Lameness in English lowland sheep flocks: farmers' perspectives and behaviour

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Dedication

Fideliter, Fortiter, Feliciter

Dedicated to: my parents, my husband George, my daughters Summer Charlotte and Tia Amelia; and my supervisor Professor Laura Green

This thesis would not have been possible without you. Thank you.

I am privileged and proud to have the most amazing parents who have always supported and encouraged their girls to follow their dreams. Thank you for teaching me that anything is possible. I hope I can be as fantastic as you for my girls –some big footsteps to follow!

George: my 'Mr Perfect' and my rock, thank you for patiently standing by me.

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Declaration

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

The work presented (including data generated and data analysed) was carried out by the author. Advice sought and any assistance received with data collection is clearly acknowledged within the materials and methods and acknowledgements sections.

Parts of this thesis have been published by the author.

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Abstract

Lameness in sheep is an important welfare concern causing financial loss through lost performance. This thesis increases epidemiological understanding of sheep lameness from the farmers' perspective, using interdisciplinary approaches.

Previous work indicated that routine foot trimming (RFT), used by >75% of farmers to control lameness, correlated with higher lameness prevalences. A within farm, clinical trial using stratified random sampling examined the effect of RFT *versus* no RFT on 173 ewes. RFT was not beneficial and over-trimming was detrimental.

Thirty-five farms were visited to assess accuracy of farmers' estimated lameness prevalence in their sheep flocks compared with a researcher's observations. Farmers' estimates were consistently, closely and significantly correlated with the researcher's estimates.

Successful knowledge transfer and research impact requires understanding lameness management from farmers' perspectives. Qualitative interviews with 17 farmers examining attitudes towards lameness management were used to inform design of a questionnaire, sent to 1000 randomly selected farmers, to quantify farmers' attitudes towards lameness. Farmers considered interdigital-dermatitis and footrot distinct. Barriers to prompt treatment (*e.g.* lack of time/labour) accounted for most observed variance, with non-financial motivators rated higher than financial motivators. Ineffective flock record keeping, environmental subsidies and market price fluctuation may reduce financial motivation. Consistent with the RFT trial, there was no difference ($p>0.5$) in lameness prevalence by RFT frequency/absence. Despite RFT trial evidence given, farmers were reluctant to stop RFT; with reluctance less from those with higher lameness prevalences, large, commercial flocks, infrequently using parenteral antibacterial treatments or not treating mildly lame sheep.

This thesis provides evidence that farmers' lameness estimates are sufficiently accurate and can be used in research. Routine foot trimming appears to be of no benefit to reduce lameness but farmers require further evidence to be convinced of this. Further farmer focused research into RFT, barrier cause and effect, and whole flock managements is required.

Abbreviations

%	Percentage
±	plus or minus
ADAS	Agricultural Development and Advisory Service
BCS	Body Condition Score
C	Control group
CI	Confidence interval (95%)
CODD	Contagious Ovine Digital Dermatitis
CVA	Canonical Variates Analysis
d.f.	Degrees of freedom
DEFRA	Department for Environment, Food and Rural Affairs
EBLEX	The organisation for the English beef and sheep industry
FAWC	Farm Animal Welfare Committee
FCS	Foot Conformation Score
FR	Footrot
ID or scald	Interdigital Dermatitis
IQR	InterQuartile Range
N	Number
NERC	Natural Environment Research Council
OR	Odds Ratio
PCA	Principal Component Analysis
RFT	Routine Foot Trimming
Rho	Spearman's rank correlation coefficient
SE	Standard Error
T	Treatment group
VAS	Visual Analogue Scale

Chapter 1 General Introduction

1.1 Implications of lameness

UK sheep farmers list lameness as their primary or secondary health concern of sheep (Waterhouse *et al*., 2003; Morgan-Davies *et al*., 2006). Lame sheep are in pain (Ley *et al*., 1989; Ley *et al*., 1994) and are a significant health and welfare concern because they breach all five of the five freedoms of farmed livestock (FAWC, 1979): freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury and disease; freedom to express normal behaviour; and freedom from fear and distress. Freedom from hunger and thirst may be breached because lame sheep may not be able to graze as frequently. In addition, lame sheep considerably reduce the income a farmer can achieve from his flock by reducing overall flock performance. Weight loss (Marshall *et al*., 1991), reduced body condition, fertility, lambing percentage (Wassink *et al*., 2010a) and wool growth (Stewart *et al.* 1984; Marshall *et al*., 1991), increased mortality and also an increased time to finish lambs (Wassink *et al*., 2010a) are reported outcomes of lameness in sheep. In 2005, the financial loss to the UK sheep industry for one of the primary causes of lameness, footrot (FR), was estimated to be >£24 million (Nieuwhof and Bishop, 2005). This estimate comprised £6.8 million in lost performance, £3.6 million in treatment and £13.9 million in prevention. Each individual case of FR was estimated to cost the farmer £2.42 per ewe and £2.24 per lamb in treatment. In addition, the authors of a 2 year, on farm, stratified random intervention study, carried out in 2005-2006, reported that a 6% to 2% reduction in prevalence of lameness increased the farm income by £6.30 per ewe put to the ram; despite the increased costs of treatment and labour necessary to achieve this reduction (Wassink *et al*., 2010a).

1.2 Prevalence of lameness in the UK

Current estimates of the prevalence of lameness in sheep flocks in the UK come from epidemiological studies that have relied on farmer recognition and estimates of lameness. Two separate stratified random postal surveys carried out in 1994 and 2006 provide the only estimates for the UK average annual period prevalence of lameness: 8% (Grogono-Thomas and Johnson, 1997) and 10.4% respectively (Kaler and Green, 2008a) with lame sheep present on 97% of farms (Kaler and Green, 2008a). Despite concerns from industry, government and non-governmental bodies, these studies suggest that the prevalence of lameness is not decreasing; it may perhaps be increasing.

Researchers have used farmer estimates of prevalence of lameness to identify risk factors for the prevalence of FR (Wassink *et al*., 2003a) and ID (Wassink *et al*., 2004), farmer satisfaction with strategies for management of lameness and interest in change (Wassink *et al*., 2010b) and the proportion of lameness attributed to foot lesions (Kaler and Green, 2008a). All these studies have assumed that farmers can both recognise lame sheep and that they report the prevalence of lameness accurately. This is a substantial limitation to the validity and reliability of their findings.

Research shows that dairy cattle farmers underestimate the prevalence of lameness in their herds considerably when compared with an independent observer (mean prevalence of 5.73% (SD 7.07) *cf.* 22.11% (SD 9.61)) (Whay *et* *al*., 2002). The authors reported that the prevalence of lameness (22%), as reported by the independent observer was similar to the 21% reported by Clarkson *et al.* (1996) in the 1980s. They then compared the farmers' estimated incidence of lameness, 13.3 cases per 100 cows per year, (Whay *et al*., 2003) with the 50.6 cases per 100 cows per year reported by Clarkson (Clarkson *et al*., 1996). Based on findings from these two studies they concluded that dairy farmers not only substantially underestimate the prevalence of lameness but also the incidence. Whay *et al.* (2003) also reported that farmers overestimated the incidence of lameness when compared with their treatment records, suggesting that either they do not record all treatments in their records or that not all lame cows are treated, or both (Whay *et al*., 2003). In contrast, when the incidence of mastitis estimated by the farmer was compared to farm medicine records (Whay *et al*., 2003) there was good agreement. The authors concluded that this was almost certainly because of the immediate and direct loss in income through penalties for raised somatic cell counts and discarded milk (Whay *et al*., 2003) but it might also be because veterinary medicines are perhaps more likely to be used for cases of mastitis than for cases of lameness.

Whatever the underlying reason behind the inaccuracy of estimates of prevalence and incidence of lameness given by dairy farmers, it is clearly a concern that sheep farmers might also be unable to accurately estimate lameness in their flocks. If they do to the same extent as dairy cattle farmers, then the true prevalence of lameness in UK sheep flocks could be as high as 31-54%.

1.3 Causes of lameness in sheep

Causes of lameness in sheep may be grouped into three categories: physical injury (*e.g.* fracture, abrasion or penetrating wound); systemic disease (*e.g.* Bluetongue, Foot-and-Mouth, joint-ill, arthritis, mastitis or diet deficiencies) (see the Merck Veterinary Manual (2012) for a fuller list of common systemic causes of lameness in sheep) or foot lesions. The latter category of causes of lameness in sheep is the most common cause listed by farmers (Grogono-Thomas and Johnston, 1997; Winter, 2004a; Kaler and Green, 2008a) and comprises infectious and non-infectious foot lesions. Infectious foot lesions include: interdigital dermatitis (ID), footrot (FR) and contagious ovine digital dermatitis (CODD). Non-infectious foot lesions include: foot abscess, white line disease (also known as shelly hoof) and toe granuloma (also known as strawberries). The most common causes of lameness are ID and FR which cause 80-90% of lameness in UK flocks (Kaler and Green, 2008a); their aetiology is linked. The research in this thesis concentrates on ID and FR. Their aetiology and pathogenesis, clinical presentation and management practices are discussed below. For a full discussion of the clinical presentation of other foot lesions and their recommended treatments see Winter (2004a; 2004b) and EBLEX (2008a).

1.3.1 The aetiology, pathogenesis and presentation of footrot and interdigital dermatitis

Footrot is described by two distinct pathological presentations: ID and FR; although epidemiological studies suggest that they are both caused by the same gram-negative, anaerobic bacterium, *Dichelobacter nodosus* (Beveridge, 1941; Witcomb, 2012). The clinical presentation of ID (Figure 1) is inflammation of the interdigital space, with a moist, pale, pasty exudate and may be accompanied with localised hair loss. When *D. nodosus* reaches the skin/horn junction, it feeds on the collagen of the basal epidermal layer. The resulting disruption and inflammation causes the clinical presentation of FR (Figure 2): separation of the hoof horn from the underlying dermis with a grey, foul smelling, exudate in the cavity which results.

Figure 1: Severe clinical interdigital dermatitis

Figure 2: Severe clinical footrot

Photographs courtesy of the Green Group research archives, University of Warwick

The disease (ID/FR) is initiated only if the integrity of the interdigital skin of the sheep's foot is compromised through injury (Beveridge, 1941; Parsonson *et al*., 1967), irritation from long/stalky pasture (Woolaston, 1993) or persistent contact with wet ground (Egerton *et al*., 1969).

Clinical ID lesions have been reported to cause no lameness (Parsonson *et al*., 1967; Kaler, 2008) and mild to severe lameness (Morgan, 1987; Winter, 2004a; Hawker, 2008); although the latter authors did not sample lesions to investigate the bacterial cause. Sheep with clinical FR are mildly to severely lame (Kaler *et al*., 2011). Clinical ID is indistinguishable from the initial stages of mild clinical FR (Moore *et al*., 2005) and may help explain the wide range of lameness observed for cases of clinical ID, because in some cases, clinical ID may in fact be early clinical FR. Both pathological presentations are painful with no significant difference observed in plasma cortisol concentration regardless of severity (Ley *et al*., 1989; Ley *et al*., 1994).

Although it is accepted that ID/FR is caused by *D. nodosus*, historically there has been some debate about the cause and the role of other bacteria, including *Fusobacterium necrophorum* and this is discussed below. The role of *F. necrophorum* (a commensal bacterium of the gastrointestinal tract) was originally believed to be causative in the development of clinical FR (Beveridge, 1941). However, in a series of experiments Beveridge (1941) demonstrated that the causative agent of clinical FR was in fact *D. nodosus* with *F. necrophorum* believed to be a secondary opportunistic agent. The work of Roberts and Egerton (1969) described a synergistic relationship between these two bacteria with *F. necrophorum* considered a necessary pre-requisite to facilitate development of clinical FR caused by *D. nodosus*. A cross-sectional Australian study by Parsonson *et al*. (1967) of ~500 sheep on 6 farms that had been free of clinical FR for >10 years, detected *F. necrophorum* but not *D. nodosus* in clinical ID lesions. Their study additionally included *in vivo* experimental infection of scarified interdigital skin with cultured *F. necrophorum* that resulted in clinical ID; indicating that where *D. nodosus* was absent, *F. necrophorum* was the causative agent of clinical ID. Several recent studies have detected *D. nodosus* with greater frequency on the feet of sheep with clinical ID/FR lesions compared with normal and healthy feet (La Fontaine *et al*., 1993; Moore *et al*., 2005; Bennett *et al*., 2009) with *F. necrophorum* detected less frequently on feet with clinical ID than clinical FR (Bennett *et al*., 2009). The cross-sectional design of these studies means cause and effect cannot be established but they suggested the role of *F. necrophorum* was opportunistic rather than a pre-requisite, necessary to facilitate infection of the foot with *D. nodosus*. Recently an on farm, longitudinal study in the UK examined the temporal patterns of *D. nodosus* and *F. necrophorum* on the feet of sheep using quantitative Polymerase Chain Reaction assays (Witcomb, 2012). The study showed that *D. nodosus* load increases before clinical presentation of ID and FR, with *F. necrophorum* load increasing only after clinical presentation of FR. The author concluded that *D. nodosus* was causative with *F. necrophorum* an opportunistic secondary invader (Witcomb, 2012). This supports the findings of earlier work by Beveridge (1941); La Fontaine *et al*, (1993); Moore *et al*. (2005) and Bennett *et al*. (2009). The author also concluded that sheep with clinical ID were more infectious than those with clinical FR because bacterial load was highest in feet with clinical ID (Witcomb, 2012). Regardless of the debate of the role of *F. necrophorum*, the aetiology of ID/FR is linked and where FR is present on the farm, ID and FR should be treated analogously by farmers.

D. nodosus is transmitted indirectly via the surface of the field/enclosure from infected sheep to susceptible sheep because transmission is restricted by the bacterium's <2 week survival time off the host (Beveridge, 1941); optimised by warm (>10˚C), moist environments (Graham and Egerton, 1968; Whittington, 1995). Individuals can be re-infected because once recovered they have only brief immunity (Beveridge, 1941). Consequently, the rate at which susceptible sheep become infected with *D. nodosus* is influenced by the climate/environment (Beveridge, 1941; Green and George, 2008) and therefore prompt treatment may reduce the incidence of disease (Wassink *et al*., 2010a; Hawker, 2008) by reducing the infectious period of affected sheep.

In the UK two separate classification systems are used by researchers to score the severity of ID, and FR lesions (Moore *et al*., 2005), compared with one system combining both clinical presentations in Australia (Egerton and Roberts, 1971). The latter scale has been validated recently for reliability and repeatability and showed high within observer agreement, and good but reduced between observer agreement (Foddai *et al*., 2012).

1.4 Management practices to control and treat lameness

Farmers use a variety of management practices to control and treat lameness in sheep caused by ID and FR and these may be categorised into individual treatments or whole flock control measures. Individual treatments include topical and parenteral antibacterials and therapeutic foot trimming. Whole flock control measures include: isolation of lame sheep, culling of persistent or repeatedly lame sheep, footbathing, vaccination and routine foot trimming. There is now substantial evidence for the effectiveness of individual treatments but the evidence for the effectiveness of whole flock management tools remains sparse.

1.4.1 Individual treatment of interdigital dermatitis and footrot

1.4.1.1 Topical antibacterials

Topical antibacterials are beneficial because they kill surface bacteria and therefore prevent subsequent contamination of the environment. However, bactericidal footbath solutions cannot fully penetrate the epidermis of the foot (Egerton, 1985). This author recommended that for topical antibacterials to be successful, prior therapeutic foot trimming was required to expose the extent of the lesion to the antibacterial being applied. Indeed, Grogono-Thomas *et al*., (1994) reported that therapeutic foot trimming increased the efficacy of footbathing in zinc sulphate. Topical antibiotics sprays have only recently been tested in a clinical trial (Kaler *et al*., 2010a) and have greater efficacy when they are not accompanied with prior foot trimming (see 1.4.1.3 below). Current studies indicate that 90% of UK farmers use topical antibacterials to treat ID/FR with 60% using this treatment for all cases of ID/FR (Kaler and Green, 2009).

1.4.1.2 Parenteral antibiotics

Parenteral antibiotics have also been shown to be effective without necessitating the time-consuming task of prior trimming (Egerton *et al*., 1968; Jordan *et al*., 1996). They also simultaneously treat concealed lesions. In clinical trials, approximately 90% of sheep with FR lesions recovered after treatment with parenteral antibiotics (Egerton *et al*., 1968; Venning *et al*., 1990; Webb Ware *et al*., 1994; Grognon-Thomas *et al*., 1994; Jordan *et al*., 1996). In 2003, Wassink *et al.* (2003a) reported the results of an observational, retrospective postal survey in which farmers that reportedly used parenteral and topical antibacterials had a significantly lower prevalence of FR compared with farmers who used this treatment infrequently or never. The authors of this study subsequently tested this finding in a 2 year stratified random clinical trial on one farm (Wassink *et al*., 2010a). They reported that prompt treatment of lame sheep with ID/FR with parenteral and topical antibacterials reduced the prevalence and incidence of lameness, the time to recovery and additionally increased flock performance; compared with topical antibacterials and trimming alone. Prompt treatment of ID/FR with parenteral and topical antibiotics has additionally been reported to reduce an individual animal's subsequent susceptibility to new cases of FR/ID and furthermore it reduced the development of poor foot conformation (Kaler *et al*., 2010b). A practical limitation of parenteral antibiotic use in Australia was the recommendation that feet are kept dry for 24 hours after treatment (Egerton *et al*., 1968), since wet environments are believed to reduce their effectiveness (Webb Ware *et al*., 1994). Clinical trials in the UK have not used a dry environment following their administration and have successfully reduced both the prevalence and incidence of lameness (Wassink *et al*., 2010a; Kaler *et al*., 2010a). Recent studies indicate that 49% of UK sheep farmers use parenteral antibiotics to treat ID/FR, with 10% using it to treat all cases of ID/FR (Kaler and Green, 2009).

1.4.1.3 Therapeutic foot trimming of sheep with footrot

Therapeutic foot trimming is regarded as a treatment measure, carried out on lame sheep with diseased feet. It prepares the foot to allow access for medication, or traditionally, because *D. nodosus* is known to be an anaerobic bacterium, to expose diseased tissue to the perceived curative effects of the air (Abbot and Lewis, 2005). The hoof wall is trimmed back to expose the foot lesion and as a consequence the sensitive tissues of the foot are exposed. It was carried out by >90% of farmers in the UK in 2000 and 2004 (Wassink *et al.*, 2003a; Kaler 2008). However, Malecki and Coffey (1985) demonstrated that with this treatment sheep remain lame once the FR lesion has healed because trimmed horn is slow to re-grow (Shelton *et al.*, 2012) (see Chapter 2). Therapeutic foot trimming has also been associated with a higher incidence of ID/FR (Green *et al.*, 2007a). More recently, a randomised, factorial-designed clinical trial showed that lame sheep with FR recovered significantly faster when treatment with parenteral antibiotics was not accompanied with therapeutic foot trimming (Kaler *et al.*, 2010a). The study showed that therapeutic foot trimming was detrimental to recovery time and should not be recommended because sheep with FR treated with topical antibiotic foot spray alone recovered faster than those given spray and foot trim. Therapeutic foot trimming is discussed further in Chapter 2.

1.4.2 Whole flock control measures in the management of lameness

1.4.2.1 Isolation of lame sheep

As sheep with ID/FR are thought to shed *D. nodosus* into the environment, isolation of sheep lame with ID/FR is recommended (Jopp *et al.*, 1984a; 1984b;

Winter, 1998). Their removal consequently reduces environmental contamination and the transmission rate to other susceptible sheep. Similarly, the quarantine of new stock (a good bio security measure) reduces the risk of introducing new *D. nodosus* serogroups into the flock. A postal survey carried out by Wassink *et al*., (2003a) in 2000 reported that farmers who always isolated new stock (51% of respondents) or always isolated lame sheep (7% of respondents) had a significantly lower prevalence of lameness. However their results also suggested that isolating diseased sheep was not a practical recommendation for 93% of farmers.

1.4.2.2 Culling of repeatedly lame sheep

The culling of lame sheep after three lameness events is recommended (EBLEX, 2008a) because these animals may increase transmission of *D. nodosus* amongst the flock. Whether these individuals are genetically pre-disposed to the disease or are simply more susceptible as a result of damage caused by earlier exposure, repeatedly lame sheep are likely to be a source of *D. nodosus* to other sheep in the flock. Current studies suggest that <30% of UK farmers include lameness caused by ID/FR as part of their culling policy (Wassink *et al*., 2010b).

1.4.2.3 Footbathing

In a clinical trial conducted in Australia, footbathing with solutions of zinc sulphate or formalin provided effective treatments for ID/FR within 21 days (Skerman *et al*., 1983). Nevertheless, in the UK footbathing results in a longer time to recovery and lower cure rate compared with treatment with parenteral antibiotics (Grogono-Thomas *et al*., 1994). Two observational retrospective studies also reported that footbathing was, at best, not associated with a reduced prevalence of FR and, at worst, positively associated with a greater prevalence of FR (Wassink *et al*., 2003; Grogono-Thomas and Johnston, 1997). Cause and effect cannot be established from these two postal surveys and it may be that the farmers in these studies footbathed their sheep because they had a high prevalence of FR. Inadequate facilities and poor planning reduce the effectiveness of footbathing. Best results are achieved when it is carried out on clean, free-draining concrete and the flock subsequently moved to clean pasture (Jopp *et al*., 1984b; 1984c). Consequently, it is plausible that the majority of farmers are not able to carry out footbathing to the required standard for the practice to be significantly beneficial. This theory is supported by the Wassink *et al.* (2003a) study, where farmers who rated their handling facilities as excellent (13%) had a significantly lower prevalence of FR compared with farmers rating them below excellent (87%). Over 60% of UK farmers use routine footbathing (Wassink *et al*., 2003a; Kaler and Green, 2009). Anecdotal evidence suggests that there is a recent trend for farmers to use antibiotic footbaths on the whole flock to control FR using unlicensed antibiotic agents.

1.4.2.4 Vaccination

There are 19 serotypes in 10 serogroups of *D. nodosus* and multi-serogroup infections occur within flocks. *Footvax* is a polyvalent serotype vaccine comprised of 10 serogroups of inactivated *D. nodosus* and it is the only FR vaccine available to farmers in the UK. The vaccine is short-lived and therefore animals require repeat vaccination at intervals specific to the severity of FR challenge within the flock (MSD Animal Health, 2013a). This type of vaccine is not 100% effective because unequal or reduced protection may be given to each serogroup; either as the number of serogroups increases in a vaccine (Schwartzhoff *et al*., 1993) or through biased presentation of T-cell antigens during antigenic competition (Raadsma *et al*., 1994). Vaccination is recommended as part of a lameness control programme (EBLEX 2008a; MSD Animal Health, 2013a) and studies suggest that vaccination is carried out by ~10% of farmers (Wassink *et al*., 2010b; Kaler and Green, 2009). Retrospective observational studies provide no evidence to suggest vaccination is beneficial in the reduction of FR in UK flocks (Wassink *et al*., 2003a; Grogono-Thomas *et al*., 1997). However, a recent UK randomised trial on one farm indicated that the vaccines efficacy for FR was 62% when used in conjunction with individual parenteral antibiotics and successfully reduced new incident cases of FR (Duncan *et al*., 2012); compared with individual parenteral antibiotics alone. Anecdotal evidence, along with data published by Wassink *et al.* (2010b) suggests that farmers have doubts about the efficacy of the vaccine and consider it a poor use of money. This may perhaps be attributed to the vaccination programme the farmer uses (*i.e.* proportion of flock covered and frequency of administration *cf.* disease challenge) and what, if any, other lameness management strategies they accompany the vaccination programme with.

1.4.2.5 Routine foot trimming

Routine foot trimming is recommended as a whole flock control measure that removes loose, excessive and overgrown hoof horn caused through physical damage, disease or abnormal growth (Abbot and Lewis, 2005) to improve the appearance of the foot (Stewart, 1989; Wassink *et al*., 2005) or to control disease (Wassink *et al*., 2005); irrespective of whether or not the sheep is lame or the foot diseased. There is no evidence for or against this practice, nor how frequently it should be done. In the early 2000's most farms were carrying out the procedure on the whole flock one or more times per year (Wassink *et al.* 2003a) with rams treated more frequently (Wassink *et al*., 2005). The practice was carried out by 87% and 76% of farmers in 1994 and 2004 (Grogono-Thomas and Johnston, 1997; Kaler and Green, 2009). Routine foot trimming has been associated with a higher prevalence of FR (Wassink *et al*., 2003a; Grogono-Thomas and Johnston, 1997) in observational studies and an increased incidence of ID and FR in a longitudinal study (Green *et al*., 2007a). This is discussed further in Chapter 2.

From research based evidence, as highlighted above, prompt individual treatment

of lame individuals with topical and parenteral antibacterials without therapeutic foot trimming is the best current treatment and control of ID/FR. It provides an economical and effective treatment which additionally controls transmission since it reduces the exposure of susceptible sheep to *D. nodosus.* Further studies, specifically clinical trials, are needed to evaluate the efficacy of whole flock control measures currently used by some farmers.

1.5 Locomotion scoring in sheep

There is a validated 7 point numeric-verbal locomotion scoring system for sheep which has good agreement both within and between trained observers (Kaler *et al*., 2009). This tool has been used successfully by trained researchers for on farm assessment of lameness in sheep in clinical trials (Wassink *et al*., 2010a; Kaler *et al*., 2010a; Kaler *et al*., 2011; Kaler *et al*., 2012). Consequently, it is possible to use this scoring system to independently and reliably assess an accurate on farm prevalence of lameness and compare this with a figure given by the farmer.

