.

Table 4.2: Regions of the UK where respondents practised

<table>
<thead>
<tr>
<th>Region currently practising</th>
<th>Number of respondents</th>
<th>Percentage of respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland</td>
<td>7</td>
<td>8.05</td>
</tr>
<tr>
<td>Wales</td>
<td>5</td>
<td>5.75</td>
</tr>
<tr>
<td>North of England</td>
<td>16</td>
<td>18.39</td>
</tr>
<tr>
<td>North West of England</td>
<td>9</td>
<td>10.34</td>
</tr>
<tr>
<td>East Anglia</td>
<td>11</td>
<td>12.64</td>
</tr>
<tr>
<td>The Midlands</td>
<td>10</td>
<td>11.49</td>
</tr>
<tr>
<td>South West of England</td>
<td>7</td>
<td>8.05</td>
</tr>
<tr>
<td>South East of England</td>
<td>22</td>
<td>25.29</td>
</tr>
</tbody>
</table>
4.2 Objective one
This section addresses the first research objective, outlined in Section 3.1:

To determine current levels of OC awareness and knowledge amongst UK equine veterinary surgeons

4.2.1 Awareness of *Onchocerca cervicalis* amongst UK equine veterinary surgeons
When asked if they had ever heard of OC (Q5), 78.41% (n=69) of respondents reported they had and 21.59% (n=19) reported they had not (Figure 4.2).

![Figure 4.2: Respondent awareness of *Onchocerca cervicalis*](image)

Respondents who had heard of OC (‘aware respondents’) were asked where they had heard about the parasite (Q6). Figure 4.3 shows the number of times each location was reported. 79.71% (n=55) had heard about OC at university, 49.28% (n=34) stating this as the only place where they had been made aware of the parasite; 39.13% (n=27) had heard about OC while working in practice. Of the respondents who selected ‘other’ 50% reported wider reading as a source of knowledge and 25% stated that clients had asked them about OC.

![Figure 4.3: Where respondents had heard about *Onchocerca cervicalis*](image)
4.2.2 Knowledge of *Onchocerca cervicalis* amongst UK equine veterinary surgeons

Table 4.3 summarises ‘aware respondents’ responses to questions 9-12. One respondent did not answer question nine and five did not answer question 12, these respondents were therefore removed from the data analysis for that particular question.

Table 4.3: Responses to *Onchocerca cervicalis* knowledge questions

<table>
<thead>
<tr>
<th>Question 9 - Which class of parasite does <em>Onchocerca cervicalis</em> belong to?</th>
<th>Number of 'aware respondents'</th>
<th>Percentage of 'aware respondents' (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nematode (Correct response)</td>
<td>50</td>
<td>73.53</td>
</tr>
<tr>
<td>Cestode</td>
<td>4</td>
<td>5.88</td>
</tr>
<tr>
<td>Trematode</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Protozoa</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unsure</td>
<td>14</td>
<td>20.59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 10 - Which of the following acts as the intermediate host for <em>Onchocerca cervicalis</em>?</th>
<th>Number of 'aware respondents'</th>
<th>Percentage of 'aware respondents' (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culicoides spp (Correct response)</td>
<td>32</td>
<td>46.38</td>
</tr>
<tr>
<td>Stomoxys spp</td>
<td>3</td>
<td>4.35</td>
</tr>
<tr>
<td>Tabanus spp</td>
<td>1</td>
<td>1.45</td>
</tr>
<tr>
<td>This parasite has no intermediate host</td>
<td>2</td>
<td>2.90</td>
</tr>
<tr>
<td>Unsure</td>
<td>31</td>
<td>44.93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 11 - Which of the following best describes the clinical signs of <em>Onchocerca Cervicalis</em> infection?</th>
<th>Number of 'aware respondents'</th>
<th>Percentage of 'aware respondents' (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal dermatitis and pruritus, mainly on the ventral abdomen and thorax, occasionally around the poll and eyes (Correct response)</td>
<td>23</td>
<td>33.33</td>
</tr>
<tr>
<td>Seasonal identifiable circular skin lesions that can be found anywhere on the body with alopecia and scaling</td>
<td>7</td>
<td>10.15</td>
</tr>
<tr>
<td>Seasonal severe pruritus, leading to itching and self-trauma particularly around the crest and tail</td>
<td>22</td>
<td>31.88</td>
</tr>
<tr>
<td>Unsure</td>
<td>17</td>
<td>24.64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 12 How long do the adult <em>Onchocerca</em> live within the horses body?</th>
<th>Number of 'aware respondents'</th>
<th>Percentage of 'aware respondents' (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>3</td>
<td>4.69</td>
</tr>
<tr>
<td>6 months</td>
<td>5</td>
<td>7.81</td>
</tr>
<tr>
<td>1 year</td>
<td>8</td>
<td>12.50</td>
</tr>
<tr>
<td>5 years</td>
<td>5</td>
<td>7.81</td>
</tr>
<tr>
<td>10 years</td>
<td>2</td>
<td>3.13</td>
</tr>
<tr>
<td>15 years (Correct response)</td>
<td>4</td>
<td>6.25</td>
</tr>
<tr>
<td>unsure</td>
<td>37</td>
<td>57.81</td>
</tr>
</tbody>
</table>
Figure 4.4 displays the percentage of responses for each question which were correct, and the corresponding standard errors, calculated using Equation 2 (Appendix 2).

![Percentage of responses correctly answered](image)

Figure 4.4: Percentage of correct responses to knowledge questions

Each ‘aware respondent’ was assigned a ‘knowledge score’ (KS) representing the number of correct responses they gave (Figure 4.5). 49.27% answered less than two questions correctly, 33.33% answered two correctly and 17.39% gave either three of four correct responses. The mean KS was 1.58 with a standard error of 0.114; the mean was considered the most appropriate measure of central tendency as the data was normally distributed, with a skewness value of 0.19. These findings show nearly half of ‘aware respondents’ had little knowledge about OC with regards to the questions asked, with less than 18% being able to answer three or four of the questions correctly.