In a recent study, sheep farmers correctly identified non-lame sheep and sheep lame with varying locomotion scores from 2 to 6 when looking at video clips of sheep standing and walking (Kaler and Green, 2008b). Farmers' decisions on when to catch and treat lame sheep varied by the severity of lameness and the number of sheep lame in a group. Farmers who self-reported a low prevalence of lameness (mean 5%) reported that they caught lame sheep as soon as they saw them, and were significantly more likely to catch one mildly lame sheep than those who waited more than three days, or who never caught the first lame sheep in a group. Those who waited for several sheep to be lame before inspection or who caught only more severely lame sheep, reported a higher prevalence of lameness (11%). From this study the authors concluded that sheep farmers recognise lame sheep, even when their locomotion is only mildly abnormal, but that they make a separate decision on when to treat lame sheep. They added the proviso that they did not know whether farmers identify lameness in sheep in their flocks as they did from video clips.

We currently do not know whether the figure a farmer gives for the prevalence of lameness in his/her flock includes all severities of lameness from mild to severe or only those that are perceived to be sufficiently lame to require treatment or to those which have been treated. We also do not know whether the farmer estimate of prevalence is correlated to the true prevalence within a flock. This is important because in studies of risk, the prevalence does not have to be precise but they do need to be consistently lower or higher, so that when flocks are compared the relative risks are valid. The source of the estimate of prevalence given by the farmer is also currently unknown and may vary *e.g.* a recall from a recent inspection or a figure obtained from farm records.

1.6 Farmer attitudes towards management of lameness in their sheep flock

Some farmers will need to modify existing management practices, and perhaps farm facilities, if they are to meet the Farm Animal Welfare Committee's (FAWC, 2011) target of ≤2% prevalence of lameness in Great Britain sheep flocks by 2021. If scientific research is to have successful impact on the industry, an understanding of the causes of lameness in sheep and the factors that drive increased efforts by farmers to reduce lameness, as well as those that act as a barrier, are essential. This will allow key messages to be framed using methods that motivate and maintain change. The causes of lameness in UK sheep flocks have already been identified (Grogono-Thomas and Johnston, 1997; Kaler and Green 2008a) and there has been considerable effort by research and industry to ensure that farmers and vets diagnose the causes correctly to ensure appropriate treatment (Kaler and Green, 2008a; Winter 2004a; 2004b; EBLEX 2008a). Whether this has improved farmer recognition of causes of lameness is not known. Research on farmer behaviour and motivation has received increasing attention in the last decade but the literature in relation to flock health is limited. Current knowledge of farmer attitude and motivation toward decision making comes from agriculture generally and indicates that for sheep farmers non-financial motivators are generally more important than financial ones. This is discussed further in Chapter 4. To the author's knowledge, currently there is no published literature on the barriers and motivators to treatment of lame sheep.

In 2010, Wassink *et al.* (2010b) reported the results of a UK postal survey conducted in 2006 that examined farmer attitude towards management practices to treat and control ID and FR in their flocks. As highlighted by the authors, some of the results were puzzling because some of the attitudes reported were paradoxical. For example, footbathing and vaccination were associated with dissatisfaction and a poor use of time and money, and were not associated with a lower reported prevalence of lameness. Yet farmers ranked these practices highly within both their current and ideal management practices to prevent ID/FR. In addition, even though farmers that used individual treatments were satisfied with them, the study indicated that farmers would ideally like to give fewer individual treatments. The external validity of this study's findings are limited because the study population was small (161 respondents), used compliant farmers interested in research into lameness in sheep and cause and effect could not be established. The authors suggested three explanations for the inconsistent findings reported: a knowledge gap between research, vets and farmers; practical difficulties giving individual treatment consequently making whole flock managements more attractive; or cognitive dissonance.

Cognitive dissonance (Festinger, 1957) is a very well-studied theory in social psychology used to comprehend human behaviour and explains irrational or destructive behaviour. A central element of the theory is that people are driven to maintain a consistent belief system balanced against reality. When imbalances arise a person will reduce the discomfort (dissonance) they feel by a process of ‘dissonance reduction’ that can be achieved by changing or reducing the discordant element or adding a compatible element. Accordingly, Wassink *et al*. (2010b) suggested that farmers with high prevalence of lameness using footbaths and vaccination may have adapted their belief to balance their current behaviour; advocating the use of current behaviours (footbathing and vaccination) as an ideal, when in reality they are dissatisfied with them and consider them a poor use of time and money. Otherwise they would be stating that they did not believe in their own actions. Further qualitative and quantitative research would be beneficial to elucidate and understand farmer attitudes toward management of lameness in sheep and to give external validity to subsequent findings that should aid successful research impact.

1.7 Summary

Lameness in sheep is an important health and welfare concern; one that additionally causes financial loss to the farmer through lost flock performance. Estimates for and risk factors associated with the prevalence of lameness in the UK have come from epidemiological studies that assume farmers can reliably and accurately assess lame sheep and report prevalence of lameness in their flock. This requires validation.

Currently there are no published clinical trials to assess the effectiveness of routine foot trimming as a method to control lameness in sheep. It is used by >75% of farmers, yet observational retrospective studies suggest that farmers who practice routine foot trimming have a higher prevalence of lameness in their flock. Athough the methodology utilised by these studies means cause and effect cannot be distinguished; the consistency of this finding over time does indicate cause and effect. These studies suggest that routine foot trimming may perhaps be detrimental and highlight the need for a clinical trial. This hypothesis is further supported by a longitudinal study (Green *et al*., 2007a). Work by Wassink *et al.* (2010b) suggests that farmers may be more inclined to stop routine foot trimimng than other whole flock control measures. In addition, an understanding of the evidence required by farmers to stop routine foot trimming, should it prove detrimental or non-beneficial, would enable informed, targeted message framing. Subsequently, this will increase the likelihood of successful knowledge transfer/research impact because it takes account of the beliefs and attitudes of potential adopters (Rehman *et al*., 2007).

There has been increased attention within academia and industry to focus on the improvement of knowledge transfer and research impact to enable targeted and successful message framing. Currently there is no published literature on the motivators and barriers to the treatment of lame sheep. An understanding of these concepts and management of lameness from the farmers perspective would enable informed and directed message framing. It would also enable researchers to design future epidemiological studies with a greater understanding and sensitivity to farmer concerns; thus increase the appeal and ability of farmers to uptake/implement/maintain the outcomes of their research. These issues can be addressed with well-designed epidemiological studies.

Therefore the overall aim of this thesis was to increase our understanding of the epidemiology of lameness in sheep from the farmers' perspective by addressing these knowledge gaps using multi- and interdisciplinary approaches.

There were five objectives:

1. To assess whether routine foot trimming is an effective management practice in the control of lameness (Chapter 2).
2. To assess whether farmer estimates of the prevalence of lameness on their farm are accurate, reliable and a valid tool for epidemiological studies (Chapter 3).
3. To qualitatively explore and understand farmers beliefs and attitudes towards management of lameness in sheep and the motivators and barriers to treatment of lame sheep as perceived by farmers (Chapter 4).
4. To quantify the motivators and barriers to treatment of lame sheep as perceived by farmers (Chapter 5).
5. To assess the evidence required by farmers to stop routine foot trimming should the practice be detrimental or non-beneficial (Chapter 5).

Chapter 2 A clinical trial of routine foot trimming in sheep

2.1 Introduction

Trimming or paring of hoof horn is frequently used as both a control and treatment measure to reduce the prevalence of FR and lameness in UK sheep flocks (Morgan, 1987). Until 2002 foot trimming was recommended as both a control and treatment measure for FR in UK flocks (Morgan, 1987; Winter, 1998). Unsurprisingly therefore, results from two stratified random UK postal surveys reported that routine foot trimming was used as a control measure by 87% and 76% of farmers in 1994 and 2004 (Grogono-Thomas and Johnston, 1997; Kaler and Green, 2009). Similarly, therapeutic foot trimming was reported to be the most frequently used treatment for FR, carried out by >90% of farmers in the UK in 2000 and 2004 (Wassink *et al.*, 2003a; Kaler, 2008). However, despite widespread and popular use, there are no randomised controlled trials evaluating the role of foot trimming as a control measure and none as a treatment measure until 2010 (Kaler *et al.*, 2010a). In addition, there have been a number of studies published that raise considerable doubts about their efficacy and there has been some debate in the UK whether or not they should be used.

In 1983 Skerman *et al.* raised doubts about the use of therapeutic foot trimming prior to foot bathing. In a series of controlled experiments the authors demonstrated that foot trimming prior to foot bathing, in either formalin or zinc sulphate solutions, did not significantly benefit the therapeutic effect of foot bathing. In 1994, a UK stratified random postal survey published by Grogono-Thomas and Johnston (1997) reported a positive association between high levels of FR and routine foot trimming. This finding was reproduced by Wassink *et al*. (2003a) who reported an association between higher prevalence of FR and ID (Wassink *et al*., 2004) on farms where routine foot trimming was practiced more than once a year; in a retrospective study of 251 farmers that compared management and prevalence of FR and ID in 2000. The study also reported a positive association between the prevalence of FR and therapeutic foot trimming (Wassink *et al*., 2003a). These authors raised questions on the use of routine foot trimming as an effective control measure. They hypothesised that the trimming of healthy and diseased hooves increased transmission *via* two potential routes: Firstly, through environmental contamination, *i.e.* as a result of the higher stocking density during gathering and penning. Secondly through increased susceptibility of sheep to disease either *via* excessive trimming, where the sensitive tissues of the foot are exposed or, where knives or foot shears are not disinfected between sheep and feet, direct inoculation of *D. nodosus.* They recommended that further studies be conducted. Their findings were however criticised by Abbott *et al*. (2003) because the study design was observational and retrospective, and Abbott *et al.* (2003) stated that the authors could not infer a causal relationship (although Wassink *et al*. (2003a) had in fact raised hypotheses). Abbott *et al*. (2003) proposed an alternative explanation that high levels of FR in a flock could lead to farmers trimming more regularly. Wassink *et al*. (2003b) responded with a follow up study with 80 of the farmers from their original study. They suggested that evidence for the associations they reported earlier was strengthened by the fact that the majority of the farmers followed up (77%) had not changed their practices for more than 5 years.

In 2002 a longitudinal study was carried out on one farm by Green *et al.* (2007a). Results from this study reinforced the negative association previously reported between routine foot trimming and an increased incidence of ID and FR by earlier studies. Although, converse to Wassink *et al*. (2003a; 2004) a negative association between therapeutic foot trimming and the incidence of ID and FR was also reported. A second hypothesis was generated by these authors: that foot trimming (whether routine or therapeutic) was detrimental to foot health.

Further weight to this hypothesis was added by Kaler and Green (2009) from a stratified random postal survey with 809 English sheep farmer respondents carried out in 2004. The results again suggested that routine foot trimming was significantly associated with a higher prevalence of ID, FR and lameness. Furthermore that routine foot trimming just once a year was associated with an increased risk. This was slightly more extreme than the associated risk reported by Wassink *et al*. (2003a; 2004) as only being significant when routine foot trimming was carried out twice or more per annum. Wassink *et al*. (2003a; 2004) did not report or analyse the number and percent of farms that routinely foot trimmed 'once' or 'never' separately in their publication; neither did they report why these categories were combined. It may have been that there were too few farms in the 'once' or 'never' category for data to be analysed separately, and the data combined produced misleading results. *Wassink et al.* (2003a; 2004) had 251 respondents, their target population selected from a compliant group of farmers who had expressed interested in taking part in further research after the 1994 survey by Grogono-Thomas and Johnston, and therefore were not randomly selected. In comparison Kaler and Green (2009) had 809 respondents from a random sample of sheep farmers stratified by region and flock size within region, obtained from EBLEX (the organisation for the English beef and sheep meat industry). It is therefore proposed that more weight should be given to the findings of Kaler and Green (2009).

In 2007 a randomised factorial-design clinical trial was conducted by Kaler *et al*. (2010a) on one farm in England to examine time to recovery using 6 treatments, that included therapeutic foot trimming used alone and in combination with other antibacterials. Results showed that therapeutic foot trimming delayed recovery regardless of whether or not it was combined with topical or parenteral antibiotics. The authors concluded that therapeutic foot trimming, even when it did not cause bleeding, was in fact detrimental and should not be recommended. The study did not however involve any non-lame sheep and the effect of routine foot trimming in a randomised clinical trial has still not been investigated. Kaler *et al*. (2010a) did, however, propose a third hypothesis: that routine foot trimming might have an indirectly causal relationship where farmers use routine foot trimming as a control measure but then neglect to treat individual lame sheep *i.e.* choosing to use whole flock control measures rather than treat lame individuals (Kaler and Green, 2009; Kaler *et al*., 2010a). This hypothesis is entirely plausible given that farmers who do not treat individual lame sheep (and therefore use whole flock control measures) have a higher prevalence of lameness (Kaler and Green, 2009) and that routine foot trimming is also associated with a higher prevalence of lameness (Grogono-Thomas and Johnston, 1997; Wassink *et al*., 2003a; 2003b; 2004; Green *et al*., 2007a; Kaler and Green, 2009).

By 2009 advice given to farmers by veterinary practitioners was still somewhat varied, a few still recommended rigorous trimming of the horn at diagnosis (Duncanson, 2009). An increasing majority (>50%) recommended hoof horn should be trimmed carefully only after lesions were healing and 5 days after treatment (Winter, 2004b; EBLEX, 2008a). However these recommendations were not based on any scientific evidence. Furthermore, in 2010 Wassink *et al*. (2010b) reported results of a farmer satisfaction poll with regard to current and ideal management practices. Up to five current management practices used to prevent FR were listed by 161 farmers in 2006. Therapeutic foot trimming of lame sheep was listed as the most popular management practice (66% of farmers) and routine foot trimming listed as the least popular (39% of farmers) of farmers top five management practices. Of those that routinely foot trimmed, 22% trimmed all the feet of all their ewes and 16% trimmed more than half of their ewes' feet. While it was not drawn attention to by the authors, of concern is that 99 (62%) of the farmers in this survey carried out therapeutic foot trimming to treat ID. The aetiology of ID and FR is linked (see Chapter 1). Foot trimming sheep with ID is likely to lead to increased recovery time, particularly if the sensitive tissues of the foot are exposed; as well as increasing transmission of *D. nodosus via* direct inoculation from shears/knives. The study highlighted that foot trimming the feet of all ewes more than once a year was associated with famers feeling unsatisfied with their use of time and that whole flock control measures (such as routine foot trimming) were associated with higher prevalence of lameness (>5 *cf.* ≤5%). These authors proposed that if foot trimming was demonstrated to be detrimental or ineffective these results would be easily accepted by farmers and that further research was needed.

Foot trimming is a skilled procedure, which requires a sharp paring tool (usually a knife or foot shears) and ‘adequate restraint’ for the sheep (Morgan, 1987). Care and attention is required in order to avoid damage to hooves that can result in lameness (Hosie, 2004) or, hypothetically, give causative agents a site to colonise the hoof (Wassink *et al*., 2003a; 2004). Sheep at pasture have a hoof horn growth rate of 3.6mm per month (Shelton *et al*., 2012), perhaps less in colder months (Wheeler *et al*., 1972) and hoof horn growth may vary by age (Dekker *et al*., 2005), diet (Butler and Hintz, 1977; Buffa *et al*., 1992; Smith *et al*., 1999), environment (Vokey *et al*., 2001) and breed (Shelton *et al*., 2012). Consequently, if a farmer trims a hoof to expose just 5mm of sensitive tissue it could take >6 weeks to re-grow leaving the foot susceptible to infection for this period. Conversely if a foot is trimmed once per year it will have grown ~ 43mm by the next foot trim, and so sheep hoof horn would either be very overgrown or have worn away. It is also well documented that foot trimming that results in bleeding or damage to the sensitive tissues of the foot causes pain and can lead to the formation of toe granulomas (Morgan, 1987; Hosie, 2004; Winter, 2004a; 2004b), persistent lameness (Morgan, 1987; Winter, 2004a) and these sheep may be more likely to develop footrot (Kaler *et al*., 2010b), either because of increased susceptibility to a new infection or recrudescence of existing infection.

There is very little literature on the standard to which foot trimming is carried out by sheep farmers. Grogono-Thomas and Johnston (1997) visited 30 farmers in a follow up to their 1994 postal survey. They reported that 50% of the farmers visited did not have a good technique; 10% of these were considered to have extremely bad technique that could in fact attribute to increased levels of lameness on these farms. Furthermore, none of the farmers visited disinfected trimming apparatus between infected and healthy feet; although, Abbott *et al*. (2003) suggests that this practice is unimportant where sheep have been co-grazing beforehand. Wassink *et al*., (2005) reported that 50% of farmers trimmed to either reshape the foot or to remove overgrowth. To the author's knowledge, there is no further research on foot trimming technique. Given that at least 66% of farms have sheep with toe granulomas (Kaler and Green, 2008a) and that one reason toe granulomas develop is as a result of damage to the sensitive tissue of the dermis through excessive trimming it is probable that poor foot trimming technique is quite widespread.

Finally, farmers indicated that it takes on average 1 hour to foot trim 15 sheep (Wassink *et al*., 2005). Consequently, if foot trimming was proved to be either detrimental or not beneficial to the control of lameness, a farmer's time would be better spent on implementing an alternative treatment and control programme(s) that has proved to be cost and time effective.

2.1.1 Study aims

The aims of this study were to use a within farm stratified random control clinical trial to examine the effect of routine foot trimming compared with no routine foot trimming on lameness in sheep.

2.1.2 Study hypotheses

Four alternative hypotheses concerning routine foot trimming were tested:

1. Routine foot trimming is detrimental.
2. Routine foot trimming is neither beneficial nor detrimental.

3. Routine foot trimming instead of treatment results in a high prevalence of lameness.
4. The technique of routine foot trimming is important.

2.2 Materials and Methods

2.2.1 Farm selection

The study farm was located at the Department of Clinical Veterinary Science at the University of Bristol. It was convenience-selected based on reasonable travelling distance to the University of Warwick and the University were content for the trial to be carried out, and to provide assistance with data collection and farm personnel. The farm was lowland, it's maximum height above sea level was 30m (Ordinance Survey, 2012). The geology of the land is Mercia mudstone and halite stone with sedimentary deposits of clay, silt sand and gravel (NERC, 2013a). Its hydrogeology is categorised as a low productivity aquifer taking in less than 0.5 litres of water per second (NERC, 2013b). The flock was run as a commercial enterprise, although it was also used for teaching and research. Everyday care of the flock was provided by a full-time shepherd (SNL) and a part-time assistant (AD) under guidance from the General Farm Manager (MJ). The flock was not used for other research during the study period. Ethical approval for the research project was granted in accordance with the University of Bristol's and University of Warwick's ethics approval procedures.

2.2.2 The study flock

The flock comprised 220 Mule and Suffolk-cross commercial ewes and 203 lambs. Approximately 200 ewes were used for breeding purposes with the remainder kept to teach sheep handling to undergraduate students. The flock was run as a closed flock until 1998 when new stock was purchased for research purposes. At the time of the study the flock was considered closed with the exception of ram purchases.

Mule ewes were crossed with Suffolk and Hampshire Down sires and Suffolk ewes were crossed with Texel sires in the autumn of 2008 and the farm bred its own replacement ewes. In addition to the main flock, there were approximately 50 replacement one year old ewes that were not included in the research project. Sheep were culled selectively once a year in the autumn before tupping when the shepherd gathered the sheep for an annual health check. As part of this health check feet were routinely inspected, any loose or overgrown hoof horn was trimmed and foot lesions were treated (see section 2.2.5.7). Prior to this study the flock was last routinely foot trimmed in September 2008. Foot trimming was also used as part of standard treatment for lameness. One hundred and seventy three Mule and Suffolk cross commercial ewes were used in the current study.

2.2.3 Study design

2.2.3.1 Personnel and training

The study started in June 2009 when lambs were > 14 weeks of age and still with their mothers. Data were recorded by EMK and GJW from the University of Warwick. EMK and GJW were trained to score ewe locomotion (Kaler *et al*., 2009) (Table 1), body condition (DEFRA, 1997) (Table 2), foot conformation (Egerton *et al*., 1989) (Table 3 and Table 4) and foot lesions (Moore *et al*., 2005) (Table 5).

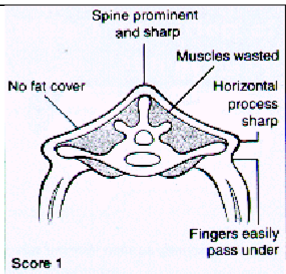
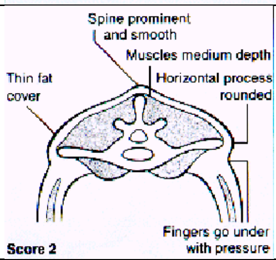
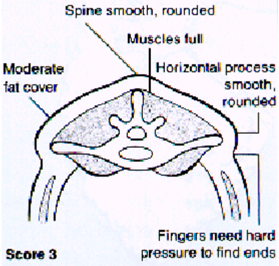
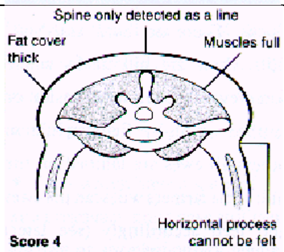
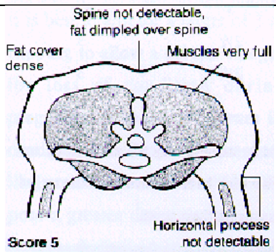
The following were recorded at the start of the project: body condition and age by GJW, locomotion, foot conformation and foot lesions by EMK. These were recorded again by EMK at the project conclusion. A number of additional observers were also present at these time points to help turn sheep and to record data in duplicate onto forms (LEG, RGT, NU, CR, RA, ES, SNL, AD and MJ; see Section 2.6 page 90). EMK then visited the farm twice weekly from 02/06/2009 until 20/07/2009 to collect data on locomotion and to record treatments given for lameness.

Table 1: Locomotion classification (source Kaler *et al*., 2009)

Score	0	1	2	3	4	5	6
Posture and locomotion							
Bears weight evenly on all four feet							
Uneven posture, but no clear shortening of stride							
Short stride on one leg compared with others							
Visible nodding of head in time with short stride							
Excessive flicking of head, more than nodding, in time with short stride							
Not weight bearing on affected limb when standing							
Discomfort when moving							
Not weight bearing on affected limb when moving							
Extreme difficulty rising							
Reluctant to move once standing							
More than one limb affected							
Will not stand or move							

Shaded area is the definition for each score.

Table 2: Body condition classification

Picture	Score*	Description
	0	Seldom used - extremely emaciated & on the point of death. Not possible to feel any muscle or fatty tissue between skin & bone.
	1	The vertical & horizontal processes are prominent & sharp. The fingers can be pushed easily below the horizontals and each process can be felt. The loin muscle is thin and with no fat cover.
	2	The vertical processes are prominent but smooth, individual processes being felt only as corrugations. The horizontal processes are smooth & rounded, but it is still possible to press the fingers under. The loin muscle is of moderate depth but with little fat cover.
	3	The vertical processes are smooth & rounded; the bone is only felt with pressure. The horizontal processes are also smooth and well covered; hard pressure with the fingers is needed to find the ends. The loin muscle is full, with a moderate fat cover.
	4	The vertical processes are only detectable as a line; the ends of the horizontal processes cannot be felt. The loin muscles are full and have a thick covering of fat.
	5	The vertical processes cannot be detected even with pressure; there is a dimple in the fat layers where the processes should be. The horizontal processes cannot be detected. The loin muscles are very full and covered with very thick fat.

*: Score all ewes on a scale of 0-5, using half scores as intermediate points along the scale. Adapted from DEFRA, 1997

Table 3: Classification of conformation of the feet

Sole and heel of the digit	
0	Undamaged sole and heel area with a perfect shape
1	Mildly damaged/misshapen sole and/or heel area of the digit (<25%)
2	Moderately damaged/misshapen sole and/or heel area of the digit (≥25% and <75%)
3	Severely damaged/misshapen sole and/or heel area of the digit (≥75%)
Wall of the digit	
0	Undamaged wall hoof horn with a perfect shape
1	Mildly damaged/misshapen wall hoof horn (<25%)
2	Moderately damaged/misshapen wall hoof horn (≥25% and <75%)
3	Severely damaged/misshapen wall hoof horn (≥75%)

Adapted from Egerton *et al*. (1989)

Table 4: Classification of overgrowth of the sole

Score	Description
None	<20% of wall overgrowing sole
Part	≥20% but <75% of the sole covered by wall overgrowth
Full	≥75% of the sole covered by wall overgrowth

Table 5: Foot lesion scoring

Classification of interdigital lesions (ID/Scald/Strip)	
0	Clean interdigital space with no dermatitis (ID) lesion or fetid smell
1	Slight interdigital dermatitis, irritation of the skin, but dry
2	Slight interdigital dermatitis with a fetid smell (<5% affected)
3	Moderate interdigital dermatitis with a fetid smell (5 to 25% affected)
4	Severe interdigital dermatitis with a fetid smell (>25% affected)
Classification of footrot (FR) lesions	
Sole and heel of the digit	
0	No under-running of the heel and sole area of the digit
1	An active FR lesion with a degree of under running of the heel and/or sole area of the digit (≤50%)
2	An active FR lesion with a marked degree of under running of the heel and/or sole area of the digit (>50% but <100%)
3	An active FR lesion with complete under running of the heel and/or sole area of the digit (100%)
Wall of the digit	
0	No under-running of the wall of the digit
1	An active FR lesion with a degree of under-running of the wall hoof horn of the digit (≤50%)
2	An active FR lesion with a marked degree of under running of the wall hoof horn of the digit (>50% but <100%)
3	An active FR lesion with complete under running of the wall hoof horn of the digit (100%)

Adapted from Moore *et al*. (2005)

2.2.3.2 Data collection

On 01/06/2009 ('T1') ewes and lambs were gathered into a handling facility. Ewes were shed off into a handling pen and lambs were released into the field. One hundred and sixty-seven ewes were examined. The ear tag number and breed of each ewe was recorded. Body condition was scored (DEFRA, 1997; Table 2) and age estimated from dentition by GJW. Each ewe was then turned, the foot conformation (Table 3 and Table 4) and the presence and severity of foot lesions (Table 5) of each foot were scored by EMK and recorded. All records were made on standard forms (Appendix 1). After all data had been recorded ewes were individually numbered on the flank with paint applied using branding irons. This number was the key identifier for each ewe. If ewes were lame on leaving the pen, their identity was recorded. The initial examination of ewes on 01/06/2009 as described above is abbreviated to 'T1'.

2.2.3.3 Sample size calculations

Using a two-tailed test it was estimated that a minimum of 88 sheep per group were necessary to detect a change in lameness or foot conformation from 20% to 5% with 80% power and 95% confidence (Stata® SE 10.0, StataCorp LP).

2.2.3.4 Allocation of ewes to clinical trial

Ewes were allocated by stratified randomisation (Dohoo *et al*., 2003) into one of two groups, stratified by body condition score (BCS), age, foot conformation score (FCS) and the presence of interdigital dermatitis (ID) or footrot (FR) lesions.

From the records above, each ewe was categorised as:

Thin = ≤ BCS 2	or	Fit = ≥ BCS 2.5
Young = ≤4 adult teeth	or	Old = ≥6 adult teeth (or broken mouth)
Good feet = ≤ FCS 1	or	Poor feet = ≥ FCS 2 on any foot
Lesions = ID or FR ≥ 1	or	No lesions = ID or FR lesions of 0

Ewe record sheets were placed into one of 16 possible piles based on the combinations of above categories. Each pile was split into one of two groups of equal size by tossing a coin. Where there were odd numbers of records in a pile (8), the most similar were split between groups by allocating one to each group by tossing a coin. At the end of the allocation a coin was tossed to decide which group was to be trimmed (the treatment group ‘T’) and which group of sheep left untrimmed (the control group ‘C’). Ewes lame on the day were checked for even distribution between the two groups.

2.2.3.5 Foot trimming

On 02/06/2009 (‘T1+1’) ewes and lambs were gathered and penned. A further six ewes that had escaped the pen the previous day, were scored as above (see section 2.2.5.2). Ewes were allocated to each treatment group alternately. Ewes to be trimmed were shed into a handling pen. Ewes to be left untrimmed and all lambs were returned to the field.

Ewes in the treatment group were caught and turned and their ear tag and brand number recorded. They were then foot trimmed by the farm shepherd, details of the trim were recorded by EMK on a standard form (Appendix 2). Ewes were released into the field once they had been foot trimmed.

Once all ewes had been trimmed the flock was left for approximately 1 hour and then their locomotion was scored (Table 1) (Kaler *et al*., 2009) by EMK on a standard form (Appendix 2).

The examination of ewes on 02/06/2009 as described above is abbreviated to ‘T1+1’.

2.2.3.6 Locomotion scoring

At each locomotion scoring assessment EMK walked slowly through the field and recorded the brand number, locomotion score and, where lame, the foot/feet considered lame for each ewe. The locomotion score of all sheep was recorded twice each week on Monday and Thursday or Tuesday and Friday until 20/07/2009. The inspection lasted approximately 1 hour. Ewe deaths and removal for treatments (see section 2.2.5.7) were recorded by the farm staff.

2.2.3.7 Treatment of lame sheep

All sheep in the group, whether foot trimmed or not, were managed in the same way. Sheep with locomotion score ≥4 were investigated as soon as practical, usually within 1-3 days. Those with lower locomotion scores (<4) were investigated when gathering for other purposes, *e.g.* worming or selecting lambs for slaughter, usually within 1-2 weeks of becoming lame. Treatments were recorded by EMK and were carried out by the farm shepherd or assistant. They generally coincided with the researcher's visit, but where treatments were given when the researcher was not present they were recorded by the shepherd/assistant shepherd. Data were recorded onto standard forms (Appendix 3).

Sheep with ID or FR were foot trimmed and antibacterial spray (Terramycin®) was applied to affected feet. It was the farm's policy to treat cases of FR ≥score 2 with parenteral antibiotics (Oxytetracycline LA). Parenteral antibiotics were not carried by the shepherd, consequently animals requiring parenteral antibiotics were removed from the field to an indoor facility for the duration of their treatment. The dates ewes were removed from the field for treatment and returned were recorded.

The identity of ewes with a foot granuloma was noted. Animals with abscesses or foot granuloma were removed from the field and treated in an indoor pen. Abscesses were treated with hot water baths and parenteral and topical antibiotics. Toe granulomas were treated with a copper sulphate bandage and parenteral and topical antibiotics.

2.2.3.8 July foot conformation scoring

On 20/07/2009 (‘T2’) ewes’ locomotion was scored by EMK. The flock was then gathered into a handling facility. One hundred and seventy-two ewes (initial 173 less one death) were examined and their body condition was scored by EMK. Each ewe was then turned, the conformation and overgrowth (Table 3 and Table 4) of feet and the presence and severity of foot lesions (Table 5) were recorded. All records were made on standard forms (Appendix 1). The ear tag number and branding number of each ewe was recorded after all data had been recorded. A number of additional helpers were present (RGT, ES, SNL, AD, SM and SC). Four of the 172 ewes that were housed for treatment were examined separately. The examination of ewes on 20/07/2009 as described above is abbreviated to ‘T2’.

2.2.4 Data input, preparation and management

Data were entered from the recording sheets into Access® 2007 (Microsoft®). Where possible data were coded and drop-down lists were used in preference to text fields. Queries were used to check for errors and any anomalies were checked against the original paper record sheets. Data were extracted from the database and checked for errors before exporting to a spreadsheet (Excel® 2007, Microsoft®) and then to a statistical analysis programme (Stata® SE 10.0, StataCorp LP).

2.2.6 Definitions and categorisations

ID	interdigital dermatitis
FR	footrot
FR±ID	footrot with or without interdigital dermatitis
Granuloma	toe granuloma
T1	01/06/2009; initial examination of ewes and allocation
T1+1	02/06/2009; date treatment ewes given routine trim
T2	20/07/2009; final examination of ewes
C	control ewes
T	treatment ewes
T+t	treatment and trimmed ewes
BCS	body condition score
FCS	foot conformation score
~	approximately
N	number
%	percentage
CI	confidence interval
SE	standard error
d.f.	degrees of freedom
IQR	interquartile range

2.2.8 Statistical analysis

Comparisons of proportions were made with a χ^2 test, two means with *t*-test, two medians with modified *t*-test (not normally distributed), and more than two medians with Kruskal-Wallis test (Petri and Watson, 1999) with significance set at $p \leq 0.05$. Part of the analysis at sheep level was repeated at foot level. For this purpose a third treatment group 'Treatment and trimmed' (abbreviated to 'T+t') is shown which excludes any untrimmed feet of treatment ewes.

2.2.8.1 Multilevel modelling

A binomial mixed effect model was used to investigate patterns of associations between treatments and sheep level attributes and the prevalence of lameness.

The database was set up so that for each sheep (n=173) and each observation (n=14), the following were coded: breed (Mule, Suffolk-cross, missing), age (by dentition), body condition score, treatment allocation, the absence or presence and sheep maximum severity of ID lesion at T1, the presence or absence of FR±ID at T1, sheep maximum conformation score at T1, the presence or absence of treatments at T1, the severity classification of the trim at T1+1.

A two level binomial model with locomotion score ≥2 as the outcome, accounting for repeated observations of sheep at two weekly intervals was used to investigate how the presence of sheep attributes, disease and treatment at T1 influenced the risk of becoming lame with locomotion score ≥2 at any observation between T1 and T2.

The model took the form:

$$\text{Logit } y_{ij} = \alpha_{ij} + \beta x_j + u_j + e_{ij}$$

Where y is locomotion score ≥2 at each observation, i the observation (i =1-14), j the sheep (j = 1-173), α the intercept, and β_j the coefficients of the explanatory variables outlined above, u_j the between sheep residual error and e_{ij} is the residual error for a binomial distribution.

The model was developed in MLwiN 2.25 (Rasbash *et al*., 2009). Initially each variable was checked for co-linearity and confounding. The variables body condition, sheep identity and observation were modelled as continuous data; all remaining variables were modelled as categorical data. Four of the explanatory variables were recoded. Body condition score was recoded to give 3 separate categories: body condition score <3, body condition score = 3 and body condition score >3. Age was recoded to give 3 separate categories: ≤ 4 = sheep with ≤ 4 teeth, 6 = sheep with 6 teeth, and ≥ 8 = sheep with full or broken mouths. The presence and severity of ID lesions at T1 were recoded to give 2 categories: ≤1 = maximum ID lesion score of 1 on any foot, and ≥2 = minimum ID lesion score of 2 on any foot. Foot conformation score at T1 was recoded to give 3 separate categories: 0 = sheep with maximum conformation score 0 without FR at T1 and all sheep with FR (regardless of integrity score), 1 = sheep with maximum conformation score 1 without FR at T1, 2 = sheep with maximum conformation score 2 without FR at T1, and 3 = sheep with maximum conformation score 3 without FR at T1. All four recoded variables were modelled as categorical data.

Explanatory variables were added to the model by forward step-up selection (Petri and Watson, 1999).

2.3 Results

One hundred and seventy three ewes were included in the study: 85 ewes were allocated to the treatment group and had at least one foot trimmed; 88 ewes were allocated to a control group and their feet were left untrimmed. One ewe in the treatment group had data missing for body condition at T1 (initial examination on 01/06/2009). During the study one ewe was euthanized due to poor health and a further 4 ewes were removed for other treatments (2 for toe granuloma, 1 for a foot abscess and one for poor general health). Ewes that died were censored, *i.e.* removed from the analysis (numerator and denominator) from the point of death. Those that were housed for treatment were removed from the analysis (numerator and denominator) only for the duration of their treatment due to difficulties locomotion scoring in a confined space and on straw bedding. All other ewes were included in the analysis.

Ewes were caught and their body condition recorded and feet inspected at two time points during the study; at the start of the study on 01/06/2009 (T1) and at the end of the study on 20/07/2009 (T2). Their locomotion was scored (Kaler *et al*., 2009) on 15 occasions at twice weekly intervals between 02/06/2009 and 20/07/2009. Lambs were weaned on 06/07/2009.

2.3.1 Allocation of groups

There were similar numbers of ewes by age, body condition, foot conformation score, and presence and severity of foot lesions in each group ($p > 0.05$) (Table 6 - Table 10). There were 7 ewes lame on 02/06/2009; 3 were in the treatment group and 4 in the control group.

Age was estimated by dentition and was therefore approximate. Excluding 4 sheep with broken mouths, because age could not be confirmed, the estimated mean age of ewes was at least 3.5 (SE = 0.8, CI = 3.4, 3.7) in both the treatment and control groups and was not significantly different (p = 0.94, t = -0.08, d.f. = 167) (Table 6).

Table 6: Frequency distribution of age at T1 by treatment group

Age by dentition	Control N (%)	Treatment N (%)
2 tooth (~1 year)	1 (1.1)	1 (1.2)
4 tooth (~2 years)	7 (8.0)	8 (9.4)
6 tooth (~3 years)	21(23.9)	17 (20.0)
Full mouth (~4 years +)	57 (64.8)	57 (67.1)
Broken mouth	2 (2.3)	2 (2.4)
n	88	85
Mean (excl. broken mouth)	3.56	3.57
SE	0.75	0.79
Lower and upper 95% CI	3.41, 3.71	3.41, 3.72

SE = standard error; CI = confidence interval; p = 0.94, t = -0.07, d.f = 167

The mean body condition score of ewes in the treatment and control groups at T1 was 2.91 (SE = 0.06, CI = 2.78, 3.03) and 2.92 (SE = 0.06, CI = 2.79, 3.05) and not significantly different (p = 0.86, t = -0.18, d.f = 170) (Table 7).

Table 7: Frequency distribution of body condition score at T1 by treatment group

Body condition score	Control N (%)	Treatment N (%)
0.5	0 (0.0)	0 (0.0)
1	0 (0.0)	0 (0.0)
1.5	1(1.1)	2 (2.4)
2	11(12.5)	8 (9.4)
2.5	22 (25.0)	21 (25.0)
3	30 (34.1)	30 (35.7)
3.5	15 (17.1)	19 (22.6)
4	9 (10.2)	4 (4.8)
4.5	0 (0.0)	0 (0.0)
5	0 (0.0)	0 (0.0)
n	88	84
Mean	2.92	2.91
SE	0.06	0.06
Lower and upper 95% CI	2.79, 3.05	2.78, 3.03

SE = standard error; CI = confidence interval; p=0.86, t=-0.18, d.f = 170

The maximum of the 16 foot conformation scores given for each ewe at T1 was calculated to give one score per ewe. The median maximum foot conformation score of ewes in both the treatment and control groups at T1 was 1 (IQR = 0, 2) (Table 8) and was not significantly different (p = 0.88, z = -0.15).

Table 8: Frequency distribution of foot conformation score at T1 by treatment group

Foot conformation score	Control N (%)	Treatment N (%)
0	38 (43.2)	37 (43.5)
1	25 (28.4)	22 (25.9)
2	18 (20.5)	18 (21.2)
3	7 (8.0)	8 (9.4)
n	88	85
Median	1	1
IQR	0, 2	0, 2

IQR = interquartile range; p=0.88, z=-0.15

The number and percentage of ewes with ID only (an ID lesion score >0 on any foot where the FR lesion score was 0 on all four feet) was calculated at T1 by group. This was repeated for ewes with FR±ID (a FR lesion score >0 on any foot) and for ewes with a granuloma on any foot. There were 21 (24.7%) and 19 (21.6%) ewes with ID only lesions, 2 (2.4%) and 4 (4.5%) ewes with FR±ID lesions, and 0 and 1 (1.2%) ewe with toe granuloma in the treatment and control groups respectively at T1 (Table 9). Chi-squared tests confirmed that the presence of ID only, FR±ID, and ID with FR±ID combined was not significantly different between groups (p>0.6). Tests for significance were not performed on foot granuloma due to the small numbers of ewes in this category.

Table 9: Number and percent of sheep with interdigital dermatitis, footrot and granuloma by treatment group at T1

Lesion	Control N (%)	Treatment N (%)
ID	19 (21.6)	21 (24.7)
FR±ID	4 (4.5)	2 (2.4)
ID and FR±ID combined	23(26.1)	23 (27.1)
Granuloma	1 (1.1)	0 (0.0)
n	88	85

Table 10: Frequency distribution of interdigital dermatitis and footrot lesion scores at T1

	ID		FR	
Lesion score	Control N (%)	Treatment N (%)	Control N (%)	Treatment N (%)
0	69 (78.4)	62 (73.0)	84 (95.5)	83 (97.6)
1	1 (1.1)	0 (0.0)	3 (3.4)	2 (2.4)
2	13 (14.8)	12 (14.1)	1 (1.1)	0 (0.0)
3	4 (4.5)	10 (11.8)	0 (0.0)	0 (0.0)
4	1 (1.1)	1 (1.2)	-	-
n	88	85	88	85
Median	0	0	0	0
IQR	0, 0	0, 2	0, 0	0, 0

IQR = interquartile range; - = no score 4 for footrot

The severity of ID and FR lesions were not significantly different between treatment and control groups. The median severity of ID lesions were 0 (IQR = 0, 0) and 0 (IQR = 0, 2) (z = -1.03, p = 0.30) and the median FR lesion scores both 0

(IQR = 0, 0) in the treatment and control groups respectively (z = 0.80, p = 0.43) (Table 10).

2.3.2 Prevalence of lameness

There were 439 observations with locomotion scores ≥2 in 110 sheep between T1 and T2 at 15 locomotion scoring inspections; 234 (53.3%) observations were of 56 control ewes and 205 (46.7%) of 54 treatment ewes (χ^2 = 2.09, p = 0.15, d.f. = 1).

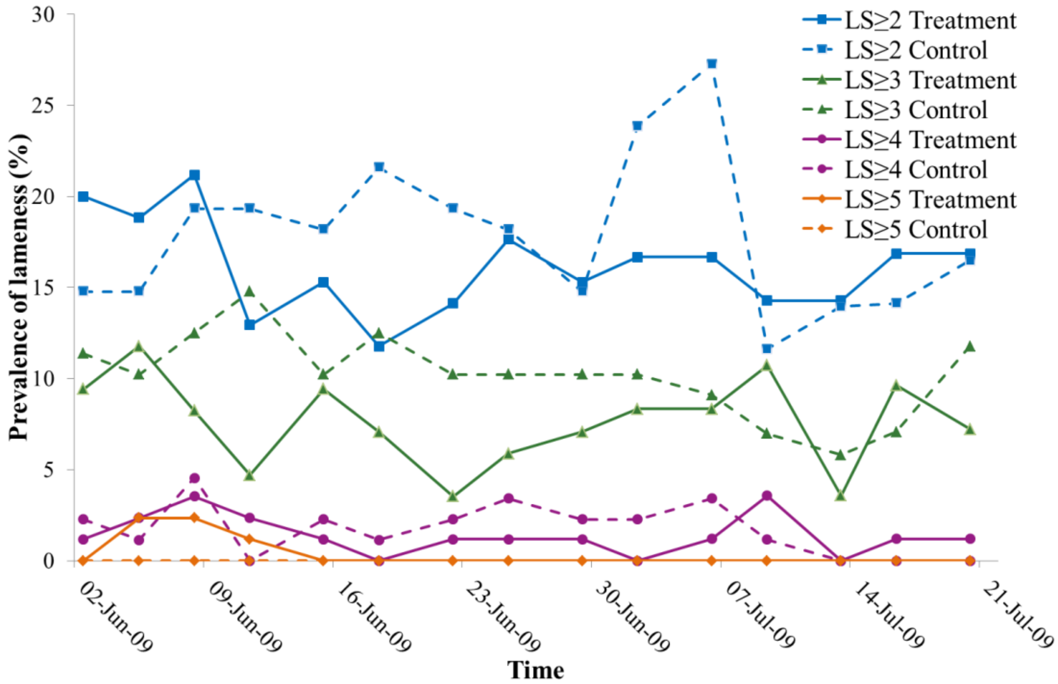
The mean prevalence of lameness (locomotion score ≥2) was 16.2% in the treatment group and 17.8% in the control group (Table 11). A frequency distribution of prevalence of lameness by locomotion score was calculated (Figure 3, Table 11). Each score was compared by group using a Mann-Whitney *U* test and were not significantly different (p >0.05), except where the locomotion score severity was ≥3 when the prevalence of lameness in the control group was significantly higher than in the treatment group (z = 2.54, p = 0.01) (Table 11).

Table 11: Mean observed prevalence of lameness by increasing thresholds of locomotion severity over time by group

Locomotion score threshold		Mean	SE	95% CI		*U* test
≥2	T	16.19	0.67	14.76	17.62	z = 0.91
	C	17.85	1.08	15.53	20.16	p = 0.36
≥3	T	7.65	0.63	6.30	9.01	z = 2.54
	C	10.21	0.60	8.92	11.50	p = 0.01
≥4	T	1.43	0.29	0.82	2.05	z = 0.11
	C	1.75	0.36	0.96	2.53	p = 0.92
≥5	T	0.40	0.22	-0.08	0.88	z = -1.79
	C	0.00	0.00	0.00	0.00	p = 0.07

T = treatment group; C = control group; SE: standard error of the mean; CI = confidence interval

Figure 3: Prevalence of lameness by increasing thresholds of locomotion severity between T1 and T2 by treatment group



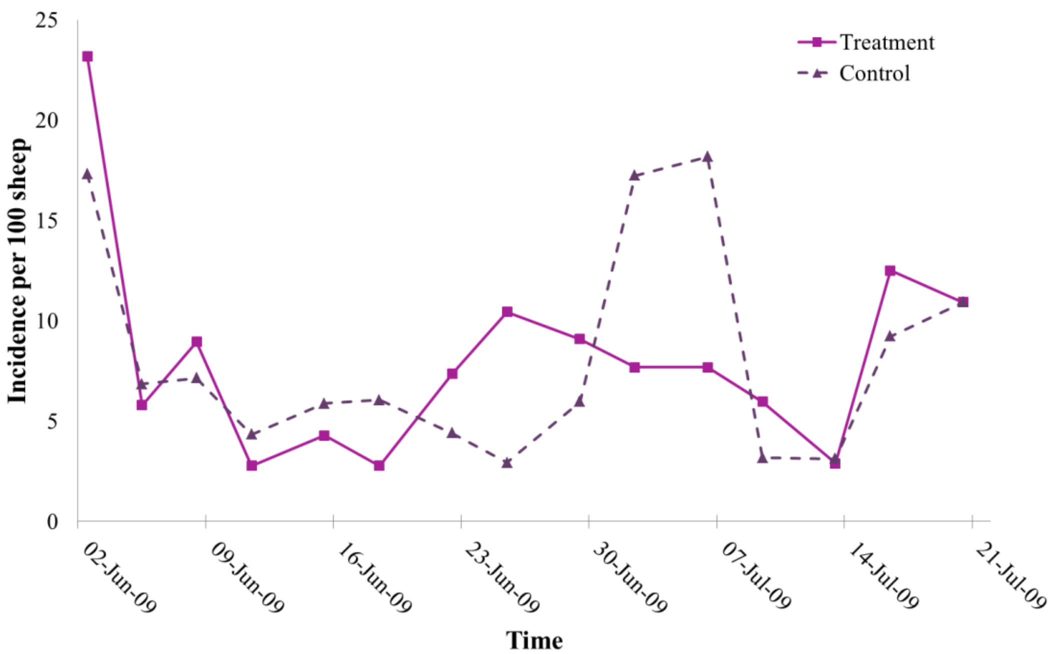
LS = locomotion score

At the very end of June, into early July, there was sharp rise in the prevalence of mild lameness within the control group which was not seen in the treatment group (Figure 3). The flock was gathered by the shepherd on the 29th June to remove faecal-matted wool from hindquarters, worm, weigh and treat lame lambs only. When the shepherd examined the feet of lame lambs, it was noted by the researcher (EMK) that a large number of lambs had FR lesions.

2.3.3 Incidence of lameness

The number of new cases of lameness (locomotion score ≥2) at each of the 15 locomotion inspections between T1 and T2 was calculated by group. The mean incidence of lameness for treatment and control groups was 8.2 (SE = 1.33, 95% CI = 5.32, 11.02) and 8.2 (SE = 1.38, 95% CI = 5.22, 11.13) respectively and was not significantly different (z = -0.10, p = 0.92). A frequency distribution graph of incidence per 100 sheep over time is shown in Figure 4.

Figure 4: Incidence of lameness between T1 and T2 by treatment group



2.3.4 Body condition score

One hundred and seventy one ewes were body condition scored at T2. The mean body condition score of ewes in the treatment and control groups at T2 was 2.59 (SE = 0.05, 95% CI = 2.49, 2.69) and 2.57 (SE = 0.06, 95% CI = 2.45, 2.70) and were not significantly different (p >0.05) (Table 12).

Table 12: Frequency distribution of body condition scores at T2 by treatment group

Body condition score	Control N (%)	Treatment N (%)
0.5	1 (1.1)	0 (0.0)
1	1 (1.1)	1 (1.2)
1.5	1 (1.1)	0 (0.0)
2	21 (23.9)	16 (19.0)
2.5	32 (36.4)	37 (43.4)
3	25 (28.4)	27 (32.1)
3.5	4 (4.5)	2 (2.4)
4	2 (2.3)	1 (1.2)
4.5	1 (1.1)	0 (0.0)
5	0 (0.0)	0 (0.0)
n	88	83
Mean	2.57	2.59
SE	0.06	0.05
95% CI	2.45, 2.70	2.49, 2.69

SE = standard error; CI = confidence interval; p= 0.84, t= 0.20, d.f. = 169

2.3.5 Presence of disease at T2

There were 16 (19.0%) and 21 (23.9%) ewes with ID lesions only, 5 (6.0%) and 7 (8.0%) ewes with FR±ID lesions, and 3 (3.4%) and 1 (1.2%) ewes with foot granuloma in the treatment and control groups respectively at T2 (Table 13). The presence of each lesion were not significantly different between groups (p >0.05).

Table 13: Presence of interdigital dermatitis and footrot lesions and foot granuloma at T2 by group

Lesion	Control N (%)	Treatment N (%)
ID	21 (23.9)	16 (19.0)
FR±ID	7 (8.0)	5 (6.0)
Total ID/FR	28 (31.8)	21 (25.0)
Granuloma	3 (3.4)	1 (1.2)
n	88	83

Table 14: Frequency distribution of interdigital dermatitis and footrot lesion scores at T2

	ID		FR	
Lesion score	Control	Treatment	Control	Treatment
	N (%)	N (%)	N (%)	N (%)
0	66 (75.0)	68 (81.0)	81 (92.1)	79 (97.6)
1	4 (4.5)	2 (2.4)	5 (5.7)	4 (4.8)
2	6 (6.8)	7 (8.3)	2 (2.3)	1 (1.2)
3	10 (11.4)	3 (3.6)	0 (0.0)	0 (0.0)
4	2 (2.3)	5 (6.0)	-	-
n	88	84	88	84
Median	0	0	0	0
IQR	0, 0.5	0, 0	0, 0	0, 0

IQR = interquartile range; - = no score 4 for footrot

Similarly, there was no significant difference in the frequency distribution of ID or FR scores between groups at T2 (Table 14) (ID: z = 0.71, p = 0.48; FR: z = 0.55, p = 0.58).