![Knowledge score distribution](image)

Figure 4.5: Respondent ‘knowledge scores’

### 4.2.3 Statistical analysis

No significant associations were found between any sets of the demographic data and awareness or knowledge score. There was also no significant association between where ‘aware respondents’ had qualified and whether they had heard about OC at university.

Two-sample binomial comparison tests (Appendix 4) showed a significantly higher proportion of ‘aware respondents’ answered question nine correctly compared to the other three knowledge questions and that a significantly lower proportion answered question 12 correctly when compared to the other questions (Q9 vs Q10: s.e. of difference=0.0804, p=0.001; Q9 vs Q11: s.e. of difference=0.0780, p=<0.001; Q9 vs Q12: s.e. of...
difference=0.0615, p=<0.001; Q10 vs Q12: s.e. of difference=0.0672, p=<0.001; Q11 vs Q12: s.e. of difference=0.0643, p=<0.001). This shows respondents were more likely to know what class of parasite OC belonged to but less likely to know details about the parasite, particularly how long it could live in horses’ bodies for.

### 4.2.4 Diagnosed *Onchocerca cervicalis* cases

Six of the total 88 respondents reported that they had diagnosed a case of OC during their time in practice, four of these cases being within the previous ten years. Skin testing was used in one case (2012), the remainder relied on clinical signs and therefore were not definitely confirmed. Table 4.4 shows the details respondents provided about these cases.

Table 4.4: Diagnosed cases of *Onchocerca cervicalis* in the UK

<table>
<thead>
<tr>
<th>Postcode</th>
<th>When diagnosed</th>
<th>Method of diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX</td>
<td>2016</td>
<td>Clinical signs</td>
</tr>
<tr>
<td>ST</td>
<td>2012</td>
<td>Skin scrapes, presentaion and response to treatment</td>
</tr>
<tr>
<td>CH</td>
<td>2010</td>
<td>Diagnosis not confirmed but strongly suspected in a few adult horses that become intensely pruritic after an ivermectin wormer. None of the horses would have ever been wormed before (feral)</td>
</tr>
<tr>
<td>SG</td>
<td>2018</td>
<td>Clinical signs</td>
</tr>
<tr>
<td>WV</td>
<td>About 10-15 years ago</td>
<td>Clinically, horse had odd lumps in crest which seemed to respond to ivermectin</td>
</tr>
<tr>
<td>BH</td>
<td>1990-2</td>
<td>Used to get swelling on neck when treated horses with ivermectin which was still relatively new then. Was in practice in Devon at that time.</td>
</tr>
</tbody>
</table>

### 4.3 Objective two

This section addresses the second research objective, outlined in Section 3.1:

*To determine an approximate number of horses in the UK affected with skin conditions including IBH that do not respond to standard treatment and management*

#### 4.3.1 Cases of unresponsive skin conditions

Five respondents did not complete question 13 and hence were excluded from this questions analysis. Table 4.5 displays for each skin condition, the number of responses available for analysis and the median percentage of unresponsive cases. The median was considered the most appropriate measure of central tendency as the data was unevenly distributed, with skewness values of over 0.5.

Table 4.5: Summary of skin conditions respondents saw that were unresponsive to standard treatment and management

<table>
<thead>
<tr>
<th>Skin condition</th>
<th>Number of analysed responses</th>
<th>Median percentage of unresponsive cases (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBH (sweet itch)</td>
<td>76</td>
<td>25</td>
</tr>
<tr>
<td>Lice infestations</td>
<td>71</td>
<td>0</td>
</tr>
<tr>
<td>Bacterial skin infections</td>
<td>76</td>
<td>10</td>
</tr>
<tr>
<td>Seasonal contact dermatitis</td>
<td>60</td>
<td>16</td>
</tr>
</tbody>
</table>

This shows that IBH and pyoderma were more commonly seen than lice infestations and contact dermatitis. Approximately one-quarter of IBH cases respondents saw were unresponsive to standard treatment and management, in comparison very few cases of lice infestations were unresponsive.
4.3.2 Onchocerca cervicalis as a differential diagnosis

Two respondents failed to answer question 14 correctly and therefore were removed from this questions analysis. Of the 86 responses remaining, 16.28% had considered OC as a differential diagnosis in unresponsive cases of the above conditions and 83.72% had not (Figure 4.6). This shows that the majority of equine vets which responded to this survey do not consider onchocerciasis as a differential in unresponsive cases of conditions which cause similar clinical signs.

![Figure 4.6: Percentage of respondents which had considered Onchocerca cervicalis as a differential diagnosis in cases of unresponsive skin conditions](image)

Of the respondents which had considered OC as a differential, 57.14% had taken further action to confirm their suspicions, two of these were respondents who had diagnosed a case of OC. To confirm their suspicions, one respondent reported using a skin biopsy or scrape and the remainder reported the use or recommendation of anthelmintic treatment.

Respondents who had not considered OC as a differential were asked why this was (Q14b). Approximately 40% of these selected ‘other’, rather than the choices provided; 12.5% selected that OC is not present in the UK equine population and 33.33% selected that OC is present but is very rare (Figure 4.7).

![Figure 4.7: Reasons why respondents had not considered Onchocerca cervicalis as a differential diagnosis in cases of unresponsive skin conditions](image)

The majority of respondents which selected ‘other’ to question 14b (n=29) reported either a lack of awareness of OC (n=11) or that it had never ‘crossed their mind’ (n=8) as the reason why they had not considered it as a differential (Figure 4.8).
4.3.3 Statistical analysis
It was hypothesised that respondents who considered OC as a differential (Q14) were more likely to correctly identify the clinical signs (Q11). Less than 50% of those who had considered OC as a differential also answered question 11 correctly and hence this hypothesis was deemed incorrect. Fisher Exact analysis confirmed there was no association.