2.3.6 Presence of disease between T1 and T2

The treatment results presented in this section (2.3.6) are a product of the farm shepherd's independent assessment of lameness and his independent decision to investigate. A total of twenty five ewes were caught by the farm shepherd for diagnosis and treatment of lameness between T1 and T2; 11 (44%) were treatment ewes and 14 (56%) control ewes. This was not significantly different by group (χ^2 = 1.4, p = 0.2, d.f. = 1), though 1 of the 25 ewes was never recorded lame by the researcher. Thirty three treatments were given in total. Four ewes (3 control, 1 treatment) each received 2 treatments for lameness and a further 2 control ewes each received 3 treatments for lameness. Diagnoses for lameness for these repeat cases are shown in Table 15.

Table 15: Diagnoses of lameness for repeat cases at each treatment: decision to treat as assessed by the farm shepherd.

Sheep		Treatment number and diagnosis		
ID	Group	1	2	3
11	T	ID only	Injury	
60	C	ID and injury	ID and abscess	Abscess
110	C	ID only	ID only	
112	C	FR±ID and granuloma	FR±ID and granuloma	Granuloma
142	C	ID only	ID only	
169	C	ID only	ID only	

T=treatment; C=control; Granuloma=foot granuloma; ID = interdigital dermatitis; FR = footrot

The number and percentage of ewes that were treated for lameness between T1 and T2 that had ID only; FR±ID, granuloma or other (abscesses and injuries or damage from external objects) with or without FR or ID were calculated for each group. Individuals that were treated more than once were included in the analysis; their diagnoses were combined and recorded once per animal. There was no significant difference between the presence of ID, FR±ID, foot granuloma, other ± FR /ID or their combined totals between treatment groups ($p > 0.05$) (Table 16).

Table 16: Number and percentage of sheep with disease between T1 and T2: decision to treat as assessed by the farm shepherd

Disease	Treatment N (%)	Control N (%)	Total N (%)
ID only	5/84 (6.0)	6/88 (6.8)	11/172 (6.4)
FR ± ID	0/84 (0.0)	5/88 (5.7)	5/172 (2.9)
Granuloma	1/84 (1.2)	4/88 (4.6)	5/172 (2.9)
Other ± FR/ID	5/84 (6.0)	2/88 (2.3)	7/172 (4.1)
Total	11/84 (13.1)	17/88 (19.3)	28/172 (16.3)

Eighty-two of the 106 ewes lame between T1 and T2 (excluding data from 02/06/2009, immediately after trimming) were never investigated or treated for lameness and either spontaneously recovered or went untreated. The proportion untreated was not significantly different between groups, 40 (74.1%) control *cf.* 42 (80.8%) treatment ($\chi^2 = 0.48$, p = 0.49, d.f. =1).

2.3.7 Foot conformation

The maximum of the 16 foot conformation scores given for each ewe at T2 was calculated (Table 17). The median maximum foot conformation score of ewes in treatment and control groups at T2 was 1 (IQR = 0, 1) and was not significantly different (p = 0.25, z = 1.16).

To examine whether routine trimming affected the conformation of the foot, the median foot conformation score at T1 (Table 8) was compared to the median foot conformation score at T2 (Table 17) within each group. There was no significant change to either group's median foot conformation score between T1 and T2 suggesting that trimming did not significantly benefit the conformation of the foot at T2 (treatment group at T1, 1 (IQR = 0, 2) *cf.* T2, 1 (IQR = 0, 1) (z = 0.40, p =

0.69); control group at T1, 1 (IQR = 0, 2) *cf.* T2, 1 (IQR = 0, 1) (z = -0.77, p = 0.44)).

Table 17: Frequency distribution of foot conformation score at T2 by treatment group

Foot conformation score	Control N (%)	Treatment N (%)
0	24 (27.3)	29 (34.5)
1	47 (53.4)	42 (50.0)
2	12 (13.6)	12 (14.3)
3	5 (5.7)	1 (1.2)
n	88	84
Median	1	1
IQR	0, 1	0, 1

IQR = interquartile range; p=0.25, z=1.16

Foot conformation scores were recoded to define a ewe as having ‘good’ or ‘poor’ foot conformation. Definitions were as follows:

‘Good’ = a maximum conformation score of 0 on all feet

‘Poor’ = a minimum conformation score of 1 on any foot

Changes to foot conformation state between T1 and T2 were analysed by treatment group. The number and percentage of ewes that had no change or changed foot conformation state were calculated (Table 18). There were 108 sheep, 56 (67%) treatment and 52 (59%) control, that did not change foot conformation state between T1 and T2 (χ^2 = 0.89, p = 0.35). Eighteen (21.4%)

treatment and 25 (28.4%) control ewes moved from ‘good’ to ‘poor’ foot conformation states (χ^2 = 0.78, p = 0.38) and 10 (11.9%) treatment and 11 (12.5%) control ewes moved from ‘poor’ to ‘good’ states (χ^2 = 0.00, p = 1.00). Routine foot trimming did not significantly influence change in foot conformation state between T1 and T2 (p >0.2)

Table 18: Changes to foot conformation state between time periods T1 to T2

Foot conformation state	Treatment N (%)	Control N (%)	Total N (%)	$\chi 2$ test, p value
Good - good	19 (22.6)	13 (14.8)	32 (18.6)	1.38, 0.24
Poor - poor	37 (44.1)	39 (44.3)	76 (44.2)	0.00, 1.00
Good - poor	18 (21.4)	25 (28.4)	43 (25.0)	0.78, 0.38
Poor - good	10 (11.9)	11 (12.5)	21 (12.2)	0.00, 1.00
n	84	88	172	

2.3.8 Foot conformation and disease

The number and percentage of ewes that had ‘good’ foot conformation at T1, that had ID or FR±ID lesions at treatments for lameness between T1 and T2 was calculated. This was repeated for sheep with poor foot conformation at T1. Individuals that were treated more than once were included in the analysis; their diagnoses were combined and recorded once per animal.

There were 75 ewes with ‘good’ foot conformation of which 5, 1 (2.7%) treatment and 4 (10.5%) control, developed ID or FR lesions between T1 and T2. There were 97 ewes with ‘poor’ foot conformation of which 11, 4 (8.5%) treatment and 7 (14.0%) control, developed ID or FR lesions between T1 and T2 (Table 19). This was not significant between treatment and control groups (p >0.3).

Table 19: Number and percentage of sheep that had good or poor foot conformation at T1 that developed interdigital dermatitis or footrot between T1 and T2 (regardless of lesion state at T1)

T1 foot conformation	Treatment N (%)	Control N (%)	Total N (%)	χ2 test, p value
Good	1/37 (2.7)	4/38 (10.5)	5/75 (6.7)	0.84, 0.36
Poor	4/47 (8.5)	7/50 (14.0)	11/97 (11.3)	0.40, 0.53

The above analysis was repeated for ewes that developed ID only or FR±ID at T2 (Table 20). Of the 75 ewes with ‘good’ foot conformation at T1, 16 (9 (24.3%) treatment and 7 (18.4%) control) had ID or FR at T2 (p = 0.58). Of the 97 ewes with ‘poor’ foot conformation, 33 (12 (25.5%) treatment and 21 (42.0%) control) had ID or FR lesions at T2 (p = 0.30). Although there was no significant difference between treatment and control groups, ewes within the control group were significantly more likely to have lesions on ‘poor’ feet than on ‘good’ feet (χ^2 = 5.24, p = 0.02, d.f. = 1).

Table 20: Number and percentage of sheep that had good or poor foot conformation at T1 that had interdigital dermatitis or footrot at T2 (regardless of lesion state atT1)

T1 foot conformation	Treatment N (%)	Control N (%)	Total N (%)	χ2 test, p value
Good	9/37 (24.3)	7/38 (18.4)	16/75 (21.3)	0.30, 0.58
Poor	12/47 (25.5)	21/50 (42.0)	33/97 (34.0)	1.09, 0.30

2.3.9 Results of analysis by feet

The analysis in section 2.3.7 and 2.3.8 (foot conformation and foot conformation and disease) was repeated using data at foot level.

All ewes allocated to the treatment group received a trim by the farm shepherd on at least one foot but not every foot was trimmed. Therefore the following analysis shows a third treatment group for the purposes of foot level analysis: treatment and trimmed (T+t).

2.3.9.1 Foot conformation

The maximum score of the 4 foot conformation scores given for each foot of each ewe at T1 was calculated to give one score per foot of each ewe. This was repeated for data at T2. The median maximum foot conformation score of feet of ewe's in control, treatment and treatment and trimmed groups at T1 was 0 (IQR = 0, 0), 0 (IQR = 0, 0) and 0 (IQR = 0, 1) (Table 21) and was not significantly different between groups (χ^2 = 0.80, p = 0.67, d.f = 2). Similarly, the median maximum foot conformation score of feet of ewe's at T2 in control, treatment and treatment and trimmed groups was not significantly different (χ^2 = 0.27, p = 0.87, d.f = 2) with medians of 0 (IQR = 0, 1) for all three groups (Table 21).

There was also no significant change within each group's median foot conformation score between T1 and T2 (p >0.05) suggesting that routine foot trimming did not significantly improve the conformation of feet at T2.

Table 21: Frequency distribution of foot conformation scores at T1 and T2 at foot level by control, treatment and treatment and trimmed groups.

Foot score	T1			T2		
	C	T	T+t	C	T	T+t
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
0	276 (78.4)	259 (76.2)	206 (74.4)	250 (71.0)	245 (72.9)	193 (70.7)
1	50 (14.2)	52 (15.3)	46 (16.6)	84 (23.9)	75 (22.3)	67 (24.5)
2	18 (5.1)	21 (6.2)	17 (6.1)	13 (3.7)	15 (4.5)	12 (4.4)
3	8 (2.3)	8 (2.4)	8 (2.9)	5 (1.3)	1 (0.3)	1 (0.4)
n	352	340	277	352	336	273
Median	0	0	0	0	0	0
IQR	0, 0	0, 0	0, 1	0, 1	0, 1	0, 1

C = control; T = treatment; T+t = treatment and trimmed; IQR = interquartile range

A comparison of the frequency distribution of foot conformation scores by foot for the treatment and treatment and trimmed groups (Table 21) reveals the foot conformation scores that the farm shepherd chose to trim. All 8 feet with foot conformation score 3 in the treatment group were trimmed whereas only 79.5, 88 and 81% of score 0, 1 and 2 feet were trimmed and this difference was significant ($\chi 2 = 13.1$, $p < 0.01$, d.f = 1).

Details of the trim given to each foot were coded and categorised into 5 trim levels classified by increased severity of trim: 0 = no trim, feet of control group ewes; 1 = no trim, feet of treatment group ewes; 2 = trimmed, no notable damage recorded; 3 = trimmed, tip of toe horn cut off no blood or sensitive tissue exposed; and 4 = trimmed, sensitive tissue exposed or bled. Each foot was accorded a trim level. To establish whether foot conformation was associated with trim level a frequency distribution of foot conformation score at foot level by trim level was compiled (Table 22). Sixty three (18.5%) of the 340 feet of treatment group ewes did not receive a trim (level 1), 46 (13.5%) had the tip of their toes cut off (without bleeding or sensitive tissue exposed) (level 3), 11 (3.2%) bled or had sensitive tissue exposed (level 4) with the remainder of treatment feet (65%) receiving a trim that did not show notable damage (level 2). There was a higher proportion of feet with conformation score 3 in the level 4 trim category (25.0% compared with 1.1, 1.0 and 0.0% with foot conformation score 0, 1 and 2) and this was significant ($p < 0.01$). Similarly, there was a higher proportion of feet with conformation score 2 and 3 in the level 3 trim category (20.5 and 18.8% compared with 6.0 and 1.0% with foot conformation score 0 and 1) and this was again significant ($p < 0.01$). Within the trim level 2 category, there were significantly fewer feet trimmed with foot conformation score 3 (6.3%) than score 0 (31.4%) or score 1 (41.2%) ($p < 0.05$) and significantly more score 1 (41.2%) than score 0 (31.4%) ($p = 0.04$).

Table 22: Frequency distribution of foot conformation scores by trim level

Foot conformation score	Trim level					
	Control	1	2	3	4	Total
	N (%)	N (%)	N (%)	N (%)	N (%)	
0	276 (51.6)	53 (9.9)	168 (31.4)	32 (6.0)	6 (1.1)	535
1	50 (49.0)	6 (5.9)	42 (41.2)	3 (3.0)	1 (1.0)	102
2	18 (46.2)	4 (10.3)	9 (23.1)	8 (20.5)	0 (0.0)	39
3	8 (50.0)	0 (0.0)	1 (6.3)	3 (18.8)	4 (25.0)	16
Total	352	63	220	46	11	692

One hour after trimming, 4 (36.4%) of the trim level 4 ewes were lame, three with locomotion score 3 (not weight bearing on affected limb when standing, discomfort when moving) and one with locomotion score 4 (not weight bearing when standing or moving, discomfort when moving). Eight (23.5%) of the level 3 trimmed ewes were lame, six with locomotion score 2 (mildly lame) and two with locomotion score 3. Of the 40 trim level 2 sheep, 5 (12.5%) were lame, three with locomotion score 2 and two with locomotion score 3. Thirteen (14.8%) of the control sheep were lame. Sheep that had sensitive tissue exposure or bled (level 4) were significantly more likely to be lame compared with level 2 or control ewes ($p < 0.1$).

There were 11 sheep (a total of 13 feet) that were treated by the shepherd with topical antibacterial at trimming (Table 23). Four ewes were treated for damage acquired through trimming alone the remaining 7, for disease and or damage through trimming.

Table 23: Sheep and feet treated with topical antibacterial at trimming with accompanying reason

	Foot			
Sheep ID	Left Fore	Right Fore	Left Rear	Right Rear
8			Injury + toe cut	
12	ID lesion (4)			
18			toe cut + bled	
39				'Old FR?'; toe cut, tissue exposed and bled
53				ID lesion (3)
62				Toe cut + bled
66	ID lesion (3)			
76			Toe cut	
81	Toe cut			
103				Very overgrown; toe cut, tissue exposed (FR) + bled
144				Interdigital growth

Shaded area = topical antibacterial applied; *italicised font* = recorded at T1; normal font = recorded at trimming; (n) = lesion score

Foot conformation scores were then recoded to define a foot as having 'good' or 'poor' conformation. Definitions were as follows:

'Good' = a maximum conformation score of 0

'Poor' = a minimum conformation score of 1

Changes to foot conformation state between T1 and T2 were analysed at foot level by treatment group and the number and percentage of feet that had no change or changed foot conformation state was calculated (Table 24). There were 248 (70.5%), 242 (72.0%) and 188 (68.9%) of feet in the control, treatment and treatment and trimmed groups that did not change conformation state between T1 and T2 (Table 24). Sixty five (18.5%), 53 (15.8%) and 45 (16.5%) of feet in the control, treatment and treatment and trimmed groups changed conformation state from 'good' to 'poor' and 39 (11.1%), 41 (12.2%) and 34 (12.5%) of feet in the control, treatment and treatment and trimmed groups changed conformation state from 'poor' to 'good'. Similar to the findings at sheep level (Table 18), there were no significant differences between treatment and control groups for any of the foot conformation state changes between T1 and T2 at foot level ($p > 0.05$) indicating that routine foot trimming did not significantly improve the conformation of feet at T2.

Table 24: Changes to foot conformation state at foot level between T1 and T2 by group

Foot conformation state	C N (%)	T N (%)	T+trimmed N (%)	Total N (%)
Good - good	211 (59.9)	204 (60.7)	154 (56.4)	415 (60.3)
Poor - poor	37 (10.5)	38 (11.3)	34 (12.5)	75 (10.9)
Good - poor	65 (18.5)	53 (15.8)	45 (16.5)	118 (17.2)
Poor - good	39 (11.1)	41 (12.2)	34 (12.5)	80 (11.6)
n	352	336	273	688

C = control; T = treatment

2.3.9.2 Disease

There were 24/352 (6.8%), 35/340 (10.3%) and 33/277 (11.9%) feet in the control, treatment and treatment and trimmed groups with ID only at T1 and 4

(1.1%), 2 (0.6%) and 1 (0.4%) feet with FR±ID. There were no significant differences between treatment groups ($p > 0.05$), except that there were significantly more feet with ID lesions in the treatment and trimmed group than in the control group ($\chi^2 = 4.29$, $p = 0.04$) indicating that the presence of ID was part of the shepherd's subjective trimming criteria.

The number and percentage of feet that had no ID or FR lesions at T1 that developed ID or FR at T2 was calculated by group. Twenty-six (8.0%), 24 (8.0%) and 18 (7.7%) feet in the control, treatment and treatment and trimmed groups developed ID at T2 and 4 (1.2%), 5 (1.7%) and 4 (1.7%) developed FR±ID (Table 25). There was no significant difference between treatment groups in the prevalence of ID or FR lesions ($p > 0.05$).

Table 25: Number and percentage of feet by group that had no interdigital dermatitis or footrot at T1 that developed interdigital dermatitis or footrot at T2

Group	n	ID only N (%)	FR±ID N (%)	ID or FR N (%)
Control	324	26 (8.0)	4 (1.2)	30 (9.3)
Treatment	299	24 (8.0)	5 (1.7)	29 (9.7)
Treatment and trimmed	233	18 (7.7)	4 (1.7)	22 (9.4)

n = number of feet with no disease at T1 minus sheep lost to follow up

2.3.9.3 Disease and foot conformation

The number of feet with an ID or FR lesion at T1 was calculated by group. The foot conformation state change between T1 and T2 was followed for these sheep. The number and percentage of feet by state change category is presented in Table 26. There were 21 (75.0%), 18 (51.4%) and 17 (50.0%) feet that did not change conformation state between T1 and T2 in the control, treatment and treatment and trimmed groups (p >0.05). Three, (10.7%), 10 (28.6%) and 9 (26.5%) feet changed from ‘good’ to ‘poor’ conformation and 4 (14.3%), 9 (25.7%) and 8 (23.5%) feet from ‘poor’ to ‘good’ (P > 0.05). The prevalence of foot conformation state changes was not significantly different between treatment groups (p >0.05).

Table 26: Foot conformation state change at foot level between T1 and T2 by treatment group where interdigital dermatitis or footrot was present at T1.

State change	Control N (%)	Treatment N (%)	Treatment & trimmed N (%)
Good – good	15 (53.6)	14 (40.0)	13 (38.2)
Poor – poor	6 (21.4)	4 (11.4)	4 (11.8)
Good – poor	3 (10.7)	10 (28.6)	9 (26.5)
Poor - good	4 (14.3)	9 (25.7)	8 (23.5)
n	28	35	34

The number of feet with an ID or FR lesion at T1 that also had an ID or FR lesion between T1 and T2 (including T2) was calculated. The prevalence of disease by foot conformation state change was not significantly different between the treatment groups (p >0.05), except for in the ‘poor to poor’ foot conformation state category where control feet had significantly more ID and FR lesions (83.3%) between T1 and T2 or at T2 than either the treatment (0.0%) or treatment and trimmed groups (0.0%) (p = 0.048) (Table 27).

Table 27: Number and percentage of feet that developed interdigital dermatitis or footrot lesions between T1 and T2 (including T2) where feet had interdigital dermatitis or footrot at T1 by foot conformation state change and treatment group

State change	Control N (%)	Treatment N (%)	Treatment & trimmed N (%)
Good – good	3/15 (20.0)	3/14 (21.4)	3/13 (23.1)
Poor – poor	5/6 (83.3)	0/4 (0.0)	0/4 (0.0)
Good – poor	1/3 (33.3)	4/10 (40.0)	4/9 (44.4)
Poor - good	3/4 (75.0)	2/9 (22.2)	2/8 (25.0)

The number of feet with no ID or FR lesions at T1 that developed an ID or FR lesion between T1 and T2 (including T2) was then calculated (Table 28). The development of ID or FR lesions by foot conformation state change was not significantly different between the treatment groups ($p > 0.05$).

Table 28: Number and percentage of feet with no lesions at T1 that developed interdigital dermatitis or footrot lesions between T1 and T2 (including T2) by foot conformation state change by group

State change	Control N (%)	Treatment N (%)	Treatment & trimmed N (%)
Good – good	28/196 (14.3)	27/190 (14.2)	16/141 (11.3)
Poor – poor	10/31 (32.3)	8/32 (25.0)	6/30 (20.0)
Good – poor	12/62 (19.4)	5/43 (11.6)	4/36 (11.1)
Poor - good	7/35 (20.0)	6/34 (17.6)	5/26 (19.2)

There were 3 control ewes and 1 treatment ewe, that had a toe granuloma at T2 (Table 13) compared with one in a control ewe at T1 (Table 9). The toe granuloma of the treatment ewe was located on the tip of the toe of the outer digit of the right hind foot. At T1, this digit had a foot conformation score of 3 for both the wall and heel and sole, no active ID or FR lesions were recorded, though a comment of '*Old FR?*' was entered. The digit was trimmed (trim level 4) by the shepherd at T1 +1 day, the toe of the outer digit cut perpendicular to the sole, sensitive tissue exposed and bleeding occurred (Table 23, sheep identity 39). The identical location of the toe granuloma and preceding over trim suggest that the toe granuloma was caused by the over trim. The foot conformation scores of this digit at T2 was heel and sole = 1, wall = 2 and suggests that the trim may have improved the foot conformation slightly.

Of the two ewes in the control group that had a toe granuloma at T2 but not at T1: Sheep 112 had an ID (score 2) on her right fore foot at T1 and was treated with a trim and topical antibacterial for lameness on 08/06/2009 for ID (score 2), an injury that was bleeding and FR (score 1) on her outer digit of her front right foot, the site of the later observed granuloma. The physical injury and/or FR lesion probably caused her granuloma. Her foot conformation scores at T1 for this digit were heel and sole = 0, wall = 2 and heel and sole = 2, wall = 1 at T2 and were not improved between T1 and T2 despite three therapeutic trims, and three applications of topical antibacterial applied between 08/06/2009 and 14/07/2009. Sheep 122 had no active lesions on her right fore at T1 but was treated for lameness on 09/07/2009 with a therapeutic foot trim and topical antibacterial for FR (score 2) and a toe granuloma. Her foot conformation scores remained similar between T1 and T2; heel and sole = 2 and wall = 3 at T1, heel and sole = 3, wall = 2 at T2 despite a therapeutic foot trim.

2.3.10 Associations between treatments, sheep features and the risk of becoming lame

To investigate crude patterns of associations between treatments, sheep level features and the risk of becoming lame, a frequency distribution of the 106 ewes that were lame with locomotion score ≥2 between T1 and T2 (excluding initial locomotion score on 02/06/2009) by treatment group and sheep level features was performed. For conciseness, a brief summary of significant findings is presented here with the complete frequency distribution presented in Appendix 4.

There were no significant findings from this exploratory analysis between treatment and control ewes, except for a greater proportion of ewes lame between T1 and T2 in the trim level 4 category (bled or had sensitive tissue exposed) than in level 0 ($p = 0.09$), 2 ($p = 0.04$) and 3 ($p = 0.07$) (10 (90%) *cf.* 54 (61.4%), 22 (55.0%) and 20 (58.8%) (Table 29) and indicates that poor trimming technique in routine foot trimming is detrimental.

Table 29: Frequency distribution of lame sheep (locomotion score ≥2) by trim level categories by group

Trim level	Control N (%)	Treatment N (%)	$\chi 2$, p value (cf. level 4)
0	54 (61.4)	-	2.86 ,0.09
1	-	0 (0.0)	-
2	-	22 (55.0)	4.34, 0.04
3	-	20 (58.8)	3.28, 0.07
4	-	10 (90.9)	-

2.3.10.1 Multilevel model of factors associated with lameness

There were 106 sheep lame with locomotion score ≥2 (73 with locomotion score ≥3) between T1 and T2. The univariable crude associations between explanatory variables and the risk of becoming lame with locomotion score ≥2 is shown in Table 30.

Table 30: Univariable multilevel model results of factors associated with the risk of becoming lame with locomotion score ≥2 in 173 sheep with up to 14 observations.