4.4 Objective three
This section addresses the third research objective, outlined in Section 3.1:

To determine whether use of ivermectin and moxidectin is declining in the UK equine industry

4.4.1 Vet reported levels of faecal egg count use amongst their clients
Figure 4.9 shows vets responses regarding how many of their clients used FEC tests prior to administering anthelmintics. The median value was 51-60%, this measure was used as the data was ordinal and therefore the mean would not have been appropriate. This shows that according to the data provided by veterinary respondents, just over half of their horse owning clients carry out FEC tests before administering anthelmintics.
4.4.2 Vet reported levels of ivermectin and moxidectin use amongst their clients

Figure 4.10 shows the majority of respondents (57.96%) reported that 81-100% of their clients used ivermectin or moxidectin on an annual basis (median = 81-90%). This shows respondents considered that either ivermectin or moxidectin was administered to the majority of their clients horses at least once a year.

Figure 4.10 Vet reported levels of annual ivermectin or moxidectin use by their clients

Figure 4.11 summarises the findings from questions 17 and 18. One respondent did not answer question 17 and hence was removed from this questions analysis. Approximately 41% thought that ivermectin/moxidectin use had declined over the last ten years and approximately 60% thought that use would decline or decline further over the next ten years. This shows that the majority of respondents expected the use of these anthelmintics in the UK equine industry to reduce in the near future.

Figure 4.11 Vet opinions on current and future ivermectin and moxidectin use in the UK equine industry
Figure 4.12 shows reasons respondents provided for why they thought there would be a decline or further decline in use (Q18a). The most common reason was that new testing, particularly for EC, would reduce anthelmintic dependence. This shows that a considerable proportion of respondents thought being able to assess parasitic burdens in horses would reduce the use of ivermectin and moxidectin.

Figure 4.12 Reasons provided by respondents for why ivermectin/moxidectin use may decline over the next ten years

Figure 4.13 summarises the reasons respondents who thought there would not be a decline or further decline in use provided for why this was (Q18a). The most common reason was that ivermectin and moxidectin were currently the most effective anthelmintics or had the least resistance, showing that some respondents thought the use of these drugs would still be required to treat worm burdens.

Figure 4.13 Reasons provided by respondents for why ivermectin/moxidectin use may not decline over the next ten years

The complete responses to Question 18a are included in Appendix 3.
4.4.3 Statistical analysis

It was hypothesised respondents who reported lower levels of ivermectin/moxidectin use would also report higher levels of FEC use. However, chi-squared analysis found no association between respondents selecting below the median value (<81%) for ivermectin/moxidectin use and selecting at or above the median value (>50%) for FEC use, showing there was no association between levels of product use and levels of FEC use that vets reported.

A large proportion (72.73%) of respondents who selected ‘yes’ to question 17 reported levels of client ivermectin/moxidectin use below the median value (<81%). Chi square analysis found there was a significant association ($X^2=4.40$, d.f. = 1, $p=0.036$) between the two variables (Appendix 4), showing that veterinary respondents who saw a lower proportion of their clients using these products considered that their use was in decline.
Chapter Five: Discussion

This study aimed to establish current awareness and knowledge levels of OC amongst UK equine vets, to determine how many horses in the UK are suffering from unresponsive cases of skin conditions which act as differential diagnosis for onchocerciasis and to determine if ivermectin and moxidectin use is declining in the equine industry. There was a lack of comparable research on OC and cases of unresponsive skin conditions, therefore findings are predominantly discussed theoretically, however comparisons are made to current research where possible.

5.1 Awareness and knowledge of *Onchocerca cervicalis* in the UK equine veterinary profession

Results showed that 78.41% of respondents were aware of OC. It was expected awareness would be less than 100%, due to the lack of recent OC research and discussion in British literature (Section 2.1.3). Statistical analysis found no significant associations between awareness and demographic factors, showing an equal level of OC awareness across the UK equine veterinary profession.

University was the most frequently reported place where ‘aware respondents’ had heard about OC, with approximately 50% reporting this as the only place where they had been made aware of the parasite. This indicates that a large proportion of equine vets are taught about OC at university, but never come across the parasite again. There was no association between where ‘aware respondents’ had qualified and whether they had heard about OC at university, suggesting an equal level of OC teaching across UK vet schools.

Results indicated that OC knowledge amongst UK equine vets is relatively low (Section 4.2.2). This could be due to respondents forgetting facts about OC if they had not heard about it since university. Statistical analysis found no significant associations between KS and demographic factors, showing an equal level of OC knowledge across the UK equine veterinary profession.

The proportion of ‘aware respondents’ which correctly classed OC as a nematode (73.53%) was significantly higher than proportions of correct responses for the other three knowledge questions. This shows respondents could identify what class of parasite OC belongs to but lacked knowledge of its lifecycle. Only one third of ‘aware respondents’ identified the clinical signs of onchocerciasis correctly, which could explain why the majority had not considered it as a differential diagnosis. This will be discussed further in Section 5.2. Approximately another third confused the clinical signs of OC with the clinical signs of IBH. This could indicate that a proportion of equine vets are aware onchocerciasis closely resembles IBH but are unsure how the two conditions can be clinically distinguished from each other. Approximately 46% correctly selected *Culicoides* as the IH; indicating UK equine vets may not correlate an increase in *Culicoides* abundance with a potential rise in onchocerciasis cases and a rise in onchocerciasis with an increased threat of vector transmitted diseases including BTV and AHSV. Question 12 had a significantly lower proportion of correct responses than the other three questions, with only 6.25% selecting OC can live in horses’ bodies for 15 years. It is important vets know OC can persist in the nuchal ligament for the majority of a horse’s life, as horses which suffer from onchocerciasis require regular retreatment when clinical signs recur (Rashmir-Raven, 2018).

Only one of the six diagnosed OC cases was confirmed using skin testing. This may be due to skin sample collection being an invasive procedure where sedation can be required (Knottenbelt, 2012). In addition, ivermectin and moxidectin are widely available, low-cost and highly effective in removing MF (Mancebo et al., 1997); therefore it is probable treatment without confirming the diagnosis was considered the most cost-effective approach in these cases. The lower cost of treatment compared to testing would likely have made owners reluctant to pay for diagnostics (Rendle, 2018). These reasons could
also be why only one vet reported using skin samples when investigating OC as a differential.

When asked how they had diagnosed OC, two responses were particularly interesting.

“Clinically, horse had odd lumps in crest which seemed to respond to ivermectin.”

“Used to get swelling on neck when treated horses with ivermectin which was still relatively new then.”

These findings are indicative of fistulous withers which as discussed in Section 2.1.2, OC is no longer considered a causative agent of (Mair and Divers, 2009). In comparison to the other cases, these two had been diagnosed more than ten years ago and the vet which diagnosed the former case had been qualified the longest out of all respondents; this could explain why these respondents associated swelling on the neck or crest with OC. The fact that in the latter case swelling occurred after treatment could suggest that if OC were present, MF were most highly concentrated around the neck rather than the ventral midline. Carithers (2017) stated the highest concentrations of MF were in the soft tissue near the adult worms.

5.2 Cases of unresponsive skin conditions

From the results, it can be inferred that 25% of IBH cases in the UK are unresponsive to standard treatment and management. Using an estimated horse population of 847,000 (BETA, 2019) and an IBH prevalence of 2.8% (Slater, 2018) it can be predicted there are approximately 5,929 horses (0.7% of population) in the UK suffering from unresponsive IBH. As IBH is the most likely differential diagnosis (Nielsen et al., 2014), a proportion of these horses could be suffering from onchocerciasis. However, the value for percentage of unresponsive cases may be inaccurate as vets are more likely to see severe cases unresponsive to management techniques first carried out by the owner (Lomas and Robinson, 2018).

There was a lack of data on the prevalence of bacterial skin infections and seasonal contact dermatitis in the UK equine population, and therefore approximate number of horses affected by unresponsive cases of these conditions could not be determined. It is possible a number of these cases could be onchocerciasis, although further research would be required to confirm this. Very few cases of lice infestations were unresponsive, suggesting this is the least likely differential out of the four dermatoses investigated and that the number of cases of this condition which could be onchocerciasis is very low.

It is feasible to assume the lack of knowledge on the clinical signs of onchocerciasis would explain why the majority of respondents had not considered it as a differential in unresponsive cases of the investigated dermatoses. However, statistical analysis found no association between these two variables (Section 4.3.3), which shows this hypothesis is incorrect. When asked why they had not considered it as a differential, 33.33% considered OC to be very rare and 12.5% thought it was not present in the UK. This highlights the need to increase OC awareness and knowledge; particularly as UK prevalence could increase in the near future, it is important equine vets consider onchocerciasis as a potential cause of skin disease.
5.3 Ivermectin and moxidectin use in the UK equine industry

Current consensus on best practice for anthelmintic use in horses is that FEC tests should be carried out regularly over the grazing season, and their results used to inform whether horses require treatment (Rendle et al., 2019). Results showed a median of 51-60% of participants’ clients used FEC tests prior to administering anthelmintics. However, it should be noted vet-reported levels may be inaccurate as literature suggests owners who purchase or seek anthelmintic advice from vets are more likely to use FEC’s. Easton et al. (2016) found owners who purchased anthelmintics from vets were significantly more likely to be recommended FEC tests than those who purchased from other sources. However, Tzelos et al. (2019) and Fitzgibbon (2019) found similar levels of FEC use when surveying horse owners, 60.9% and 52.3% respectively, which supports the validity of this result.

It is currently recommended moxidectin is administered to horses at risk of cyathostominosis in autumn to prevent mass emergence of EC in spring, and ivermectin is administered in response to high FEC results during the grazing season (Rendle et al., 2019). Respondents reported high levels of client annual ivermectin or moxidectin use (median of 81-90%). This is higher than owner-reported use found by Allison et al. (2011) and Ireland et al. (2013) of 73% and 74% respectively. This difference could be attributed to a small proportion of horse owners purchasing anthelmintics from vets. Tzelos et al. (2019) found that 3.2% of owners purchased anthelmintics from vets and that 38% sought veterinary advice when selecting an anthelmintic; therefore it is unlikely vets are aware of the worming practices all their clients use.

There was no association between vet-reported levels of FEC use and ivermectin/moxidectin use (Section 4.4.3), suggesting that increased uptake of FEC tests may not lower use of these products. This contrasts with previous research which found FEC results did affect owners choice of worming practices (Fitzgibbon, 2019). This difference could also be attributed to vets not being aware of all their clients worming practices.

Approximately 41% of respondents thought ivermectin/moxidectin use had reduced over the last ten years. These respondents were more likely to report levels of client ivermectin/moxidectin use below the median value (p=0.036) (Section 4.4.3). This was expected as vets answers to this question would likely be influenced by the number of their clients using these products.

The majority of respondents (60.23%) thought ivermectin/moxidectin use would decline over the next decade. The main reasons provided for this were that new diagnostic tests, particularly for EC, and increased uptake of FEC tests would reduce dependence on these anthelmintics. The first test to detect EC, an enzyme-linked immunosorbent assay for blood analysis was commercially launched in autumn 2019 (Moredun Foundation, 2019). It is not currently possible to determine how many horse owners will adopt using this before administering moxidectin in the autumn, however, Easton et al. (2016) found 70% of owners said they would utilise this type of diagnostic test, suggesting uptake could be high. Research into a saliva-based assay is ongoing (The Veterinary Times, 2019); should this become available, it would likely have higher uptake than the blood test as sampling could be carried out by owners. Increased awareness and understanding of AR amongst horse owners was also reported as a reason for ivermectin/moxidectin use declining. This correlates with literature showing owner concern about AR has increased in recent years; Allison et al. (2011) found 56% of owners were concerned about AR, whereas Tzelos et al. (2019) found 69.4% were. As owners become more aware of AR and the need to preserve drug efficacy, uptake of targeted treatment practises will likely increase and therefore overall levels of anthelmintic use will reduce.
5.4 Limitations
The low response rate was the primary limitation in this study resulting in a larger margin of error at the 95% confidence level than was desired. This reduced the confidence that the results represented the entire population of UK equine vets and therefore placed limitations on the conclusions that could be drawn from this research. However, online surveys targeted towards vets typically have low response rates; Parkin et al. (2018) obtained a 18.7% response rate from emailing 1700 equine vets when conducting a survey regarding the occupational risks of working with horses. Industry-led surveys also obtain relatively low numbers of responses; the 2019 RCVS Survey of the Veterinary Profession attained a 31.8% response rate (IES, 2019). This shows it is difficult to obtain high response rates for vet-targeted surveys and hence the low numbers of responses in this study were not unexpected.