Variable		N (%) of lame sheep	Coefficient	S.E.	OR	Lower CI	Upper CI
Breed	Mule	41 (61.2)	Reference				
	Suffolk x	60 (60.6)	0.048	0.253	1.05	0.64	1.72
	Missing	5 (71.7)	0.571	0.620	1.77	0.53	5.97
Age recode	≤4	8 (47.1)	-0.312	0.481	0.73	0.32	1.66
	6	25 (65.8)	Reference				
	≥ 8	73 (62.0)	0.201	0.301	1.22	0.68	2.21
BC	continuous	105 (61.1)	0.182	0.212	1.20	0.79	1.82
BC recode	<3	40 (61.5)	-0.312	0.286	0.73	0.42	1.28
	3	33 (55.0)	Reference				
	>3	32 (68.1)	0.145	0.306	1.16	0.63	2.11
Allocation	C	54 (61.4)	Reference				
	T	52 (61.2)	-0.141	0.242	0.87	0.54	1.40
Maximum ID lesion score at T1	0	74 (55.6)	Reference				
	1	1 (100.0)	1.711	1.547	5.53	0.27	114.8
	2	20 (80.0)	0.252	0.349	1.29	0.65	2.55
	3	9 (75.0)	0.706	0.474	2.03	0.80	5.13
	4	2 (100.0)	0.795	1.113	2.21	0.25	19.62
ID at T1 recode	≤1	75 (56.0)	Reference				
	≥2	31 (79.5)	0.414	0.290	1.51	0.86	2.67
FR at T1	Absent	101 (60.5)	Reference				
	Present	5 (83.3)	1.624 *	0.629	5.07	1.48	17.41
Conformation score at T1	0	40 (53.3)	Reference				
	1	28 (59.9)	0.358	0.299	1.43	0.80	2.47
	2	24 (66.7)	0.578	0.323	1.78	0.95	3.36
	3	14 (93.3)	1.366 *	0.437	3.92	1.66	9.23
Trim Level	0	54 (61.4)	Reference				
	1	0 (0.0)	No sheep with this score at sheep level				
	2	22 (55.0)	-0.301	0.308	0.74	0.40	1.35
	3	20 (58.8)	-0.111	0.324	0.89	0.47	1.69
	4	10 (90.9)	0.259	0.503	1.30	0.48	3.47
Treated at T1	No	97 (60.0)	Reference				
	Yes	9 (81.82)	0.268	0.493	1.31	0.50	3.44
Conformation score at T1 recode for FR	0	45 (55.6)	Reference				
	1	27 (58.7)	0.037	0.298	1.04	0.58	1.86
	2	22 (64.7)	0.366	0.326	1.44	0.76	2.73
	3	11 (91.7)	0.797	0.483	2.22	0.86	5.72

There were two factors that were associated with an increased risk of becoming lame with locomotion score ≥2 between T1 and T2: presence of footrot at T1 ($P < 0.05$) and poor foot conformation (conformation score 3) at T1 (Table 30). The latter was not significant once the confounding effect of poor foot conformation and presence of FR were accounted for (conformation score at T1 recode for FR). Two explanatory variables remained in the final model: presence of FR and conformation score at T1 recoded to account for footrot. The intercept coefficient (B_{0j}) for the final model was -1.975 (0.188) and the variance and standard deviation of the random effects (U_{0j}) for sheep was 1.995 (0.273) (Table 31). Sheep were at increased risk of becoming lame with locomotion score ≥2 at the 14 observations if they had poor foot conformation (score 3) at T1 or a FR lesion at T1.

Table 31: Two level model of factors associated with the risk of becoming lame with locomotion score ≥2 in 173 sheep with 14 observations.

Variable		N (%) of lame sheep	Coefficient	S.E.	OR	Lower CI	Upper CI
Intercept			-1.975	0.188	0.14	0.10	0.20
Conformation score at T1 recode for FR	0	45 (55.6)	Reference				
	1	27 (58.7)	0.269	0.301	1.31	0.73	2.36
	2	22 (64.7)	0.598	0.328	1.82	0.96	3.46
	3	11 (91.7)	1.029 *	0.481	2.80	1.09	7.18
FR at T1	Absent	101 (60.5)	Reference				
	Present	5 (83.3)	1.927 *	0.645	6.87	1.94	24.32
			Variance	S.D.			
Random effects	Sheep		1.995 *	0.273			

N = number; % = percentage; S.E = standard error; OR = odds ratio; CI = 95% confidence interval; * = $p<0.05$; S.D. = standard deviation

The outcome variable was changed to lame with locomotion score ≥3 between T1 and T2 and the model was re-run. The univariable crude associations between explanatory variables and the risk of becoming lame with locomotion score ≥3 is shown in Table 32.

Table 32: Univariable the multilevel model results of factors associated with the risk of becoming lame with locomotion score ≥3 in 173 sheep with up to 14 observations.

Variable		N (%) of lame sheep	Coefficient	S.E.	OR	Lower CI	Upper CI
Breed	Mule	27 (40.3)	Reference				
	Suffolk x	43 (43.4)	0.525	0.318	1.69	0.91	3.15
	Missing	3 (42.9)	0.909	0.757	2.48	0.80	7.66
Age recode	≤4	6 (35.3)	0.068	0.593	1.07	0.33	3.42
	6	15 (39.5)	Reference				
	≥ 8	52 (44.1)	0.169	0.380	1.18	0.56	2.49
BC	continuous	73 (42.2)	0.095	0.267	1.10	0.65	1.86
BC recode	<3	25 (38.5)	-0.409	0.357	0.66	0.33	1.34
	3	27 (45.0)	Reference				
	>3	21 (44.7)	-0.057	0.382	0.94	0.45	2.00
Allocation	C	36 (40.9)	Reference				
	T	37 (43.5)	-0.312	0.302	0.73	0.40	1.32
Maximum ID lesion score at T1	0	52 (39.1)	Reference				
	1	1 (100.0)	2.175	1.903	8.80	0.21	366.82
	2	13 (52.0)	0.234	0.444	1.26	0.53	3.02
	3	6 (50.0)	0.622	0.598	1.86	0.58	6.01
	4	1 (50.0)	0.937	1.388	2.55	0.17	38.76
ID at T1 recode	≤1	53 (39.6)	Reference				
	≥2	20 (51.3)	0.372	0.363	1.45	0.71	2.95
FR at T1	Absent	69 (41.3)	Reference				
	Present	4 (66.7)	1.634 *	0.782	5.12	1.11	23.73
Conformation score at T1	0	24 (32.0)	Reference				
	1	20 (42.6)	0.872 *	0.365	2.39	1.17	4.89
	2	18 (50.0)	1.118 *	0.390	3.06	1.42	6.57
	3	11(73.3)	2.042 *	0.511	7.71	2.83	20.98
Trim Level	0	36 (40.9)	Reference				
	1	0 (0.0)	No sheep with this score at sheep level				
	2	15 (37.5)	-0.459	0.388	0.63	0.30	1.35
	3	13 (38.2)	-0.280	0.406	0.76	0.34	1.67
	4	9 (81.8)	0.035	0.628	1.04	0.30	3.55
Treated at T1	No	67 (41.4)	Reference				
	Yes	6 (54.5)	0.032	0.627	1.03	0.30	3.53
Conformation score at T1 recode for FR	0	28 (34.6)	Reference				
	1	19 (41.3)	0.405	0.375	1.50	0.72	3.13
	2	18 (52.9)	0.767	0.406	2.15	0.97	4.77
	3	8 (66.7)	1.211 *	0.594	3.36	1.05	10.75

N = number; % = percentage; S.E = standard error; OR = odds ratio; CI = 95% confidence interval; * = p<0.05

There were two factors that were associated with an increased risk of becoming lame with locomotion score ≥3 (Table 32): footrot at T1 and poor foot conformation at T1 ($P < 0.05$). Sheep with a conformation score >0 were significantly more likely to become lame with locomotion score ≥3 in contrast to the model where locomotion score ≥2 was the outcome; when only conformation score 3 was associated with an increased risk of lameness. When the confounding effect of FR and conformation score were accounted for (conformation score at T1 recode for FR) only conformation score 3 remained significant (Table 32). Two explanatory variables remained in the final model: FR at T1 and conformation score at T1 recode for footrot. The intercept coefficient (B_{0j}) for the final model was -3.154 (0.244) and the variance and standard error of the random effects (U_{0j}) for sheep was 2.665 (0.402) (Table 33). Sheep were at increased risk of becoming lame with locomotion score ≥3 at the 14 observations if they had a FR lesion at T1 or had a foot conformation score ≥1.

Table 33: Two level model of factors associated with the risk of becoming lame with locomotion score ≥3 in 173 sheep with 14 observations.

Variable		N (%) of lame sheep	Coefficient	S.E.	OR	Lower CI	Upper CI
Intercept			-3.154	0.244	0.04	0.03	0.07
Conformation score at T1 recode for FR	0	28 (34.6)	Reference				
	1	19 (41.3)	0.822	0.370	2.28	1.10	4.70
	2	18 (52.9)	1.184	0.398	3.27	1.50	7.13
	3	8 (66.7)	1.627	0.568	5.09	1.67	15.49
FR at T1	Absent	69 (41.3)	Reference				
	Present	4 (66.7)	2.351	0.748	10.50	2.42	45.47
			Variance	S.D.			
Random effects	Sheep		2.665	0.402			

N = number; % = percentage; S.E = standard error; OR = odds ratio; CI = 95% confidence interval; * = p<0.05; S.D. = standard deviation

Sheep that either bled and or had sensitive tissue exposed during trimming were more likely to be lame between T1 and T2 than those that did not or those in the control group (Table 29). The outcome variable was therefore changed to ever lame with LS ≥2 between T1 and T2 (excluding locomotion score data for 02/06/2009). Univariable results for crude associations are given in Table 34.

Table 34: Univariable multilevel model results of factors associated with the risk of becoming lame (locomotion score ≥2) between T1 and T2 in 173 sheep.

Variable		N (%) of lame sheep	Coefficient	S.E.	OR	Lower CI	Upper CI
Breed	Mule	41 (61.2)	Reference				
	Suffolk x	60 (60.6)	-0.026	0.325	0.97	0.52	1.84
	Missing	5 (71.7)	0.461	0.821	1.59	0.32	7.93
Age recode	≤4	8 (47.1)	-0.772	0.602	0.46	0.14	1.50
	6	25 (65.8)	Reference				
	≥ 8	73 (62.0)	-0.171	0.385	0.84	0.40	1.79
BC	continuous	105 (61.1)	-0.064	0.273	0.94	0.55	1.60
BC recode	<3	40 (61.5)	0.268	0.369	1.31	0.63	2.69
	3	33 (55.0)	Reference				
	>3	32 (68.1)	0.557	0.402	1.75	0.79	3.84
Allocation	C	54 (61.4)	Reference				
	T	52 (61.2)	-0.009	0.312	0.99	0.54	1.83
ID at T1 recode	≤1	75 (56.0)	Reference				
	≥2	31 (79.5)	0.934 *	0.385	2.54	1.20	5.41
FR at T1	Absent	101 (60.5)	Reference				
	Present	5 (83.3)	1.184	0.879	3.27	0.58	18.30
Conformation score at T1	0	40 (53.3)	Reference				
	1	28 (59.9)	0.254	0.411	1.29	0.58	2.89
	2	24 (66.7)	0.558	0.449	1.75	0.72	4.21
	3	14 (93.3)	2.506 *	0.668	12.26	3.31	45.39
Trim Level	0	54 (61.4)	Reference				
	1	0 (0.0)	No sheep with this score at sheep level				
	2	22 (55.0)	-0.262	0.406	0.77	0.35	1.71
	3	20 (58.8)	-0.108	0.430	0.90	0.39	2.09
	4	10 (90.9)	1.840 *	0.718	6.30	1.54	25.72
Treated at T1	No	97 (60.0)	Reference				
	Yes	9 (81.82)	1.104	0.659	3.02	0.83	10.98
Conformation score at T1 recode for FR	0	45 (55.6)	Reference				
	1	27 (58.7)	0.128	0.397	1.14	0.52	2.47
	2	22 (64.7)	0.512	0.441	1.67	0.70	3.96
	3	11 (91.7)	2.175 *	0.704	8.80	2.21	34.98

N = number; % = percentage; S.E = standard error; OR = odds ratio; CI = 95% confidence interval; * = $p<0.05$

Similar to the first model (model 1) that used locomotion score ≥2 at the 14 observations as the outcome, in model 3 sheep with very poor foot conformation at T1 (conformation score 3) were significantly more likely to become lame (p

<0.05) and this was the case whether or not they had FR at T1 (Table 34). However, there were three differences between model 1 (locomotion score ≥2 at each observation) and model 3 (sheep ever lame with locomotion score ≥2 between T1 and T2). In model 3, converse to model 1, sheep with FR at T1 were not significantly associated with greater risk of becoming lame and sheep with an ID lesion score ≥2 were associated with a significant risk of becoming lame ($p < 0.05$). In addition, in model 3, sheep that were routinely trimmed at T1 who experienced bleeding or sensitive tissue exposure, *cf.* those that did not or were in the control group, were at increased risk of becoming lame and this was significant ($p < 0.05$). This was not the case in model 1.

Four explanatory variables remained in the final model: trim level, conformation score recode for FR, FR at T1, and ID at T1 recode (Table 35). Sheep were at increased risk of becoming lame with locomotion score ≥2 between T1 and T2 if they had an ID lesion score ≥2 at T1, conformation score of 3 at T1 or experienced bleeding or sensitive tissue exposure during routine trimming ($P < 0.05$). The presence of FR at T1 was only just not significant (Table 35).

Table 35: Two level model of factors associated with the risk of becoming lame (locomotion score ≥2) between T1 and T2 in 173 sheep with 14 observations.

Variable		N (%) of lame sheep	Coefficient	S.E.	OR	Lower CI	Upper CI
Intercept			-0.213	0.326	0.81	0.43	1.53
ID at T1	≤1	75 (56.0)	Reference				
recode	≥2	31 (79.5)	1.336 *	0.431	3.80	1.63	8.85
Trim Level	0	54 (61.4)	Reference				
	1	0 (0.00)	No sheep with this score at sheep level				
	2	22 (55.0)	-0.311	0.435	0.73	0.31	1.72
	3	20 (58.8)	-0.051	0.457	0.95	0.39	2.33
	4	10 (90.9)	1.994*	0.895	7.34	1.27	42.44
Conformation	0	45 (55.6)	Reference				
score at T1	1	27 (58.7)	0.450	0.425	1.57	0.68	3.61
recode for FR	2	22 (64.7)	0.851	0.467	2.34	0.94	5.85
	3	11 (91.7)	2.313 *	0.830	10.10	1.99	51.41
FR at T1	Absent	101 (60.5)	Reference				
	Present	5 (83.3)	1.865	0.976	6.46	0.95	43.73
			Variance	S.D.			
Random effects	Sheep		4.676 *	0.549			

N = number; % = percentage; S.E = standard error; OR = odds ratio; CI = 95% confidence interval; * = p<0.05; S.D. = standard deviation

2.4 Discussion

2.4.1 Implications

This is the first clinical trial to examine the effect of routine foot trimming in sheep flocks. There are two key findings from this study. Firstly that on this one farm routine foot trimming was not significantly beneficial. Secondly, where feet bled or had sensitive tissue exposed through over trimming, routine foot trimming was detrimental and these sheep were significantly more likely to become lame.

2.4.2 Generalisability

This was a small study on one flock of sheep. However, aside from the additional functions of teaching and research, the farm flock was not atypical of other lowland commercially run flocks in terms of its management of lameness. The farm shepherd did not ever catch the first sheep seen lame, tended to wait either for a group of sheep to be lame or wait for a routine gathering before inspection of lame individuals, with sheep with higher locomotion scores being treated more quickly. This practice is not atypical of UK farmers with 30% self-reported to treat lame sheep within a week of observing them lame and a further 14% of farmers treating lameness at routine gatherings only (Kaler and Green, 2008b). Similarly, these authors also reported that with higher locomotion scores farmers reportedly needed fewer lame sheep to prompt treatment. The median self-reported prevalence of lameness of farmers who do not catch the first sheep seen lame in their flock is 11% (IQR: 9-15) (Kaler and Green, 2008b). Given that farmers give reasonably accurate assessments of the prevalence of lameness in their own flocks but tend to under report at higher prevalence's of lameness (>9%) (Chapter 3, King and Green, 2011) a prevalence of lameness of 17% as seen in this study is high but not unreasonable.

There is very little evidence on the trimming practices used by sheep farmers and none that is recent. It is therefore difficult to say with any great certainty that the shepherd on this farm was typical in his trimming technique. The flock was routinely foot trimmed just once a year, typical of 28% of UK farms (Kaler, 2008) and the shepherd trimmed >80% of the feet of his ewes, typical of 22% of shepherds surveyed in 2000 who reportedly trimmed >50% of their ewe's feet (Wassink *et al.*, 2005). In addition he trimmed to reshape the foot and remove overgrowth similar to 50% of farmers surveyed in 2000 (Wassink *et al*., 2005) using foot shears. Similar to results of all 30 farmers surveyed by Grogono-Thomas and Johnston (1997) the shepherd on this farm did not disinfect shears between feet and sheep, though unlike their findings he did disinfect shears when they came into contact with FR lesions with either an alcohol wipe (available from the research team) or applied a topical antibacterial. Advice given to farmers in 2008 by EBLEX (2008a) was to disinfect trimming apparatus between feet, not to draw blood and not to trim unless necessary. It is therefore plausible that in the 9-12 years between the 2000 survey by Wassink *et al*. (2005) and 1994 survey by Grogono-Thomas and Johnston (1997) and this study a proportion of famers have adopted publicised advice, adjusted their trimming practice and made some practical attempts not unlike the shepherd in this study to disinfect trimming apparatus between infected and non-infected sheep. The farm shepherd in this study did not intend to over trim or damage the integrity of the foot during routine foot trimming and he had many years of foot trimming experience. Yet, 11 (12.9%) sheep received an accidental overtrim, each on one foot, which caused the foot to bleed or sensitive tissue to be exposed. Where blood was drawn, the shepherd sometimes applied a topical antibacterial in the form of a Terramycin® spray to minimise the potential for infection. One of these 11 sheep went on to develop a toe granuloma at the site of the over trim, despite application of a topical antibacterial, although this digit's foot conformation improved slightly between T1 and T2. Given that toe granulomas have an estimated flock prevalence of approximately 1%, are present on approximately 66% of UK farms (Kaler and Green, 2008a) and are commonly caused through over trimming (Kaler and Green, 2008a; Grogono-Thomas and Johnston, 1997; Winter, 2004a; 2004b) it is plausible that the nature and frequency of accidental overtrimming seen in this study is not dissimilar to that seen on other farms. From the evidence presented above, there is no reason to suspect that the shepherd's trimming technique on this farm in this study was unlike that of other UK lowland shepherds and farms.

2.4.3 Associations and significant findings

In the 7 weeks of this trial, routine foot trimming did not result in a significant reduction in prevalence or incidence of lameness or disease (ID, FR or granuloma) when compared to the control group. Treatment allocation was also not associated with a reduced risk of becoming lame in any of the three models even when the addition of treatment with topical antibacterial at trimming was accounted for. There was however a higher proportion of locomotion score ≥3 sheep in the control compared with the treatment group between T1 and T2 and this was significant. There may be four reasons for this observation. Firstly, routine foot trimming may have reduced the prevalence of higher locomotion scores but not the prevalence of lameness overall. Secondly, the initial stratification did not include locomotion score or heritability of resistance to footrot (see discussions below) and an element of error may have been introduced. Thirdly, an increase in severity of locomotion score is associated with an increased severity of FR lesion scores even prior to being visible (Kaler *et al.*, 2011). Although the frequency distribution of ID and FR lesion severity at T1 was not significantly different between groups, the slightly higher number of ewes with FR lesions (4 *cf.* 2) at T1 in the control group may have been enough to produce a difference in higher locomotion scores between groups. Finally, the application of topical antibacterial to 11 treatment ewes at trimming compared with no control ewes may have reduced the prevalence of higher locomotion scores in the treatment group.

The higher numbers of locomotion score 3 control ewes were the result of a sharp rise in the prevalence and incidence of mild cases of lameness in the control group which was not seen in the treatment group following a gathering event on the 29th June. The flock had been gathered to remove faecal-matted wool from hindquarters, worm and weigh lambs during which there were a large number of lame lambs that were examined and treated by the farm shepherd for lameness, specifically FR lesions. Gathering results in an increase in the transmission of *D. nodosus* through environmental contamination due to the increase in stocking density and may lead to increased susceptibility of the flock to disease (Wassink *et al*., 2003a; 2003b; 2004). This does not however explain why the steep rise in lameness was only seen in one group when the treatment groups were run as a single flock. Ewes are at increased risk of becoming lame when one or more of her offspring are lame and *vice versa* (Kaler *et al*., 2010b) presumably as a consequence of increased proximity from the maternal bond. Lambs were not assessed as part of the trial. Identity of lamb and dam pairs was not possible because when the study began lambs were >14 weeks, fairly independent and any original identifying management markings applied at birth were unreadable. It is therefore plausible that lambs of control group ewes had more disease (specifically FR) than those of treatment ewes leading to a spike of lameness in control ewes only. An alternative explanation is that routine foot trimming reduced the susceptibility of ewes to disease at gathering events. This explanation is however highly unlikely given that the flock was gathered more than once during the trial and the uni-lateral rise in lameness was not repeated. It is therefore recommended that future studies be conducted after weaning or include an assessment of lambs. Resistance to footrot varies between phenotypes, and research by Nieuwhof *et al*. (2008) indicates that effective selection for resistance to footrot in the UK is possible. Consequently, an alternative plausible explanation for the differences in higher locomotion scores observed between treatment groups could be differences in individual's heritability of resistance to footrot between animals in the groups.

It was estimated that with hoof horn growth rates of ~3.6 mm per month (Shelton *et al*., 2012), routine foot trimming would have little effect after 7 weeks and this was chosen as the period for re-examination of all ewes' feet. There was no significant improvement in foot conformation of those sheep that were routinely foot trimmed after 7 weeks. In addition, there was no significant difference in foot conformation detected between sheep that were routinely foot trimmed and those that were not or in the general welfare of the sheep, as measured by changes to body condition score. Feet of control ewes with ID/FR and 'poor' foot conformation at T1 were however, significantly more likely to have ID/FR lesions compared with treatment feet between T1 and T2 or at T2. Routine foot trimming allows shepherds to examine all the feet of all their ewes, and where disease is found presents an opportunity for treatment. One possible explanation is that in this study, 7 of 11 ewes received treatment with topical antibacterial by the shepherd for disease at trimming. Although treatment at trimming was not significantly associated with a reduced risk of lameness in any of the models, the 7 ewes treated in the treatment group *cf.* 0 in the control group may have been sufficient to produce this result. Alternatively, this may have been an aberration of the small numbers involved (5/6 *cf.* 0/4).

Of those feet that were trimmed, there were significantly more feet in the poorer foot conformation categories (score 2 and 3) that received a poor trim (*i.e.* toe horn cut perpendicular to the sole, bleeding or sensitive tissue exposure) and *vice versa*. The thickness of sole and wall horn is only 2-3mm thick (EBLEX, 2008a) and therefore there is only slight room for error to avoid over trimming. It may be more difficult to trim hoof horn that is very overgrown or 'abnormal' in shape compared to that which is only slightly overgrown or misshapen without damaging the integrity of the horn because more hoof horn has to be trimmed to return it to a 'normal' shape. In addition, sheep were significantly more likely to be lame during the 7 week period after trimming, if at trimming they bled or had sensitive tissue exposure and this association was confirmed by model 3. Current recommendations are that feet only be trimmed where necessary (EBLEX, 2008a). However, this study highlights that it is exactly these sheep that are at increased risk of an accidental overtrim and perhaps therefore should not be trimmed at all.

Similar to findings by Kaler *et al*. (2010b), in this study sheep with poor foot conformation or FR at T1 were significantly more likely to become lame, regardless of whether or not they received a routine trim. Treating lame sheep within 4 days of becoming lame and using parenteral antibiotics reduces the risk of developing poor foot conformation (Kaler *et al*., 2010b). If 50% of farmers are using foot trimming as a means to improve the foot conformation of their flock (Wassink *et al*., 2005), they should be advised to stop routine foot trimming and instead to appropriately and promptly treat lame ewes within 1-4 days of becoming lame, with parenteral antibiotics for cases of FR (Wassink *et al*., 2010a; Kaler *et al*., 2010a; Hawker, 2008).

At foot level, there were a significantly higher number of feet with ID only lesions in the treatment and trimmed group than in the control group at T1. There was however no significant difference in the presence of ID lesions between feet of treatment compared with feet of control sheep. This finding is as a consequence of the shepherd's subjective trimming criteria, *i.e.* he was more likely to trim feet if they had ID lesions. This is not unlikely given that 62% of farmers self-report to carry out therapeutic foot trimming to treat ID (Wassink *et al*., 2010b).

Overall, the results suggest that the 6 hours spent by this shepherd routine foot trimming 85 ewes (less than half of his flock) was not beneficial to individuals or the flock as a whole and was time ill spent, even if one considers that the small differences in lameness were entirely attributable to routine foot trimming.

2.4.4 Limitations

To minimise the risk of confounding, the study population was divided into homogenous strata and stratified random sampling was used to allocate ewes to treatment groups by body condition, age, foot conformation and the presence of ID and FR lesions; and this was successful. These risk factors were selected based on the findings of previous research. Lame sheep are significantly more likely to have a lower body condition score (Wassink *et al*., 2010a). Older sheep (>4 years) are more likely to have poor foot conformation with sheep with poor foot conformation at greater risk of becoming lame (Kaler *et al*., 2010b). In addition, there is a positive association between the severity of ID/FR lesions and lameness (Kaler *et al*., 2011). Additional risk factors such as breed and genetic heritability (Nieuwhof *et al*., 2008) were not considered in the initial stratification because the study population comprised cross-bred ewes and records of parenteral lineage were not kept.

An assessment of locomotion score was not performed prior to gathering on day one. This was an oversight. To counteract this, the identity of ewes that were noticeably lame on leaving the handling pens was recorded. The initial stratification was not based on lameness because it was possible that some ewes were made temporarily lame by the handling procedure and because it was probable that some lameness, particularly milder lameness, had been missed. Once the allocation of each ewe had been decided on paper, a comparison was made to the list of ewes recorded as lame to ensure that known lame ewes were equally split between the two groups. No allocations had to be changed. An increase in locomotion score severity is positively associated with the presence and severity of ID and FR lesions (Kaler *et al*., 2011) therefore by stratifying by these lesions the potential for bias to have been introduced between groups at allocation through the absence of a thorough locomotion assessment will have been minimised.

In the absence of a coin and to minimise any additional stress to ewes in repeated catching and handling, the 6 ewes that escaped assessment on day one were assessed and allocated on day 2 to alternate groups systematically. This was not ideal and may have introduced an element of observer bias. To minimise this, allocation of the first ewe was made prior to her assessment.