5.5 Implications of the findings
This study presents a number of implications for the UK equine veterinary industry. The main implication being there could currently be horses in the UK suffering from onchocerciasis not receiving appropriate diagnosis and treatment due to a lack of awareness and knowledge of OC amongst equine vets and the diagnostic methods available being impractical. In the near future, onchocerciasis prevalence may increase considerably due to reduced ivermectin and moxidectin use and an increase in Culicoides abundance (Section 2.2.1), therefore it is imperative that equine vets can correctly diagnose and treat this condition. In order to increase awareness and knowledge, UK vet schools may need to review their teaching on OC, parasitology CPD courses could also be used, as only three vets stated they had heard about OC in this way.

5.6 Recommendations for further research
Further social science-based research could include a survey of horse owners to obtain further data on cases of unresponsive IBH, anthelmintic use and FEC use. In particular, it would be interesting to see if horses with unresponsive IBH receive regular ivermectin/moxidectin treatment; this would enable further validation as to whether these cases could be onchocerciasis. More detailed information about equine vets knowledge of OC and why they did not consider it as a differential in cases of unresponsive skin conditions could be obtained using interviews or focus groups.

As current UK OC prevalence is unknown, it is recommended research investigating this is carried out to gain a fuller understanding of how rare or common the parasite is and hence quantify the threat it poses to the equine population. A study carrying out post-mortem examination of nuchal ligaments and skin samples would provide a good indication of both clinical and subclinical infection; however results may be inaccurate because, as discussed in Section 2.1.2, older horses are more susceptible to infection.

The only way to currently investigate OC prevalence ante-mortem is by taking skin samples; as discussed in Section 2.1.4, this procedure is invasive and has variable sensitivity, therefore such a study may present ethical issues. It is therefore also recommended research is conducted into developing less invasive diagnostic tests for OC, such as the serological tests recently utilised for OV (Vlaminck et al., 2015). Such assays would make research investigating prevalence more ethically acceptable and may also increase the uptake of testing in suspected clinical cases.
Chapter Six: Conclusion
The findings of this study indicated that the majority of UK practising equine vets are aware of OC however lack knowledge of the parasites’ lifecycle. Results showed that a quarter of IBH cases in the UK are unresponsive and that the majority of equine vets in the survey sample did not consider onchocerciasis as a differential for these cases. It was therefore hypothesised a number of these horses could be suffering from onchocerciasis and the need to carry out further research to investigate this was identified. The findings also indicated that use of ivermectin and moxidectin in the UK equine industry will decline in the near future and therefore onchocerciasis prevalence could increase. It is recommended steps are taken to improve OC knowledge amongst UK equine vets and that research is conducted into determining the parasites prevalence in the UK and developing less invasive diagnostic tests.
References


Whittmann, E.J. 2000. Temperature and the transmission of Arboviruses by Culicoides biting midges: A dissertation submitted to the University of Bristol in accordance with the requirements of the degree of Doctor of Philosophy in the Faculty of Science. Bristol: University of Bristol.


Wilson, A.D. 2014. Immune responses to ectoparasites of horses, with a focus on insect bite hypersensitivity. Parasite Immunology, 36 (11), pp.560-572.

Appendices

Appendix 1: Distributed questionnaire

Assessing the awareness of *Onchocerca cervicalis* amongst Equine Veterinary Surgeons in the UK

About this questionnaire

Participant Information Statement

Thank you for participating in this questionnaire.

This survey is being used to collect data for research that is seeking to assess the current levels of awareness and the knowledge-base of UK practising equine vets about the parasite *Onchocerca cervicalis* (neck threadworm). Completion of the survey should take no more than 10 minutes.

Please answer all questions accurately to the best of your knowledge. Once you have started the questionnaire, please do not refer to literature or the internet to answer these questions so we can accurately assess the current levels of awareness and knowledge.

Data protection: All responses are confidential and individuals and the companies they represent will not be identifiable from the research paper. Data will be handled according to the Market Research Society’s Code of Conduct. By participating in this survey, you are giving consent to the collection of data. You have the right to withdraw from this survey at any time - data will not be processed until you click FINISH at the end of the survey. The research findings will be written up as a dissertation and may also be published in academic journals and other relevant publications, used for teaching purposes with the University and disseminated as considered appropriate.

Your contribution to this research is very valuable and I thank you in advance for your time and effort taken in contributing towards this exciting area of research.

If you have any questions and for further information, please contact Sarah Mansell at 16003500@live.harper.ac.uk
About you

1. What year did you qualify as a Veterinary Surgeon?

2. Where did you qualify? If you qualified abroad, please select other and specify which country.
   - Royal Veterinary College
   - Cambridge
   - Liverpool
   - Bristol
   - Nottingham
   - Glasgow
   - Edinburgh
   - Other

2.a. If you selected Other, please specify:

3. Please provide the first two characters of the postcode of your practice.

4. Which age category do you fall into?
   - less than 25
   - 25-35
   - 36-45
   - 46-55
   - 56-65
   - Over 65
Onchocerca cervicalis

5. Have you ever heard of Onchocerca cervicalis (neck threadworm)? If yes, go to question 6, if no, please go to question 13 on the next page.
   - Yes
   - No

6. Where have you heard about Onchocerca cervicalis? Please select all that apply.
   - In practice
   - University
   - CPD course
   - Other

6.a. If you selected Other, please specify:

7. Have you ever confirmed a case of Onchocerca cervicalis in the UK during your time in practice? If yes go to question 8, if no go to question 9.
   - Yes
   - No

8. If yes, when did you diagnose it?

8.a. Please briefly describe how you diagnosed it, including any tests that you used.

9. Which class of parasite does Onchocerca cervicalis belong to?
   - Cestode
   - Nematode
   - Trematode
   - Protozoa
   - Unsure
10. Which of the following acts as the intermediate host for *Onchocerca cervicalis*?

- Tannus spp
- Culicoides spp
- Stomoxys spp
- This parasite has no intermediate host
- Unsure

11. Which of the following best describes the clinical signs of *Onchocerca Cervicalis* infection?

- Seasonal identifiable circular skin lesions that can be found anywhere on the body with alopecia and scaling
- Seasonal severe pruritus, leading to itching and self trauma particularly around the crest and tail
- Seasonal dermatitis and pruritus, mainly on the ventral abdomen and thorax, occasionally around the poll and eyes
- Unsure

12. How long do the adult *Onchocerca* live within the horses body?

- 1 month
- 6 months
- 1 year
- 5 years
- 10 years
- 15 years
- unsure

**Equine skin conditions**

13. Approximately how many cases of the following skin conditions do you see each year and how many of these cases are unresponsive to standard treatment and management?

<table>
<thead>
<tr>
<th></th>
<th>Total number of cases</th>
<th>Number of cases unresponsive to standard treatment and management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet itch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lice infestations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacterial skin infections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal contact dermatitis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
14. Have you ever considered *Onchocerca cervicalis* as a differential diagnosis in unresponsive cases of these skin conditions?

- Yes
- No

14.a. If yes, did you take further action to confirm your suspicions?

- Yes
- No

14.a.i. If so, what action did you take?

[Blank space for action description]

14.b. If no, why did you not consider it as a differential diagnosis?

- *Onchocerca cervicalis* is not present in the UK equine population
- *Onchocerca cervicalis* is present but does not cause these symptoms
- *Onchocerca cervicalis* is present but is very rare
- *Onchocerca cervicalis* is present but is asymptomatic in UK equines
- Other

14.b.i. If you selected Other, please specify:

[Blank space for other specification]
Anthelmintic use in horses

15. Approximately how many of your clients have faecal egg count tests done before using anthelmintics?

- 0-10%
- 11-20%
- 21-30%
- 31-40%
- 41-50%
- 51-60%
- 61-70%
- 71-80%
- 81-90%
- 91-100%
- Unsure

16. Approximately how many of your clients use ivermectin or moxidectin on an annual basis?

- 0-10%
- 11-20%
- 21-30%
- 31-40%
- 41-50%
- 51-60%
- 61-70%
- 71-80%
- 81-90%
- 91-100%
- Unsure
17. In your opinion, has ivermectin / moxidectin use reduced over the last 10 years?

☐ Yes
☐ No
☐ Unsure

18. Do you think that there will be a decline / further decline in ivermectin / moxidectin use over the next ten years?

☐ Yes
☐ No
☐ Unsure

18.a. Please explain why you chose this answer.

Thank you!

Thank you for taking the time to complete this questionnaire.

For further information please contact Sarah Mansell at 16003500@live.harper.ac.uk
Appendix 2: Equations used

Equation 1: Sample size calculation

\[
sample \ \text{size} = \frac{z^2 \times p \times (1-p)}{e^2} \times 100
\]

\[
1 + \left( \frac{z^2 \times p \times (1-p)}{e^2 \times N} \right)
\]

- \( z \) = z-score for desired confidence interval (1.96)
- \( N \) = population size (1800)
- \( e \) = desired margin of error (0.05)
- \( p \) = sample proportion (0.5)

Equation 2: Standard error of percentages

\[
\text{Standard error of percentage} = \sqrt{\frac{\text{proportion} \times (1 - \text{proportion})}{\text{Sample size}}} \times 100
\]
## Appendix 3: Results

Postcodes included in each region

<table>
<thead>
<tr>
<th>Region</th>
<th>Postcodes included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland</td>
<td>AB, EH, IV, KW, ML, TD</td>
</tr>
<tr>
<td>Wales</td>
<td>CF, SA, SY</td>
</tr>
<tr>
<td>North of England</td>
<td>BD, DL, DN, HG, NE, YO</td>
</tr>
<tr>
<td>North West of England</td>
<td>CH, CW, L, PR, WA</td>
</tr>
<tr>
<td>East Anglia</td>
<td>IP, NR, CB</td>
</tr>
<tr>
<td>The Midlands</td>
<td>GL, LE, OX, PE, ST, WV</td>
</tr>
<tr>
<td>South West of England</td>
<td>BA, BH, BS, EX, SN, TR</td>
</tr>
<tr>
<td>South East of England</td>
<td>AL, CM, CO, HP, ME, RG, RH, SG, SO, TN</td>
</tr>
</tbody>
</table>

### Responses to question 18

**18. Do you think that there will be a decline / further decline in ivermectin / moxidectin use over the next ten years?**

18.a. Please explain why you chose this answer.