The locomotion, foot conformation and body condition scoring scales used in this study are reported to have high intra-observer agreement (Kaler *et al*., 2009; Foddai *et al*., 2012; Phythian *et al*., 2012). Scoring scales are generally most reliable when carried out by the same person and prior training is received. To minimise potential for between observer bias, all observers were trained to use the scoring systems prior to the start of the study and assessment of locomotion, foot conformation and the presence and severity of foot lesions were carried out by one observer (EMK). Unfortunately it was not possible to have the same observer (GJW) score body condition at T2 and an element of between observer bias may have been introduced into this data between T1 and T2, though reduced by the collective training received prior to commencement of the study and the use of experienced assessors (Phythian *et al*., 2012). The ID and FR lesion scoring scales used have not yet been formally assessed for reliability and repeatability; an assessment of their validation would be useful.

Sheep are prey animals and will therefore mask signs of weakness in the presence of a perceived threat. In order to minimise disruption to the flock and to gain an accurate assessment of lameness during locomotion scoring, identification of individuals in the field was made easier by applying individual number the ewe's flank with red oxide paint and branding irons. In addition, to minimise the potential to under-report the prevalence of lameness, locomotion scoring inspections lasted approximately 1hour with a longer period of time spent recording when sheep were active.

Sheep were left one hour after trimming prior to an assessment of lameness being carried out. This was done to allow the sheep to settle to minimise the potential for under reporting. It was possible that sheep were made temporarily lame by the effect of gathering or trimming. Indeed, the prevalence of lameness was significantly higher for those that experienced an accidental overtrim. Therefore the data for locomotion scoring which immediately followed trimming was excluded from the analysis for associations between treatments, sheep features and the risk of becoming lame.

It was not possible to identify the treatment group a ewe belonged to in the field and so the farmer was blind to the grouping. To further reduce any potential for treatment bias arising between the groups, lame sheep were treated according to the farmer's usual practice with the exception that where practical all sheep with the same locomotion score were investigated at the same time. This was done to ensure uniformity across the groups. There were however 82 ewes lame between T1 and T2 (excluding the data from locomotion scoring 1 hour after trimming) that were never investigated or treated for lameness which either spontaneously recovered or went untreated. Although the proportion was not significantly different between treatment groups, in retrospect, it would have been useful to establish a cause of lameness for these ewes.

Finally, it is possible that the flock size used in this study was too small to detect enough of a difference between treatment groups. Initial calculations were based on a sample size of 88 ewes per group to detect a 20 to 5% change in lameness, disease or foot conformation with 80% power and 95% confidence. A larger clinical trial, involving more than one farm to confirm these results would therefore be useful.

2.5 Conclusions

This is the first randomised clinical trial to examine the effect of routine foot trimming in sheep. On this farm in this flock routine foot trimming was not beneficial. Furthermore, where the shepherd accidentally over trimmed the feet of sheep, which resulted in blood loss or sensitive tissue exposure, routine foot trimming was detrimental. According to published data from Wassink *et al*. (2005) it would have taken approximately 15 hours of laborious work to routinely foot trim all 220 ewes on this farm. If the results from this study are generalisable, and currently there are no reasons to suggest otherwise, routine foot trimming should not be recommended. Farmers who routinely trim in order to improve foot conformation or reduce the prevalence of lameness and disease should be advised to refocus their valuable time on other efficacious prevention and treatment practices which are more time and cost effective. Further research is needed into the factors associated with farmer uptake of advice, targeted at proven prevention and treatment strategies, such as prompt individual treatment of mildly lame sheep with topical and parenteral antibacterials (Kaler and Green, 2008b; 2009; Wassink *et al.*, 2010a; 2010b; Kaler *et al.*, 2010a).

2.6 Study personnel abbreviations used in materials and methods

SNL (Simon Leader), AD (Andy Downes), MJ (Michael Jones), EMK (Elisabeth King), GJW (Geert Wassink), LEG (Laura Green), RGT (Rose Grogono-

Thomas), NU (Natasha Underwood), CR (Claire Russell), RA (Ruth Allingham), ES (Edward Smith), SC (Selin Cooper) and SM (Sam Mason).

Chapter 3 Assessment of farmer recognition and reporting of lameness in ewes in 35 lowland sheep flocks in England

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3.1 Introduction

Lameness is an important cause of poor welfare in sheep, with up to three million sheep lame in the UK each year. Farmers in the UK list lameness as their top health concern after sheep scab (Morgan-Davies *et al*., 2006). Lameness results in reduced body weight (Marshall *et al*., 1991), poor body condition, increased mortality in lambs and ewes, increased numbers of barren ewes, an increased time to finish lambs (Wassink *et al*., 2010a) and reduced wool growth (Stewart *et al*., 1984; Marshall *et al*., 1991).

Estimates of the prevalence of lameness in sheep flocks in the UK come from studies that have relied on farmer estimates. The period prevalence of lameness from a stratified random postal survey was 8% in 1994 (Grogono-Thomas and Johnson, 1997) and 10.4% in 2006 (Kaler and Green, 2008a). Researchers have also used farmer estimates of the prevalence of lameness to identify risk factors for the prevalence of FR (Wassink *et al*., 2003a) and ID (Wassink *et al*., 2004), to investigate farmer satisfaction with management of lameness (Wassink *et al*., 2010b) and the proportion of sheep lame with specific foot lesions (Kaler and Green, 2008a). All these studies assume that farmers can both recognise lame sheep and that they report the prevalence of lameness in their flock accurately.

Research has shown that farmers underestimate the prevalence of lameness in dairy cattle considerably when compared with an independent observer, with farmer estimates of 5.7% compared with 22.1% (Whay *et al*., 2002) and 6.9% compared with 36.0% (Leach *et al*., 2010a). Whilst there was some correlation between dairy farmer and researcher estimates of lameness, farmers underestimated the prevalence of lameness by two to seven fold, with no consistent pattern to explain the variation in estimation. Whatever the underlying reason behind the inaccuracy of estimates of prevalence of lameness given by dairy farmers it is clearly a concern that sheep farmers might also underestimate the prevalence of lameness. If they do to the same extent as dairy cattle farmers, then the true prevalence of lameness in UK sheep flocks would be as high as 31-54%.

In a recent study, sheep farmers correctly identified non-lame sheep and sheep lame with locomotion score 2 to 6 (Table 36) when looking at video clips of sheep standing and walking (Kaler and Green, 2008b). From this study the authors concluded that sheep farmers recognise lame sheep in videos, even when their locomotion is only mildly abnormal (score 2) but that they made a separate decision on whether to treat lame sheep. However, the authors concluded that they did not know whether farmers identified lame sheep in their flocks as they did in video clips.

It is not known whether the figure a farmer gives for the prevalence of lameness in his/her flock includes all severities of lameness from mild to severe, or if the figure refers only to those sheep that are perceived to be sufficiently lame to require treatment or to the number that have been treated. Moreover, it is not known whether a farmer's estimate of prevalence is correlated to the true prevalence in his/her flock. These were the areas of investigation in the current study.

3.2 Materials and methods

To estimate the number of farmers visited it was assumed that 90% of farmers would recognise locomotion score of 2 (Kaler and Green, 2008b) with a 95% confidence interval and 10% precision (Stata SE 10.0, StataCorp). A sample size of 35 was estimated. Farmers were selected on the basis of compliance and a convenient travelling distance. They comprised a range of flock sizes, commercial and pedigree operations, and male and female shepherds. The 35 sheep farms were visited once by one researcher (EMK) between December 2008 and May 2009. Farmers were selected from a database of compliant farmers who had expressed an interest in participating in research into lameness in sheep at the University of Warwick (n = 29), from the EBLEX (the organisation for the English beef and sheep industry) English Performance Recorded Flocks Directory 2008 (EBLEX, 2008b) with permission from EBLEX (n = 3), by networked introductions with farmers (Rubin and Rubin, 1995) (n = 1) and through snowball sampling (Sarantakos, 2005) *i.e.* suggested by other participants (n = 2).

3.2.1 Study design

Ethical approval for the research project was granted in accordance with the University of Warwick's ethics approval procedures. Farmers were contacted by telephone and asked if they were interested in participating in a study involving a single farm visit to assess lameness. If the farmer expressed an interest, they were asked the approximate prevalence of lameness in their flock and the size of their flock. A participant information leaflet was then sent by post. A further telephone call was made approximately two weeks later to arrange a convenient date to visit the farmer. A letter confirming the date and time of the visit, the researcher's contact details and further details about the visit was then sent by post. A final telephone call was made one to two days before the visit. On all farms, the person who had every day care of the sheep flock was the person interviewed by the researcher. On the day of the visit, the interviewee was asked to sign a consent form agreeing to take part in the study.

3.2.2 Assessment of lameness in the flock

Once on the farm, the researcher asked the farmer to give an estimate of the period prevalence of lameness for the whole flock in 2008 and for an estimate of the current prevalence of lameness in the flock. The farmer was then asked to estimate the current prevalence of lameness in the group of sheep with the highest prevalence. The researcher then inspected this group for up to one hour without the presence of the farmer and estimated the prevalence of lameness using a validated locomotion scoring system (Kaler *et al.*, 2009) (Table 36). The farmer was blind to the researcher's estimate of prevalence of lameness until the end of the visit.

The farmer was then asked to return to the field and to walk with the researcher and identify all sheep that they saw lame in the group. For each sheep that was identified by the farmer, the researcher recorded the severity of lameness and asked the farmer whether the sheep was lame enough to be caught and whether or not the farmer would include this sheep in an estimate, when reporting lameness *e.g.* in a postal survey. When it was unclear which sheep was being referred to, the researcher sought clarification. To further reduce the possibility that the researcher and farmer were observing different sheep, the farmer was asked to point to all lame sheep seen until a pattern could be established. This was repeated until the threshold locomotion score of sheep that the farmer considered lame was established. The farmer was then asked to re-estimate the prevalence of lameness in the group from his/her observations.

On two farms where there were very few lame sheep and it was therefore difficult to ascertain the farmer's definition of lameness, five randomly ordered video clips (Kaler and Green, 2008b) of lame sheep with locomotion scores 1, 2, 3, 4 and 5 were shown to the farmer on a laptop computer. Farmers were not told the severity of the locomotion score of the sheep. They were asked whether the sheep was lame, was lame enough to be caught and whether or not the farmer would include this sheep when reporting the prevalence of lameness.

3.2.3 Data input, preparation and management

Data were recorded on standard forms. Each farm was given a numerical identity to ensure that the farm identities remained anonymous. Farmer names and addresses were not stored electronically. Data were entered into Access® 2007 (Microsoft®). Where possible, data were coded and drop down lists were used in preference to text fields. Queries were used to check for errors and any anomalies were checked against the original paper record sheets. Data were extracted from the database and checked for errors before exporting to a spreadsheet (Excel® 2007, Microsoft®) and then to a statistical analysis programme (Stata® SE 10.0, StataCorp LP).

3.2.4 Definitions of lameness

The *period prevalence* was the average prevalence of lameness for the whole flock between January and December 2008 estimated by the farmer on the day of the visit.

The *point prevalence* was the prevalence of lameness in the whole flock on the day of the visit, estimated by the farmer.

The *farmer initial prevalence* was the prevalence of lameness estimated by the farmer for the group of sheep inspected by the researcher.

The *farmer re-estimate of prevalence* was the prevalence of lameness re-estimated by the farmer for the group of sheep on the day of the visit, after observation with the researcher.

The *researcher estimate of prevalence* was the prevalence of lameness recorded by the researcher in the group of sheep on the day of the visit, where a lame sheep was defined as a sheep with a locomotion score ≥ 2.

3.2.5 Statistical analysis

Data from all 35 farms were included in the analysis. The median flock size and median number of sheep examined per farm were calculated. The five estimates of prevalence of lameness made by the farmer and researcher were compared with each other and with increasing thresholds of locomotion score and with the minimum locomotion score that the farmer recognised, reported and caught individual lame sheep for inspection using Spearman's rank correlation tests (Petrie and Watson, 2000). The farms were grouped into three categories ranked by the researcher's estimated prevalence of lameness of ≤ 5.0%, > 5.0 but ≤ 9.0%, and > 9.0%. The mean initial farmer estimate of lameness within each category was compared with the mean researcher estimate within each category using *t*-tests.

3.3 Results

Farms were located in Warwickshire (n = 8), Worcestershire (n = 8), Gloucestershire (n = 7), Oxfordshire (n = 7), Northamptonshire (n = 2), Herefordshire (n = 1), Cambridgeshire (n = 1) and the West Midlands (n = 1). Twenty eight farms were commercial, six were pedigree and one had both pedigree and commercial flocks. Thirty-one shepherds were male and four were female. The median number of breeding ewes per flock was 330 (interquartile range (IQR): 220 - 550).

3.3.1 Researcher estimates of locomotion score

The median number of ewes observed by the researcher per farm was 112 (IQR: 89 - 164): 5198 ewes were examined in total. Four hundred and forty (8.5%) ewes had a locomotion score > 0 with 359 (6.9%) ewes with a locomotion score of ≥ 2. Eighty one (1.6%) were locomotion score 1, 172 (3.3%) were locomotion score 2, 131 (2.5%) were locomotion score 3 and 50 (1.0%) ewes were locomotion score 4. The maximum locomotion score observed was locomotion score 5 (Table 36) in six sheep. The median abnormal locomotion score observed by the researcher across all farms was locomotion score 2 (IQR: 2 - 2.5). The mean prevalence of each locomotion score is presented in Table 36.

3.3.2 Estimates of prevalence of lameness

The median farmer estimated period prevalence of lameness for 2008 was 5% (IQR: 4 - 10%) and the median point prevalence for the flock on the day of the visit was 5% (IQR: 3 - 6%). These estimates were correlated (Spearman's rho = 0.69, $p < 0.01$) but not significantly different when compared using a paired *t*-test ($z = 1.35$, $p = 0.18$) (Figure 5 and Table 37).

The median prevalence of lameness in the group with the highest prevalence initially estimated by the farmer was 5.4%, significantly lower than the researcher's estimate of 7.9% ($z = 2.15$, $p = 0.03$). Nine farmers gave initial estimates above the researcher's estimate, 19 below and seven were identical. The correlation coefficient was 0.73 ($p < 0.01$) (Figure 6, Figure 7(c) and Table 37). The farmer re-estimate was also significantly lower than the researcher's estimate (median 5.8, $z = 2.22$, $p = 0.03$). Six farmers gave estimates above the researcher's estimate, 16 below and 13 were identical (Figure 6), giving a higher correlation of 0.86 ($p < 0.01$) (Table 37 and Figure 7(d)). The farmer initial and re-estimates were highly correlated ($rho = 0.89$, $p < 0.01$) (Figure 6).

Table 36: Percent of sheep by locomotion score with standard error and the percentage of farmers that recognised, reported and caught each locomotion score

Locomotion score	**0**	**1**	**2**	**3**	**4**	**5**
Definition (Kaler *et al*., 2009)	Sound	Uneven posture, shortened stride on one leg	Visible nodding of head in time with shortened stride	Not weight bearing on affected limb when standing	Not weight bearing on affected limb when standing or moving	Difficulty rising, reluctant to move, more than one limb affected
Mean (±SE)% adjusted for farm	90.6 (± 0.8)	1.8 (± 0.3)	3.6 (± 0.4)	3.1 (± 0.4)	0.8 (± 0.2)	0.1 (± 0.1)
Mean (±SE)% unadjusted for farm	91.5 (± 0.8)	1.6 (± 0.3)	3.3 (± 0.5)	2.5 (± 0.45)	1.0 (± 0.3)	0.1 (± 0.1)
N (%) recognised lame by farmer		9 (25.7)	35 (100)	35 (100)	35 (100)	35 (100)
N (%) reported lame by farmer		3 (8.6%)	32 (91.4%)	35 (100)	35 (100)	35 (100)
N (%) caught by farmer		2 (5.7)	16 (45.7)	33 (94.3)	35 (100)	35 (100)

Locomotion score 6, will not stand or move (no sheep were observed with this score)

Figure 5: Scatter diagram of the point prevalence of lameness on the day of the visit against the period prevalence of lameness in 2008 both reported by farmers

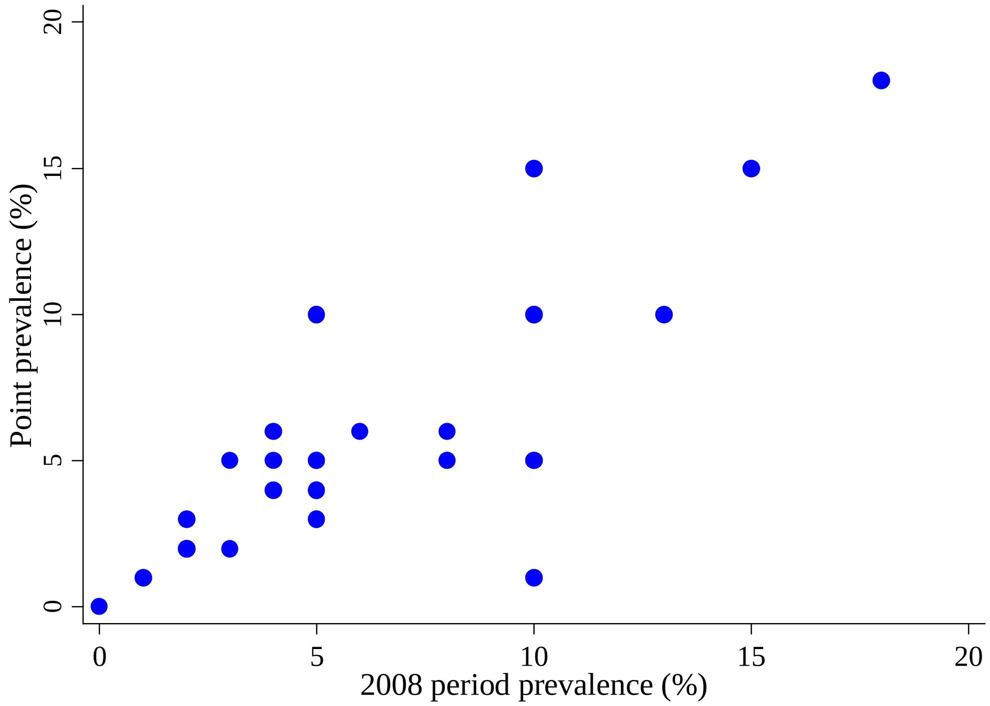
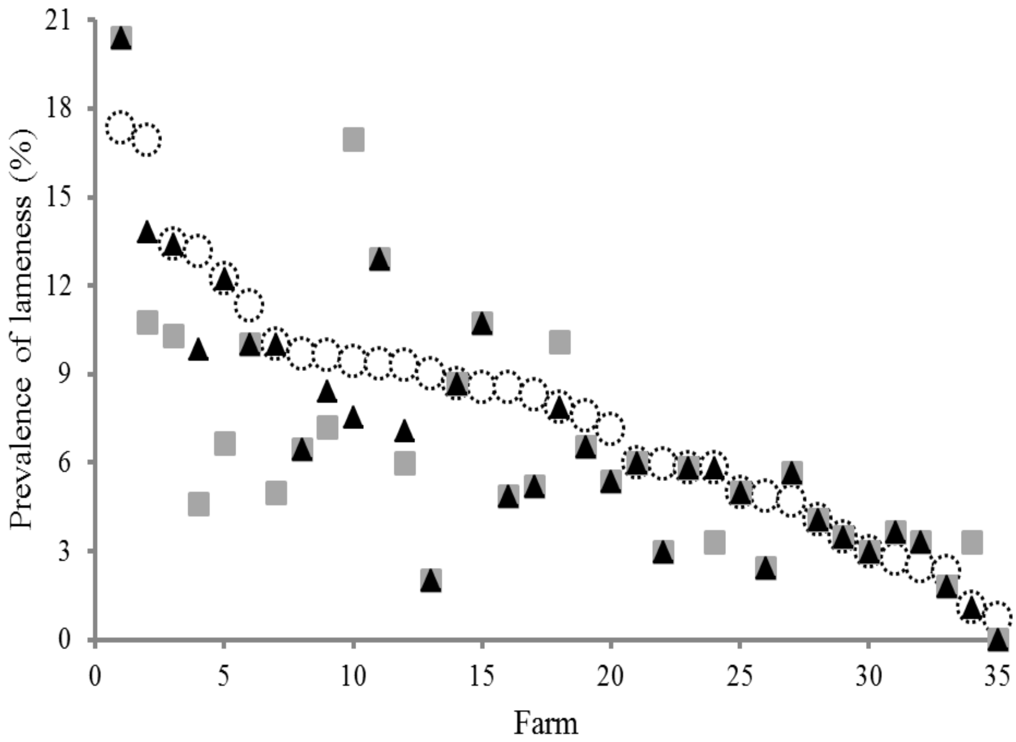


Table 37: Spearman correlation coefficients (*rho*) for observations on lameness

		1	2	3	4	5	6	7	8	9	10
1	2008 period prevalence										
2	Flock point prevalence	*0.69									
3	Farmer initial group prevalence	0.31	*0.56								
4	Farmer re-estimate group prevalence	*0.38	*0.62	*0.90							
5	Group prevalence LS ≥ 2	*0.37	*0.56	*0.73	*0.86						
6	Group prevalence LS ≥ 1	*0.40	*0.62	*0.69	*0.94	*0.83					
7	Group prevalence LS ≥ 3	0.10	0.32	*0.68	*0.85	*0.71	*0.78				
8	Farmer consider sheep lame	-0.19	-0.03	-0.24	-0.06	-0.23	-0.11	-.06			
9	Farmer report sheep lame	-0.08	-0.05	-0.07	0.17	-0.09	0.13	0.30	*0.47		
10	Farmer catch lame sheep	0.09	-0.01	-0.03	-0.12	-0.13	-0.21	-.04	0.26	0.29	

* $p < 0.05$; LS: locomotion score.

Figure 6: Prevalence of lameness in the group examined by researcher (circle), farmer initial estimate (square) and farmer re-estimate (triangle), ranked by researcher's estimate

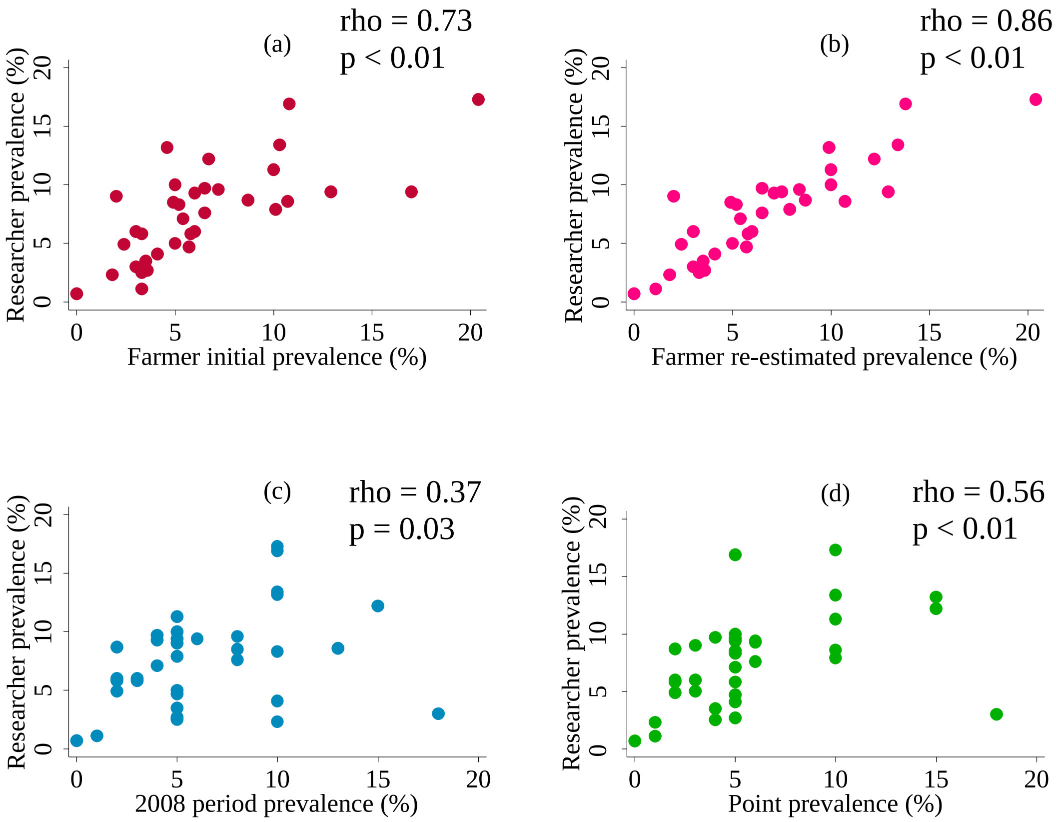


3.3.3 Correlations between estimates of lameness

The majority of estimates of lameness were correlated with each other (Table 37, Figure 7). The farmers initial and re-estimate of prevalence of lameness were highly correlated with each other and both were correlated with the researcher's estimate of prevalence of lameness with locomotion score ≥ 2. The period prevalence of lameness was correlated with the point prevalence of lameness for the flock on the day of the visit but not to the researcher's estimate of lameness in the group. The point prevalence of lameness in the flock was correlated with the farmers' initial and re-estimate of prevalence of lameness in the group.

When the three farmers who said they would report a sheep lame from locomotion score 3 and above were removed from the analysis and Spearman's rank correlation tests were re-run, the correlation coefficients increased. The analysis was also re-run excluding the three farmers who said they included sheep with locomotion score 1 and above in their estimate of lameness, and the correlation coefficients decreased. These results suggest that these farmers did in fact report lameness at locomotion score ≥ 3 and ≥ 1 respectively.