<table>
<thead>
<tr>
<th>Response</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Better client awareness and willingness to improve worming programs</td>
</tr>
<tr>
<td>Yes</td>
<td>Increased awareness of the necessity to test before treating</td>
</tr>
<tr>
<td>Yes</td>
<td>With blood testing for small red worm we will be able to reduce moxidectin use</td>
</tr>
<tr>
<td>Yes</td>
<td>People stopping routine worming through the summer</td>
</tr>
<tr>
<td>Yes</td>
<td>More people are becoming aware of targeted worming and only worming those individuals that require worming, therefore less wormers will be used in the future</td>
</tr>
<tr>
<td>Yes</td>
<td>Greater awareness raised for antihelmintic resistance</td>
</tr>
<tr>
<td>Yes</td>
<td>We are trying to educate owners to only use these products only when needed</td>
</tr>
<tr>
<td>Yes</td>
<td>More awareness of resistance and new blood test for encysted strongyles</td>
</tr>
<tr>
<td>Yes</td>
<td>More targeted use of all anthelmintics</td>
</tr>
<tr>
<td>Yes</td>
<td>Availability of encysted redworm ELISA blood test and increase in uptake of WEC overgrazing season likely to reduce use.</td>
</tr>
<tr>
<td>Yes</td>
<td>people are more aware of antihelmintic resistance and are moving away from routine worming and opting for targeted worming instead</td>
</tr>
<tr>
<td>Yes</td>
<td>With the application of an encysted redworm blood test we can avoid routine de-worming for these in the winter, but we are still waiting for the test to prove itself as currently almost all are coming back as moderate or high and therefore moxidectin is being indicated.</td>
</tr>
<tr>
<td>Yes</td>
<td>Greater awareness of resistance</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes, if owners do more FWEC based worming programs with more targeted treatment not just worming unnecessarily</td>
</tr>
<tr>
<td>Yes</td>
<td>More uptake of encysted redworm blood test</td>
</tr>
<tr>
<td>Yes</td>
<td>Wec increasing and increasing awareness that shouldn’t use so much - move away</td>
</tr>
<tr>
<td>Yes</td>
<td>from equestrian 4 times a year</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Yes</td>
<td>release of small encysted redworm blood test will hopefully reduced annual use of moxidectin</td>
</tr>
<tr>
<td>Yes</td>
<td>increase in use of FWEC</td>
</tr>
<tr>
<td>Yes</td>
<td>New testing available</td>
</tr>
<tr>
<td>Yes</td>
<td>Developing resistance</td>
</tr>
<tr>
<td>Yes</td>
<td>Pressure due to resistance and therefore recommend worm egg counts and the recent ELISA blood test</td>
</tr>
<tr>
<td>Yes</td>
<td>Cyathostomin blood test Increased awareness of fwec</td>
</tr>
<tr>
<td>Yes</td>
<td>We advise clients who submit faecal egg count testing with us on resistance problems as well as adding in the encysted red worm blood sample so that treatment is targeted at the most ‘at risk’ individuals so we can preserve the use of these drugs and their effectiveness for longer in the future. If we carry on as we are with current use then eventually we will have a serious problem on our hands. Owners need to understand that horses can live with a population of nematodes etc. and that only beyond thresholds that cause clinical disease is when we need to worry.</td>
</tr>
<tr>
<td>Yes</td>
<td>More people using FWECs to guide necessity of worming</td>
</tr>
<tr>
<td>Yes</td>
<td>Anthelmintic resistance</td>
</tr>
<tr>
<td>Yes</td>
<td>further use of FWEC, blood tests etc</td>
</tr>
<tr>
<td>Yes</td>
<td>With the advent of encysted red worm testing plus increased use of worm egg counts in general, worming is reducing</td>
</tr>
<tr>
<td>Yes</td>
<td>Further testing will hopefully reduce the amount of anthelmintics that our parasite populations are exposed to.</td>
</tr>
<tr>
<td>Yes</td>
<td>more blood testing available</td>
</tr>
<tr>
<td>Yes</td>
<td>Increased awareness of resistance and possibility of not using autumn moxidectin when using encysted redworm blood test.</td>
</tr>
<tr>
<td>Yes</td>
<td>Serological testing for encysted cyathostomes will provide confidence for reduced moxidectin use</td>
</tr>
<tr>
<td>Yes</td>
<td>eco-friendly policies</td>
</tr>
<tr>
<td>Yes</td>
<td>Pressure to reduce anthelmintic usage will lead to more egg counts</td>
</tr>
<tr>
<td>Yes</td>
<td>Better understanding of management, and diagnostic tests to detect those with infections and those without-so targeted treatment to avoid overuse and resistance</td>
</tr>
<tr>
<td>Yes</td>
<td>Pressure due to drug resistance.</td>
</tr>
<tr>
<td>Yes</td>
<td>More responsible worming</td>
</tr>
<tr>
<td>Yes</td>
<td>Most horses are hopefully now on routine WEC monitoring with an annual dose of moxidectin in the late autumn; dome owners are yet to realise this is the best practice and overwork their horses; hopefully as they become more educated use and resistance will fall</td>
</tr>
<tr>
<td>Yes</td>
<td>Hopefully the message will get through that we shouldn't just worm everything!</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Yes</td>
<td>With the push to avoid regular interval dosing with anthelmintics, it is almost certain that less of these products will be used.</td>
</tr>
<tr>
<td>Yes</td>
<td>More use of faecal egg counts and saliva testing to reduce chemical usage.</td>
</tr>
<tr>
<td>Yes</td>
<td>With further knowledge and encouragement of faecal worm egg counts, hopefully owners will use them only when required - helping prevent resistance</td>
</tr>
<tr>
<td>Yes</td>
<td>Increased WEC/ tapeworm Elisa</td>
</tr>
<tr>
<td>Yes</td>
<td>As more become used to/ aware of the necessity to only worm when indicated by diagnostic tests then use will decline further</td>
</tr>
<tr>
<td>Yes</td>
<td>Availability of tapeworm and encysted redworm testing.</td>
</tr>
<tr>
<td>Yes</td>
<td>More clients using faecal worm egg counts</td>
</tr>
<tr>
<td>Yes</td>
<td>Targeted worming is becoming more understood and use of anthelmintics generally will reduce but at a slower rate. Moxidectin sales have become much more seasonal for instance</td>
</tr>
<tr>
<td>Yes</td>
<td>Increasing awareness of resistance risk and improved testing ie. Small reform swan now available</td>
</tr>
<tr>
<td>Yes</td>
<td>more targeted worming</td>
</tr>
<tr>
<td>No</td>
<td>Drug companies are heavily marketing these drugs and SQPs also massively push them</td>
</tr>
<tr>
<td>No</td>
<td>historical used and to my knowledge moxidectin should be used annual nov/dec time</td>
</tr>
<tr>
<td>No</td>
<td>Because they have the least widespread resistance especially for small strongyles of any classes of wormer</td>
</tr>
<tr>
<td>No</td>
<td>There are very few dewormer options in horses. Even with WEC these drugs are still the most commonly used dewormer</td>
</tr>
<tr>
<td>No</td>
<td>Moxidectin only wormer useful for encysted L3. Ivermectin is cheap!</td>
</tr>
<tr>
<td>No</td>
<td>Pramox seems to be handed out left right and centre by SQPs</td>
</tr>
<tr>
<td>No</td>
<td>clients with better worming program proportions are unlikely to significantly change further.</td>
</tr>
<tr>
<td>No</td>
<td>Because it is the most effective wormer. Resistance may develop to it, but people will still use it, as it works better than Pyrantel or Fenbendazole</td>
</tr>
<tr>
<td>No</td>
<td>Effective class of anthelmintic</td>
</tr>
<tr>
<td>No</td>
<td>No other anthelmintic that treats encrusted red worm larvae well</td>
</tr>
<tr>
<td>No</td>
<td>No new alternative</td>
</tr>
<tr>
<td>No</td>
<td>Resistance to other treatments</td>
</tr>
<tr>
<td>No</td>
<td>Good results but I guess resistance may become an issue</td>
</tr>
</tbody>
</table>
Unsure more awareness will reduce anthelmintic use overall but no new anthelmintics available. Ivermectin already has widespread resistance so used less and less often but almost every horse I know has a moxidectin treatment at least once a year.