Figure 7: Scatter diagrams of researcher estimated prevalence of lameness against farmer estimates of (a) the initial group prevalence (b) re-estimated group prevalence, (c) the 2008 period prevalence and (d) the point prevalence of lameness



3.3.4 Farmer recognition, reporting and catching of lame sheep

All farmers in this study considered sheep with locomotion score 2 lame. Nine (25.7%) farmers considered that sheep with locomotion score 1 were lame, but only three of these said that they would report sheep with locomotion score 1 in their estimate of prevalence of lameness (Table 36). Thirty two (91.4%) farmers would have included sheep with locomotion score 2 in their estimate of prevalence of lameness with the remaining three farmers including only sheep with locomotion score 3 or above (Table 36). Two farmers said that they caught sheep with locomotion score ≥ 1 for inspection, 16 caught sheep with locomotion score ≥ 2, 15 farmers caught sheep with locomotion score ≥ 3 and 2 farmers caught sheep with locomotion score ≥ 4 for inspection (Table 36). The minimum locomotion score that farmers caught a lame sheep for inspection was not significantly linearly correlated with the minimum locomotion score that they recognised as lame or reported as lame. It was also not correlated with the prevalence of lameness in the flock with increasing thresholds of severity (Table 37).

Twenty five farmers in this study said that their estimate of lameness included all lame sheep on the farm. Eighteen said that they would include treated sheep that were still lame in their estimate; the remaining 17 would exclude them. Nine farmers said that their estimate referred to only those sheep that were lame enough to warrant treatment, ‘treatment’ also included whole flock treatments *e.g.* footbathing, rather than just individual treatment and so the estimate did not refer to what they would catch for individual treatment. In addition, farmers said they might sometimes exclude sheep from estimates if there was some known or unusual reason for lameness. For example, a long term medical reason such as arthritis or a prolonged recovery from a physical injury.

3.3.5 Using farmer estimates as a predictor for the true prevalence of lameness

When the prevalence of lameness recorded by the researcher by was > 9% (n = 12) the farmers mean estimate was a significant 2.0% (95% CI: 0.9 to 5%) lower. When the researcher estimate of lameness was ≤9% but > 5% (n = 12) and ≤ 5% (n = 11) the mean estimate by farmers was 1.5% (CI: -0.2 to 3.2%) lower and 0.1% (CI: -0.9 to 0.7%) higher, respectively, these differences were non-significant.

3.4 Discussion

To reduce observer bias, a single, trained researcher was used to observe and record the prevalence of lameness in all thirty-five flocks. The locomotion scoring system used was objective with very high intra-observer agreement (Kaler *et al*., 2009). Sheep were defined as lame if their locomotion score were ≥2 (Table 36) because this is the lowest score at which sheep can be consistently categorised as lame (Kaler *et al*., 2009). To observe as many lame sheep as possible and to maximise the opportunity for the farmer and researcher to observe the full range of locomotion scores, the group with the highest prevalence of lameness was inspected. Participants' responses can vary depending on the way in which research is conducted, with participants more likely to give more socially acceptable or morally correct response in face to face settings (Krysan *et al*., 1994). As a consequence, farmers may have felt pressure to identify lame sheep that they would normally not consider lame. To reduce this risk, the researcher asked the farmer to identify lame sheep rather than decide whether a sheep identified by the researcher was lame.

Whilst the farmers in this study did not use the locomotion scoring scale, their observations conformed consistently to the scale with 3, 29 and 3 farmers consistently including sheep with LS $\geq$ 1, LS $\geq$ 2 and LS $\geq$ 3 in their estimate of lameness. This indicates that farmers had some consistent mechanism to classify lame sheep. This was also apparent from the threshold figures where the farmer estimates of lameness were most highly correlated with the researcher estimates of sheep with locomotion score $\geq$2 (Table 37). This is in contrast to the results from Leach *et al*. (2010a) who reported that dairy cattle farmers used inconsistent definitions for lameness and so the researcher estimated prevalence (from a defined scale) did not consistently predict the farmer prevalence.

All the farmers in the current study considered that sheep with a locomotion score of 2 (and all >2) were lame. These were compliant farmers who were interested in research in lameness; consequently they might have been able to recognise lameness at a lower locomotion score than some of the farmers in Kaler and Green (2008b) where only 90% of farmers considered sheep with a locomotion score 2 were lame. Despite considering them lame, 50% of farmers in the current study reported that they would not treat sheep with locomotion score 2 (Table 36) with some only treating sheep with locomotion score 4 and above which has important implications for animal welfare (as discussed later). These findings are in agreement with the findings of Kaler and Green (2008b) who used video clips to prompt farmer responses and adds evidence to the hypothesis that sheep farmers can identify even mildly lame sheep but make a separate decision on whether to catch and treat them.

The farmer estimates of lameness were slight under estimates compared with the researcher estimate in the current study, particularly at a higher prevalence of lameness. There are several explanations for this, some farmers only included sheep lame enough to warrant treatment, some excluded lame sheep that had been treated and some excluded individual sheep with prolonged lameness. A few farmers also remarked that the figure that they had given as an initial estimate was what they had estimated a few days earlier. More precise estimates of lameness would therefore be gained by including subsidiary questions on numbers lame, lame and treated, insufficiently lame to treat and the frequency of inspections. This also probably explains the reduction in correlation between estimates on the day and for previous time periods (Figure 7). In future, an increased precision in estimates might be obtained by requesting the current point prevalence of lameness or shorter period prevalence eg, months of the year as in Wassink *et al.* (2004).

The underestimate in prevalence of lameness was approximately 20% in flocks where the researcher estimated the prevalence of lameness was >9%; this is small compared with the 200 – 700% underestimate reported for dairy cattle farmers by Leach *et al*. (2010a). Farmers with a higher prevalence of lame sheep might have made underestimates if there was a threshold of lameness above which farmers might have been unwilling to report accurately, *i.e.* farmers voluntarily or involuntarily reporting a lower prevalence of lameness. Voluntary underestimates might occur if there was a negative effect of reporting high prevalence of lameness *e.g.* The Single Payment Scheme in Great Britain requires that farmers keep minimum standards for the care and husbandry of their sheep to qualify for full payment, under Cross compliance Animal Welfare (Statutory Management Requirement (SMR) 18) (Rural Payments Agency, 2010). If on cross compliance inspection, a high prevalence of lameness is observed (although a recommended ceiling of acceptability is not stated) and deemed to breach SMR 18, this will reduce the payment. Consequently, some farmers might not wish to report above a certain 'acceptable' level and voluntarily under report the prevalence. Farmers might also perceive the prevalence of lameness in their flock to be lower than it actually is through an entrenched prior belief and therefore involuntarily under estimate the prevalence of lameness; this is an example of cognitive dissonance where behaviour changes belief (Festinger and Carlsmith, 1959). Finally, farmers that are exposed to lame sheep might become desensitised (Whay *et al*., 2002) and underestimate the prevalence, particularly where there is a high prevalence of lameness.

The method of participant selection in this study *i.e.* compliant farmers already interested in research in lameness in sheep probably accounts for the lower mean prevalence of lameness (5% *cf.* 8 – 10%) in the flocks in this study. Based on the findings of the current study, it is likely that the estimates from Grogono-Thomas and Johnston (1997) and Kaler and Green (2008a) are underestimates, with the actual prevalence of lameness 2 - 3% higher than that reported by these two studies. This has both welfare and economic implications with a higher prevalence of lameness in the UK than previously estimated.

Studies of risk rely on consistent reporting of exposures and disease. The results from the current study indicate that the use of farmer estimates of prevalence of lameness in sheep is a sufficiently consistent, accurate and reliable tool in studies of risk where the prevalence does not have to be precise but the estimates do need to be consistently lower or higher so that when flocks are compared the relative risks are valid. The results from the current study add validity to the findings of previous studies that have used farmer estimates of the prevalence of lameness in sheep flocks to identify risk factors associated with lameness. The significant but lower correlation coefficients observed between the period prevalence in 2008 and the researcher's estimate, in comparison with the farmer's initial, re-estimate and point prevalence, might suggest that there might be recall bias or reduced ability to appraise an average prevalence of lameness over a period of time. However, it might be that the period prevalence simply differed from that of the point prevalence and researcher estimate because the prevalence of lameness varied over the previous 12 months. It is difficult to validate a farmer estimate of the prevalence of lameness over 12 months.

3.4.1 Animal welfare implications

The precision of estimates of prevalence of lameness indicate that farmers are a reliable source for such estimates. Previous research papers into risks for lameness are therefore likely to be valid and provide useful information for farmers and advisors to reduce lameness in sheep. In addition, sheep farmers can recognise lame sheep. This means that there is one less barrier to reducing the prevalence of lameness than there is in dairy cattle (Leach *et al*., 2010). However, sheep farmers make a separate decision on when to catch and treat lame sheep; more than 50%

in the current study would not catch sheep until locomotion score 3 or 4, a similar result to Kaler and Green (2008b). FR and ID cause > 80% of lameness in sheep in the UK (Kaler and Green, 2008a) and infectious sheep are the main source of infection for susceptible sheep. Consequently, prompt, effective, individual treatment of mildly lame sheep reduces the prevalence and incidence of lameness (Green *et al*., 2007a; Hawker, 2008; Wassink *et al*., 2010a). The results of these studies suggest that > 50% of farmers in the current study could reduce the prevalence of lameness and increase the welfare of their flock if they caught and treated appropriately sheep with locomotion score 2. Lame sheep that are untreated have reduced productivity and reduced welfare (Wassink *et al*., 2010a) and so research into factors that influence farmers' decisions to catch lame sheep is still required.

3.5 Conclusion

In conclusion farmers recognise even mildly lame sheep but make a separate decision on whether to catch and treat them. The use of farmer estimates of prevalence of lameness are sufficiently accurate for studies of risk but probably underestimate the true prevalence of lameness, particularly in flocks with a prevalence of lameness >9%. It is recommended that future studies requesting farmer estimates of lameness in sheep include additional questions on numbers lame and treated, lame and not treated and lame but not sufficiently lame to warrant treatment. A further study with a random population of producers might also be beneficial to confirm these results.

Chapter 4 English lowland sheep farmers' perspectives of management of lameness in their sheep flocks: a qualitative study

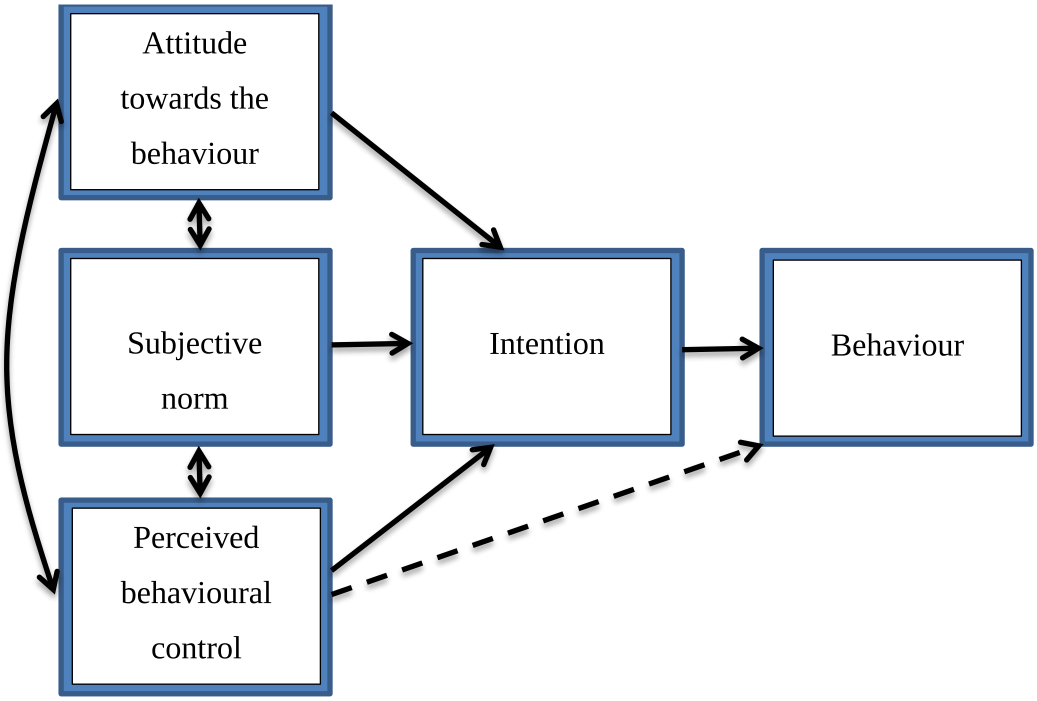
4.1 Introduction

If scientific research is to have successful impact on the sheep industry, an understanding of the factors that drive increased efforts by farmers to reduce lameness, as well as those that act as a barrier, are essential. This understanding will enable researchers and industry to successfully frame the key messages of research outcomes that inspire and motivate sustained change within the sheep farming community. It will also enable researchers to design future epidemiological studies that are sheep farmer focused, sensitive and perceptive to their concerns with outcomes that are designed to offer maximum impact to the industry.

Although research into decision making in agriculture dates back 60 years (Jones, 1963), there has been a shift away from traditional theories that consider farmers as the rational profit maximiser (Bigras-Poulin *et al*., 1985), towards a holistic, multi- and inter-disciplinary approach to understanding farmer decision making. Financial incentives alone are considered insufficient motivators for adopting change (Greiner *et al*., 2009) and there exists a wide range of potential motivators with non-financial benefits (McKenzie-Mohr and Smith, 1999). A good review of influences prompting farmers' decisions is provided by Edwards-Jones (2006). These include demographics, personality, social interactions and local culture, farm size and typology and the characteristics of the technology/practice to be adopted.

There are a number of theories that provide a framework to understand farmer decision making, three of which emerge as important. The theory of planned behaviour (TPB) (a development of the theory of reasoned action) is an important and well-established theory in social psychology that provides a conceptual framework for predicting behaviour from attitudes (Ajzen, 1991). The TPB (Figure 8) states that in order for an individual to adopt a specific behaviour the individual must have prior intention to perform the behaviour. Intention is formed from three elements: the individual’s attitude towards the specific behaviour, perceived behavioural control and subjective norm. Subjective norm is the individual’s perception of the behaviour as influenced by the opinions of those important to the individual in question; and perceived behavioural control relates to the requirement that the individual must perceive that they have the resources and opportunities to achieve the specific behaviour. The more positive these three elements are, the stronger the intention will be to perform the behaviour.

Figure 8: Theory of Planned behaviour (modified from Ajzen, 1991)



Consequently, if researchers wish to encourage farmers to foster specific lameness management behaviours, it is important to understand the attitudes, perceived obstacles and social referents of sheep farmers, within the specific context of management of lameness in sheep. TPB has been extended in recent years to incorporate: role merger *i.e.* the extent to which an individual sees their role as part of defining him/her-self (Piliavin and Callero, 1991); perceived self-efficacy *i.e.* confidence in his/her ability to effect change (Armitage and Connor, 1999); personality (Austin *et al*., 2005); moral norms *i.e.* a moral responsibility to act in a certain way (Lemmens *et al*., 2005) (although this does not consistently correspond with behavioural intention or society opinion (Hardeman *et al*., 2002)); and anticipated regret *i.e.* negative emotions associated with a future negative outcome that could be avoided by a current action (Sandberg and

Conner, 2009). Attitudes have also been split into affective and cognitive, but these are not consistently predictive of behaviour (Tramimow and Sheeran, 1998).

Two alternative models to the TPB provide a broader framework to understand farmer decision making but, to the author's knowledge, they have not been applied to understand beliefs and attitudes to animal health; although they are both being used in a current study to understand farmers' treatment decisions on lameness in sheep (Kilbride *et al*., 2012). These models are the common sense model of illness (CSM) (Leventhal *et al*., 1980) and oneness (Cialdini *et al*., 1997). CSM suggests that attitudes towards symptoms and causes of an individual's or another's illness determines management of the disease, appraisal and compliance adopted. A good review of CSM is provided by Hagger and Orbell (2006). Oneness represents the extent to which an individual views another as similar to him/her-self. Farmers that have greater oneness with their livestock may therefore have greater empathy resulting in improved farm animal welfare. Indeed, this hypothesis is conceivable because Kielland *et al*., (2010) found that dairy cattle farmers had greater empathy and better cow welfare outcomes where they perceived animals to feel pain similar to humans.

Research on farmer behaviour and motivation has received increasing attention in the last two decades but the literature in relation to sheep flock health is limited. Current knowledge of farmer attitude, motivation and decision making using TPB is greater for conservation within agriculture and less for animal health. The former includes for example adoption of conservational irrigation technology for strawberry farmers in Florida (Lynne *et al*., 1995); farm forestry programmes of farmers in Pakistan (Zubair and Garforth, 2006); business and environmental orientated farming behaviours of farmers in Scotland (Willock *et al*., 1999a) and adoption of conservation practices of farmers in England (Beedell and Rehman, 2000). The latter includes for example business and environmental orientated farming behaviours of farmers in Scotland (as above) (Willock *et al*., 1999a), adoption of oestrus detection technology by dairy cattle farmers in England (Garforth *et al*., 2006) and how behaviour and attitudes explain variability in mastitis incidence in dairy cattle herds in Holland (Jansen *et al*., 2009). Further discussion of the literature below relates to what is known about farmer attitudes towards animal health in sheep and lameness in dairy cattle.

4.1.1 Farmer attitude and decision making in flock management

The paradoxical results of the Wassink *et al*., (2010b) study which examined sheep farmer attitudes towards, and satisfaction with, management practices to treat and control ID and FR were discussed in Chapter 1. These were that footbathing and vaccination were associated with dissatisfaction and a poor use of time and money, and were not associated with a lower reported prevalence of lameness. Yet farmers ranked these practices highly within both their current and ideal management practices to prevent ID/FR. In addition, even though farmers that used individual treatments were satisfied with them, the study indicated that farmers would ideally like to give fewer individual treatments. The authors proposed three explanations for the inconsistent findings: a knowledge gap between research, vets and farmers; practical difficulties treating individual sheep increasing the appeal of whole flock measures, or cognitive dissonance. A fourth explanation was proposed by Green *et al*., (2012) that farmers want improved vaccines and footbaths and want to reduce individual treatments. The author is not aware of further literature specific to farmer attitudes or decision making towards lameness in sheep. A greater understanding of sheep farmers' attitudes towards lameness, the motivators and barriers to treatment of lame sheep would aid successful knowledge transfer and is identified as an area that requires further research (Kaler and Green, 2008b; Wassink *et al*., 2010b).

In 2003, a qualitative study to examine extensive hill sheep farmers' opinions of ectoparasites was carried out in the UK using focus group interviews (Morgan Davies *et al*., 2006). The authors reported that although there was a diverse breadth of opinion expressed by these farmers, they considered the negative impact of ectoparasites greater on welfare than productivity. Diverse opinions were partially explained by past experience; with those who had the highest incidents of ectoparasites expressing greater concern and *vice versa*. However, despite wide variation in opinion there was no relationship between the treatments used by farmers, flock size, farm typology or farming intensity. A cautionary note pertaining to the uniqueness of farms grouped within a single husbandry system (extensive hill sheep farming) was also raised by the authors against those seeking a one solution fits all policy. This study also highlighted that 50% of the farmers interviewed were unhappy with the general shortage of farm labour; a lack of which was considered a significant challenge to the application of ectoparasite control measures which might negatively impact on sheep welfare. Challenges presented included incomplete gathering resulting in some individuals missing treatment, and a lack of skill resulting in incorrect treatment and or dosage. The negative impact of farm labour shortages on extensive hill sheep farming is discussed further by Waterhouse (1996).

A study by Austin *et al*. (2005) examined the attitudes of 123 Scottish sheep farmers and 70 Scottish pig farmers to farm animal welfare. The results showed that farmers were dichotomised into two: those that were welfare orientated and those that were business orientated, with sheep farmers significantly more empathetic and welfare orientated than pig farmers. It also showed male farmers to be significantly more business orientated and less sensitive to animal welfare compared with their female counterparts (although a caution was expressed by the authors due to the small number of females (n = 12) within the study).

Using focus groups and adaptive conjoint analysis Stott *et al*. (2005) studied the effect of alternative husbandry practices on farmer perception of profit and animal welfare in extensive hill sheep systems in the UK. The study, in which farmers registered their preference for different husbandry systems, showed that elevated welfare scores were associated with elevated levels of farm input. The greatest financial gains were achieved with low welfare/low input systems; although where farms could include fixed farms costs this balance was adjusted to give high welfare for intermediate financial gain. The diverse range of welfare scores farmers gave for similar values of incomes, led to the conclusion that improvement in welfare in extensive hill sheep systems was still viable if management practices were tailored to meet individual farm circumstances. This study once again highlights the importance of the variability in farms and the need for the promotion of more than one successful management method for farmers to choose from. However, the external validity of the study is somewhat limited by the small sample size used (~48 farmers).

Although they are not discussed here, further studies include the relationship between farmers attitudes, their goals and their behaviours compared with personality traits (Austin *et al*., 1998a; 1998b; 2001; 2005; Willock *et al*., 1999b).

4.1.2 Farmer attitude and decision making towards management of lameness in dairy cattle

A study in 2006 examined the barriers and motivators for the treatment of lame dairy cattle for 222 UK farmers using a face-to-face questionnaire (Leach *et al*., 2010a; 2010b). In the case of barriers, the study showed that farmer recognition of lameness is poor, with farmers unable to consistently, reliably or accurately estimate the prevalence of lameness when compared with an independent observer (Whay *et al*., 2002; Leach *et al*., 2010a; 2010b). Their perceived concern for the scale of the lameness problem was however positively associated with both researcher and farmer estimates for the prevalence of lameness on farms. In contrast to dairy cattle farmers, sheep farmers are able to consistently, reliably and relatively accurately estimate the prevalence of lameness in their flock (Chapter 3, King and Green, 2011) and this remains one less challenge to the sheep industry. A second related barrier demonstrated by Leach *et al.* (2010a) was that almost a third of dairy cattle farmers were unable to quantify the cost of lameness despite 25 years of availability of this information. The authors provided three possible explanations for this observation: the complexity of the calculation, farmer lack of faith in the accuracy of figures provided by industry, and because losses were not as immediate and visual as other diseases such as mastitis. A third related barrier was the perception of the scale of the lameness problem compared with other herd health issues, with lameness receiving a lower ranking than mastitis (a more direct and visual loss). Overall, key barriers to treatment were lack of resources (time, farm labour and finance) and these issues were perceived by farmers to be out of their control. Lack of, or conflicting information was not a significant barrier to the treatment of lame cows.

Motivators for the treatment of lame cows were less clear. Two motivations were associated (positively) with the prevalence of lameness and these were motivation to reduce the risk of accreditation loss and motivation by pride in a healthy herd (Leach *et al*., 2010b). In addition, non-financial motivators (pride in a healthy herd and empathy for lame cows) were given more important ratings by farmers compared with financial motivators. The authors recommended that industry messages designed to motivate and sustain change would require a breadth of motivators including financial and non-financial, and should specifically include public perception. Benchmarking against other farmers in the context of lameness was not a significant motivator.

Qualitative interviewing is a well-established methodology and is a valuable, valid tool for understanding the range, depth and complexity of opinions (Devine, 1995). Traditionally qualitative methodologies were a tool of the social sciences; their use within the field of veterinary epidemiology is increasing. They are now seen as a key process in the improvement of health and welfare of farmed livestock. To the authors knowledge this is the first research examining motivators and barriers towards reducing lameness in sheep farmers' flocks.

4.1.3 Study aims

The aims of this study were to qualitatively investigate the motivators and barriers for treatment of lame sheep; and to understand what lameness means to sheep farmers; and to use these findings to develop a quantitative postal questionnaire.

4.2 Materials and methods

4.2.1 Study design, sampling strategy and farm selection criteria

This study used qualitative, individual, recorded interviews to explore farmers' attitudes, beliefs and behaviour toward management of lameness in their flock. Data for this chapter were collected in tandem with that of data for Chapter 3 (farmer recognition and reporting of lameness in their sheep flock). Accordingly, the farmers interviewed were a subgroup of the 35 farmers in Chapter 3, with interviews conducted on the same day, immediately following the assessment of lameness. The study design, method, sampling and selection strategy were the same as Chapter 3; with the exception that farmers were also asked whether they would be willing to be interviewed, confidentially, to enable researchers to better understand their perceptions and opinions of lameness in their sheep flock. The subgroup was selected on the basis of compliance, to include a range of flock sizes, prevalence of lameness, and farm characteristics. A modified version of the participant information leaflet (Appendix 5), consent form (Appendix 6), participant instructions (Appendix 7) and covering letters (Appendix 8), which included additional details relating to the interview, were used.

A semi-structured interview schedule (Appendix 9) was developed. The interview questions were divided into five sections and covered: background information about the farmer, farm and flock; flock management on a day to day basis throughout the seasons; beliefs, attitudes and behaviour towards management of lameness in the flock; social referents, the buyer (*i.e.* livestock market or contract with a food supply group), use of their vet and the future. The interview schedule was tested on research colleagues and adjustments made. Ethical approval for the research project was granted in accordance with the University of Warwick's ethics approval procedures. The final interview schedule was pilot tested on the first two farms visited. A research colleague (Dr Geert Wassink) attended the first two farm visits as an impartial observer to provide feedback after the interview, on the interviewer's approach and on the visit generally. The farmers were also asked for their feedback. No adjustments were suggested and the two pilot interviews were included in the analysis.