Unsure Risk of resistance developing might lead to vets discouraging their general use.

Unsure Depends on current veterinary university teaching, as well as pro-active client education.

Unsure

Unsure although FEC are always preferable, certain situations preclude their use and so I am unsure as to whether anthelmintic use would go down. I would like to hope it would!

Unsure We don’t dispense many worming products to our clients and although we offer worming advice and would discuss this at routine appointments we often do not know exactly which products have been used by our clients.

Unsure I think in my case load where large groups of horses are kept on heavily grazed pastures, there will always be a need for some anti parasite medications. Although through client education about which ones to use when, and routine FEC we should reduce this somewhat.

Unsure see IVM reducing but moxidectin increasing, especially now that tapeworm only treatment unavailable.

Unsure Not something I monitor. Depends on how practice evolves as to if use will change.

Unsure It would be interesting to see the sales data. I think more horses are being wormed but fewer being wormed as intensively.

Unsure Yearly treatment with moxidectin to control larval cyathostomin stages ay be replaced by ELISA test.

Unsure

Unsure
Appendix 4: Statistical analysis

Number of vets answering Q9 correctly vs number answering Q10 correctly
Two-sample binomial test
Summary

<table>
<thead>
<tr>
<th>Sample</th>
<th>Size</th>
<th>Successes</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68</td>
<td>50</td>
<td>0.735</td>
</tr>
<tr>
<td>2</td>
<td>69</td>
<td>32</td>
<td>0.464</td>
</tr>
</tbody>
</table>

Approx s.e. of difference between proportions: 0.0804
Test of null hypothesis that proportion 1 is equal to proportion 2
Normal Approximation = 3.242
Probability = 0.001

95% confidence interval for difference between proportions: (0.1139, 0.4291)

Number of vets answering Q9 correctly vs number answering Q11 question correctly
Two-sample binomial test
Summary

<table>
<thead>
<tr>
<th>Sample</th>
<th>Size</th>
<th>Successes</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68</td>
<td>50</td>
<td>0.735</td>
</tr>
<tr>
<td>2</td>
<td>69</td>
<td>23</td>
<td>0.333</td>
</tr>
</tbody>
</table>

Approx s.e. of difference between proportions: 0.0780
Test of null hypothesis that proportion 1 is equal to proportion 2
Normal Approximation = 4.715
Probability = < 0.001

95% confidence interval for difference between proportions: (0.2491, 0.5548)

Number of vets answering Q9 correctly vs number answering Q12 correctly
Two-sample binomial test
Summary

<table>
<thead>
<tr>
<th>Sample</th>
<th>Size</th>
<th>Successes</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68</td>
<td>50</td>
<td>0.735</td>
</tr>
<tr>
<td>2</td>
<td>64</td>
<td>4</td>
<td>0.062</td>
</tr>
</tbody>
</table>

Approx s.e. of difference between proportions: 0.0615
Test of null hypothesis that proportion 1 is equal to proportion 2
Normal Approximation = 7.857
Probability = < 0.001

95% confidence interval for difference between proportions: (0.5523, 0.7933)
Number of vets answering Q10 correctly vs number answering Q12 correctly
Two-sample binomial test
Summary

<table>
<thead>
<tr>
<th>Sample</th>
<th>Size</th>
<th>Successes</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64</td>
<td>4</td>
<td>0.062</td>
</tr>
<tr>
<td>2</td>
<td>69</td>
<td>32</td>
<td>0.464</td>
</tr>
</tbody>
</table>

Approx s.e. of difference between proportions: 0.0672

Test of null hypothesis that proportion 1 is equal to proportion 2

Normal Approximation = -5.204
Probability = < 0.001

95% confidence interval for difference between proportions: (-0.5330, -0.2695)

Number of vets answering Q11 correctly vs number answering Q12 correctly
Two-sample binomial test
Summary

<table>
<thead>
<tr>
<th>Sample</th>
<th>Size</th>
<th>Successes</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64</td>
<td>4</td>
<td>0.062</td>
</tr>
<tr>
<td>2</td>
<td>69</td>
<td>23</td>
<td>0.333</td>
</tr>
</tbody>
</table>

Approx s.e. of difference between proportions: 0.0643

Test of null hypothesis that proportion 1 is equal to proportion 2

Normal Approximation = -3.880
Probability = < 0.001

95% confidence interval for difference between proportions: (-0.3969, -0.1448)

Whether respondents thought there had been a decline in ivermectin/moxidectin use over the last ten years (Q17) and the percentage of clients they reported using these drugs on an annual basis (Q15)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-80%</td>
<td>16</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>81-100%</td>
<td>19</td>
<td>23</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>29</td>
<td>64</td>
</tr>
</tbody>
</table>

Chi-square test for association

Pearson chi-square value is 4.40 with 1 d.f.
Probability level (under null hypothesis) p = 0.036