After each interview, the recorded interview was replayed and examined for emerging themes and concepts. The interview questions/schedule were then adapted or modified for exploration in successive interviews (Rubin and Rubin, 2005). Consequently, analysis was integrated into the data collection process. The interview process was stopped when saturation of the data occurred, *i.e.* no new information was heard (Rubin and Rubin, 2005).

4.2.1.1 Training

Training in qualitative interview design, practical methodology and analysis was sought by the researcher (EMK) during the design phase. Training and practical guidance was provided by Dr Damian Maye (an expert in qualitative interviewing technique) at the Countryside and Community Research Institute, University of Gloucester. In addition, EMK attended lectures given by Dr Justin Greaves as part of the taught module *Introduction to* (qualitative) *research methods* in Warwick's Department of Politics and International Studies.

4.2.1.2 The interviews

The person interviewed was the person who had everyday care of the flock. Seventeen farmers were interviewed individually in-depth by one researcher (EMK) between December 2008 and March 2009. Interviews were face-to-face, soft (*i.e.* the interviewee was guided through the interview without interrogation or pressure), semi-structured, unstandardized (*i.e.* consisted of open questions only) and focused. They were recorded (with consent from the interviewee) using a small digital recording device (Olympus WS-650S) that was positioned on a table or surface between the interviewee and interviewer. It was anticipated that interviews would last approximately 1 hour. The order of sections in the interview schedule were adjusted to follow the flow of conversation for each individual interview. Non-directive probes were used to encourage interviewees to expand short, partial or unclear responses (Sarantakos, 2005; Rubin and Rubin, 2005). If there was difficultly with an interviewees interpretation of a particular question, a diverse array of potential prompts were offered (listed in the interview schedule) but only after question rephrasing had failed. Farmers were encouraged by the researcher to talk freely, openly and honestly throughout, and were told that their opinions were extremely valuable and important. This was emphasised in telephone and postal correspondence prior to the interview, at the start of the interview and, if needed, during the interview. The interview schedule was used as a guide to respectfully lead the conversation back to topic when necessary. To support discussion on lameness management, video clips (Kaler and Green, 2008b) of lame sheep with locomotion scores 1, 2, 3, 4 and 5 were shown in a random order to farmers using a laptop computer. Farmers were asked whether they considered the sheep to be lame and if so, whether it was sufficiently lame to be caught for treatment; they were not told the locomotion score. A final question was included to help uncover additional concepts and themes: whether there was some topic, within the area lameness or otherwise, that had not been covered in the interview that they felt had been missed or they considered important.

At the end of the visit, participants were given a gift bag containing a luxury tin of biscuits and two stainless steel thermos travel mugs with University of Warwick logo and lameness in sheep website address, as a thank you for their participation. Participants were not told about the gift prior to the visit.

Farms were given a numerical identity to ensure that farm and farmer identities remained anonymous. This unique identifier was used to store recordings and for analysis. Names and addresses of participants were stored separately to the digital recording and transcript along with a numerical code to allow their identification by the researcher only.

4.2.2 Analysis of interviews

Interviews were transcribed in full and verbatim by EMK. The researcher, interviewee and other parties were identified separately in the transcription; gestures and expressions were also included. Analysis was driven by the data and focused on the research questions of the study. Coding began after the researcher (EMK) had re-read all transcripts and was familiar with the data. Concepts and themes were systematically identified, refined and elaborated from the transcripts then coded using Excel® 2010 (Microsoft®). Comparisons were made within and between interviews to formulate a focused, rich and reasoned narrative of the research findings (Rubin and Rubin, 2005). The geographical locations of interviewees were plotted using ArcMap (ArcGIS 10.1. Environmental Research Institute Inc.).

The results are discussed within the context of the literature, accompanied with interviewee quotes and estimates of the prevalence of lameness. The discussion focuses on how the results can be applied to existing studies and to inform future studies. Interviewees' accounts are identified by: R (researcher); F (farmer) and W (farmer's wife), followed by a numerical identifier for the corresponding interview and accompanied with farmer's estimate of the point prevalence of lameness in the flock on the day of the researcher's visit.

4.3 Results

The response rate was high at 72.9%. Of the 13 farmers that declined to take part in the study, 9 freely gave a reason (it was not requested). Reasons included: lack of time (2); no longer farming sheep (2); not interested in taking part in research this year (2); currently lambing (1); another farmer taken over the flock (1); and felt they had too few sheep to provide benefit to the study (1).

4.3.1 Descriptive background information

Interviews ranged from 18 to 79 minutes in length (median: 46; IQR: 33 -56 minutes).

4.3.1.1 The farmer

The median age of interviewees was 46.5 years (IQR: 35.8 – 62.3; range: 20 – 82 years). Fifteen interviewees were male; with 2 interviews conducted with the husband and wife farming team. Collectively, their farming experience exceeded 550 years (median: 30; range: 3 – 82 years). In terms of their position on the farm, interviewees described themselves as: owner (including a 3 family member partnership), tenant, part tenant-part owner, shepherd, head stockman, or farm manager. Educational backgrounds and qualifications ranged from none or GCSE level (having left school at 16), to various agricultural qualifications, including degree level, a qualified chartered surveyor and a PhD.

4.3.1.2 The flocks

Fourteen farmers ran commercial flocks, 2 ran pedigree flocks and 1, both pedigree and commercial flocks. The median flock size was 380 (IQR: 250 – 700; range: 30 – 1200). Lambing occurred from December to April, included indoor and outdoor lambing, with 4 farmers having two lambing periods (one period for each of their flocks). Pedigree breeds included: Suffolk; Dorset; Lincoln Long Wool; Charmoise and Lleyns ewes. Commercial breeds included: Lleyns; Texel; North Country Mules; Welsh Mules; Suffolk; Suffolk-crosses; Charmoise x Dorset x Bleu du Maine mixed crosses; and Scotch half-bred ewes. Farmers' estimates for the average period prevalence of lameness in 2008 and point prevalence of lameness on the day of the visit (from Chapter 3) for each farm is given in Table 38.

Table 38: Farmer estimates for the average 2008 period prevalence of lameness and the point prevalence of lameness on the day of the visit by farm.

Farm No.	2008 period prevalence	Point prevalence
1	2	2
2	5	5
3	8	6
4	5	10
5	10	15
6	3	2
7	4	6
8	5	5
9	0	0
10	13	10
11	10	10
12	10	5
13	3	5
14	4	5
15	10	1
16	15	15
17	8	5
Median	5.0	5.0
IQR	4.0 – 10.0	5.0 – 10.0

4.3.1.3 The farms

Farms were located in Oxfordshire (5), Gloucestershire (4), Warwickshire (2), Northamptonshire (2), Worcestershire (2) Cambridgeshire (1) and Herefordshire (1) (Figure 9).

Figure 9: Location of the study area

The maximum altitudes of farms, as calculated from Ordinance Survey (2012) maps, were between 10 and 220 meters (mean: 115m; IQR: 95 - 155m). Farming enterprises ranged from sheep only to mixed that included: arable, other livestock and dairy cattle. Six farms had further diversification that included office and residential lettings, private functions, duck and pheasant rearing, game bird shoots, photo shoots, fishing, caravan storage, and, perhaps the most extreme, motorsport and flying clubs. Farms included organic and non-organic and both a single or interconnected parcels of land (ring-fenced), and geographically dispersed parcels of land (non-ring-fenced).

4.3.2 Monitoring and managing lameness in the flock

4.3.2.1 Farmer recognition of lame sheep in their flock

All seventeen farmers interviewed identified routine inspection of sheep for lameness at some stage during the interview. Their responses were collated to define it broadly as: a general flock check to identify health problems such as fly strike, mastitis, or other concerns, including lameness; to check for individuals that had become cast (stuck upside down) or stuck in hedges, ditches or fences; and to check an enclosure was secure and water/food was available. The majority placed paramount importance on this as a daily task which was put poignantly by one of the farmers:

"The priority, no matter whether it's summer or winter, is to check your stock are all well first thing in the morning. That's the first job. That's priority 365 days a year." (F8, point prevalence 5.0%)

Two of the farmers were keen to point out that the inspection was interactive not just visual and added:

"We always look at the sheep, so we always drive through and make them walk and you can see them." (F10, 10.0%)

We always get them up, make sure we know what's going on. We try to shepherd them from the field and not from the hedge." (F8, 5.0%)

In stark contrast to the daily checks carried out by all other interviewees, one farmer checked his flock every 2-3 days. This tenanted, non-ring-fenced farm had a larger than average ewe flock size (550 *cf.* 222) (DEFRA, 2012) recently reduced from 1200 ewes, and moved from organic to non-organic farming. It ran two commercial sheep flocks, each with its own lambing period with the earlier flock housed during lambing. In addition it had arable enterprises. It employed a full time shepherd (the interviewee), in addition to the full time tenant farmer, with additional help employed in the summer for the arable side of the business. The farm did not stand out from the group as exceptional in any way, except that there was considerable distance between parcels of land, some 7 miles. In comparison, other non-ring-fenced farms were separated by ≤3 miles. The shepherd explained:

"We wouldn't shepherd them every day. Some parts of the year we do. The reason we don't shepherd them every day is because it would probably take … three hours to do it properly. They're all so spread out. Perhaps our shepherding isn't great because we're perhaps a couple of days behind on a problem sometimes. Sometimes going round them every day isn't the best thing. If you go round them every couple of days or every three days, which you can get away with this time of year, you actually pick up more …. If you see something a lot you don't always pick it up. Sometimes if there's a sheep going backwards, after two days she's gone back quite a lot. That's perhaps not the right way to think about it but you do pick things up like that." (F5, 15.0%)

In contrast, some of the farmers added that at certain times of the year, *e.g.* when sheep were fed more than once a day and during lambing, that inspection was carried out more frequently than once per day. For example, farmer 11 who inspected his flock daily explained:

"Of course one would look round then more frequently the closer to lambing you get. … They can get cast of course because closer to lambing they are very large and cumbersome so if that starts to happen you look around them more frequently so that you can catch them before they prolapse because they're cast." (F11, 10.0%)

When farmers were asked what they considered to be the most important task for the flock, 7 of the 17 farmers stated that they considered routine inspection to be their priority. The median point prevalence of lameness for these 7 farms was 6.0% (IQR: 5.0-10.0; range: 5.0-15.0%).

4.3.2.2 Assessment of the prevalence of lameness by farmers

When in the field with the farmer, it became apparent that the number of lame sheep was not specifically counted by farmers unless the intention was to catch for treatment. However, a concept of the number of affected sheep and their relative severity was either consciously or subconsciously noted during this check; either for creating a list of priorities for the day or week ahead and for keeping a check on the prevalence of lameness. This was apparent both from what farmers said in the field and during interviews and was also backed up by the relative accuracy of farmer estimates of the prevalence of lameness in their flocks when compared with the researcher's estimate (see Chapter 3: Farmer recognition and reporting of lameness). The following two quotes typify this:

"Well no we don't specifically look for it (lameness), *we see it as we go to shepherd the sheep …"* (F1, 2.0%).

"…I sort of roughly remember thinking that there were about that many …" (F16, 15.0%).

Farmers considered both the severity of lameness and the number of lame individuals in considering both when to treat and what treatment to give; although which treatment would also partly depend on diagnosis, if any inspection was carried out. Inspections of feet might not be carried out where whole flock treatment measures were used. Farmers typically prioritised management of lameness against other farm activities, the time of year (*e.g.* risk of fly strike, production losses to lambs of lame ewes, where applicable, the availability of assistance, and location of the flock relative to handling facilities. These barriers, amongst others, are discussed further in section 4.3.5. There was unanimity from interviewees that the more severely lame the ewe, or the greater the prevalence of lameness within the flock, the greater the priority assigned to it and the quicker the response. As two farmers said:

"If I thought there were 2 or 3 ewes in a bunch that I thought needed treatment I would bring forward any management exercise … in other words instead of leaving them till next week, I'd do them this week. … I wouldn't go rushing out there this afternoon and catch 6 ewes … it is a very small part of the business … time management is as important as flock management." (F7, 6.0%)

'It just depends on how big a number it's in and how quick it will be before they're in for worm[ing] *or treated for something else and how serious it is you know. If it's really serious I'll catch it and do it straight away; but if it's only limping a little bit it'll most probably have to wait until they come in."* (F2, 5.0%)

4.3.2.3 Treatments given for interdigital dermatitis and footrot

Five farmers solely used individual treatments for lame sheep. The remaining 12 used a combination of individual and whole flock treatments, all of which included footbathing. In addition to individual treatment and footbathing, three farmers (all commercial) vaccinated part or all of their flock against FR; two of which also isolated lame sheep.

4.3.2.3.1 Footbathing

Farmers footbathed in solutions of either: formalin; zinc sulphate or lincospectin and many had experience using all three. Lincospectin was indicated as the preferred footbathing solution by several farmers because it was considered more effective, but expense and incompatibility with organic farming methods limited or precluded its use. In the quotes below farmers use ‘scald’ as the common name for ID.

“For scald I used to love lincospectin because I could walk them through one day and already they were transformed and walk them through the second day and we were back to perfect shape but I’m not allowed to do that with the soil association so I miss that.” (F1, 5.0%)

“If we could use the lincospectin all year round that would be fantastic as it’s absolutely brilliant. If I could afford it I would do it and definitely go back to it because it’s certainly the best, but to fill our footbaths up it would cost about £300 to do. It just isn’t quite viable unfortunately.” (F1, 5.0%)

One farmer considered lincospectin the only effective solution for footbathing for ID. He said:

“I’m not convinced by the footbath; other than putting them through the lincospectin for the scald, but it doesn’t seem to do a lot for anything else.” (F6, 2.0%)

Formalin was indicated by some as less than ideal because of its tendency to harden hooves and because it was unpleasant to both the farmer and painful for the sheep.

"Father was quite keen on using formalin but research has shown that formalin has limited use. All it does is make the feet hard. … I mean if you were to stick a cut finger into formalin it hurts and so you obviously can't get sheep to go through all that enthusiastically (laughs). The ones that want to go through are the ones that haven't got bad feet and I've always been fairly dubious of its efficiency." (F6, 2.0%)

The requirement to hold sheep in footbath solutions for several minutes for the solution to be effective was a limiting factor to the number of ewes that could be effectively treated in a day. One farmer who used zinc sulphate said:

"We have opted to do the footbathing on a semi-regular basis, as much as I can do it on a regular basis. That is a time consuming job because … I've got 3 footbaths in a line to stand 35/40 sheep for half an hour. It's not too bad cos obviously I turn up some of the others and do their feet and treat as necessary so … it does, but it takes up a day." (F10, 10.0%)

4.3.2.3.2 Individual treatments

Individual treatments for ID and FR were in the form of parenteral and or topical antibacterials and often accompanied with trimming of the hoof horn. Only one farmer (F12) gave sheep pain relief as part of his treatment for FR. Moreover, there was a clear distinction between how farmers treated individuals with ID and individuals with FR. Cases of ID were predominantly treated only with topical antibacterial: either selected lame individuals or the whole flock were foot bathed; or individuals were caught and affected feet were sprayed with a topical spray. Only two farmer gave parenteral antibiotic for ID; one only if the ID was '*aggravated*'. He said:

"If it was mild scald I just give it a Terramycin® spray. If I thought it was developing into something I thought was, what I call, aggravated scald, in other words, the hoof was very inflamed then I would jab it." (F7, 6.0%)

The other farmer explained:

"In one sense the scald can only really develop into footrot anyway, so it is easier to jab anything that is lame, to jab it there and then to try to prevent it." (F10, 10.0%)

When asked whether that included mild cases of scald? He went on to clarify:

"If it's [a ewe] *got just a showing in between then that would just get a spray I wouldn't necessarily jab it too much, lambs especially. I would generally only give them* [lambs] *a spray, young lambs ... it would only really get a jab if after a week or more I saw it and it hadn't really improved after 2 or 3 sprays."* (F10, 10.0%)

Cases of FR were unanimously given both parenteral and topical antibacterials, although some farmers only treated severe cases of FR with parenteral antibacterials. One farmer said:

"We never buy any purple spray, that ordinary cheap purple spray; we never have any of that. We always use Terramycin® spray. Terramycin® from the vet at £12 a pot and its money well spent and we only need a fraction of that compared with these cheap purple sprays that you can get. But that stuff actually sticks where it's going and I think that whole bit of that spray is effective. You don't need very much of that. And if you've got a lamb with scald to be fair if you spray them with that one day, and you go look at that lamb the next day, and it can be

completely raw, and the difference is magic I reckon. We have given antibiotic injection for real bad footrot yeah … we wouldn't give them too much jab to be quite honest with you. We wouldn't jab many sheep that were lame. We're probably not jabbing enough. We wouldn't do them for scald." (F8, 5.0%)

This farmer's view on the quality of spray was not shared by all, another farmer commented:

"We just use a purple spray but according to a surgeon whose house overlooks the flock he says well it's just pure alcohol that is. He says you could use anything like that. He says it just dries it up." (F1, 2.0%)

4.3.2.3.3 Trimming hoof horn

There was a trend for a recent reduction or move away from both therapeutic and routine hoof trimming; and away from severe clipping.

"We used to sometimes do the whole lot twice a year [routine foot trimming] *which we've stopped doing because it was labour intensive, because we just don't have the number of people on the farm we used to have … it's best not to do them more than you need to." (F11, 10.0%)*

"If we've got a problem then we get them in and if they've got feet that need trimming they're trimmed but that wouldn't be that many of them. And up till now we have been trimming them if they have got footrot or the abscesses you trim the hoof away to let the air in because that's always been the theory is let oxygen in because the bacteria is anaerobic. … Someone from EBLEX came in with a new theory about not foot trimming their feet. Of which there was quite a long

discussion. That's a new piece of information that we've taken on board, we've thought about and we'll think about some more." (F6, 2.0%)

"I would have said that 3 or 4 years ago we tended to treat, to foot trim everything either once, or twice a year and footbath them more regularly. But now what we tend to do is we treat individual sheep as and when, rather than getting the whole lot in to put through a foot bath or to trim all the feet in one go. It was something that [an independent livestock consultant] *had talked about but I also heard* [University Professor] *give a couple of presentations on it and it basically backed up what* [an independent livestock consultant] *had said so, and I think that until December* [referring to a rise in the prevalence of lameness in his flock], *I would have said that it had been fairly effective because there is nothing worse than turning up 150 ewes when they don't really need it."* (F7, 6.0%)

Most trimmed only excess overgrowth or loose horn, as they considered this necessary to prevent disease. This was particularly important where sheep did not have access to hard, solid ground such as concrete/tarmac perceived necessary to wear down hoof horn; or where soil might accumulate in overgrown hoof horn leading to disease.

"Well if the outer hoof is, well it does sometimes not wear off. When we used to move them quite regularly on the road that was one of the best things for trimming the feet yes but now they're always on soft ground, some of them the hoof grows and it sort of bends underneath so we trim that bit off. I always impress upon anybody that you just do it level. You never trim the back of a sheep's foot." (F1, 2.0%)

"I try not to trim. I do sometimes. I still think that if its curled right over, I know you're not supposed to, but I do take it off because I always feel, I'm probably wrong, but I feel that muck gets in from behind there and then it gets hot and doesn't help. So if something's curled over so it can get muck underneath I will take that off. But I do try not to trim." (F12; 5.0%)

One farmer believed it was necessary to trim back hoof horn of diseased feet to open the hoof up to clear up infection. He said:

"They get a jab and a spray. They would get foot trimmed if they needed it yeah. If they had footrot then it would get foot trimmed and sprayed and jabbed. We try and avoid it but if necessary then it has to be trimmed to open it up and clear it to give less infection." (F10, 10.0%)

When discussing therapeutic foot trimming, another farmer commented:

"I probably shouldn't but yeah I do (laughs). I try not to do it too much. I don't cut it right back, so you can get it all out and all the rest of it, but I do cut it back just a little bit just to get the spray in sometimes". (F16, 15.0%)

4.3.2.3.4 Vaccination and isolation

Isolating lame sheep was not always practical. The two farmers that isolated lame sheep said:

"If you have too many bunches of sheep it's too complicated" (F11, 10.0%)

"I put them in another field try and do them as a block group, erm a bit more time consuming. I haven't yet worked out whether it is effective or not (laughs)." (F10, 10.0%).

There was a trend for vaccination to be used where farmers considered there to be a problem with a high prevalence of lameness.

"I mean with what I do I can keep on top of it, it never gets out of hand that's the thing. Whereas if it started to get out of hand, then I'd probably look at the vaccine. I'd probably think about it." (F14, 5.0%)

It was clear that farmers didn't always follow the data sheet for Footvax® with regard to immediate usage once opened (or data sheets for other vaccinations) which might limit their efficacy.

"We did, as I say, Footvax® about 20 years ago I should think when we had a problem and it seemed to put it right pretty quickly. …and we've done recently Footvax® in the last 12 months when we've got them in we've given then, the bad ones Footvax® rather than do the whole lot. But I mean the trouble with that is that it means having a small pot of Footvax® which goes back in the fridge after being used. But I don't know how much its efficacy after its been in and out for a few times, because you're supposed to do them in theory as with most vaccines they say throw it away at the end of the day but that isn't practical to treat individuals like that if you're throwing it away each time. … I don't think it would do them any harm but it might do less good if it's not been used all in one go. That's why we thought we'd do them all in one go … probably in April." (F11, 10.0%)

"We've just got the ok to be able to give Footvax® to the sheep and allow me to spend some money and get some vaccine. So we just did some yesterday so we'll do some more tomorrow and do the rest. It can only get better (laughs). If it acts

as a preventative it's a cheaper way of doing it so, and if it does cut it down by 4 or 5% then it will just decrease the workload." (F10; 10.0%)

"The vaccinations and so on … I mean you know when, when my brother and the employee moved out, erm I must admit, with the Heptavac its 4-6 weeks your supposed to vaccinate and I let it go over the 6 weeks and vaccinated them then and the result was that I had terrible problems with pasteurella and all the rest of it you know. And erm I didn't realise just how you know specific these *things were, how you've got to do it. And so now I aim at 5 weeks."* (F14, 5.0%)

Heptavac-P Plus (MSD Animal Health, 2013b) is a combined clostridial and pasteurella vaccine to control lamb dysentery, pulpy kidney, struck, tetanus, braxy, blackleg, black disease, clostridial metritis, and pneumonic and systemic pasteurellosis in sheep >3 weeks old. Previously unvaccinated sheep require two doses, separated by 4-6 weeks and an annual booster is recommended 4-6 weeks prior to lambing to provide passive immunity in lambs <4 weeks (MSD Animal Health, 2013b). Consequently, it was not surprising that one farmer said of the *Footvax*® vaccine:

"We don't vaccinate because we've heard very mixed results on vaccination. Some say its jolly good and others say it's a total waste of money so we haven't done that yet." (F3, 6.0%)

4.3.2.4 Routine planning for treating lameness

Despite acknowledgment that lameness was present on the farm all year round, lameness was not a management exercise that was routinely planned. Instead it was managed as and when necessary. Only one farmer (F13, 5.0%) had a routine, year round plan for managing lameness; footbathing his commercial flock weekly when housed and every 3 weeks during the rest of the year. This farmer reported his 2008 period prevalence to be 3.0%, and explained that his increased point prevalence of lameness was attributed to the flock currently being housed. Other farmers said:

"You don't ever say I've got my first lame ewe of the year. …. You're constantly dealing with it … and it's probably the most time consuming thing out of all of it because worming isn't time consuming, treating maggots isn't particularly time consuming because you can stop it, it's quite easy to stop, but lameness is probably the most time consuming out of the lot for us at the moment." (F5, 15.0%)

For jobs outside routine tasks, lameness is probably the biggest problem we have. I think that's the same for most sheep farmers." (F6, 2.0%)

4.3.2.5 Farmer prioritisation of management of lameness

Short video clips of different severities of lameness in sheep (footage taken from other farms) prompted useful dialogue on farmers' prioritisation of farm tasks. It also helped to reveal attitudes towards lameness, and how this influenced behaviour (discussed further in sections 4.3.3 and 4.3.5). A few of the farmers' comments whilst watching the videos relating to prioritisation are given below. The locomotion score of the ewe/lamb that the farmer was watching in the video is given in brackets:

"If I was bringing them in a pen, if they were being penned for a reason then I would investigate it." (F12, 5.0%) (Locomotion score 2).

"Say there's 5 in a group of 150 ewes, I'd probably individually treat them ones, but if it gets any worse, over 10, I'd say then I'd have to get them all in and we'd run them through a solution of formalin or golden hoof or something." (F15, 1.0%) (Locomotion score 2)

"Yes it's lame (locomotion score 2) but no we wouldn't investigate. Given what they're obviously grazing (long lush clover) it's got scald." "If they've got to the stage where they're not putting their foot to the ground we think perhaps we ought to do something about it." (F6, 2.0%) (Locomotion score 5)

"I wouldn't say it was urgent … we tend to get them in when we've got, at that stage, 2 or 3 like that." (Locomotion score 2). "Oh well that one is really bad isn't it (F). And lame on more than one leg (W). Well you'd have to get that immediately." (F1, 2.0%) (Locomotion score 5)

"If that was in my field this morning, I'd do it straightaway." (F2, 5.0%) (Locomotion score 4)

*"If it's a ewe on its own without lambs, yeah you might drive away for a day and say right well I'll do that on a rainy day. If it's a ewe with young lambs you know you seriously have to go and do it because she might lie down a lot, stop producing milk so yeah ... and the temperature of the year ... it could lead to other things." (*F5, 15.0%) (Locomotion score 3)

Treatments to mildly lame sheep were assigned less priority than severe cases of lameness; the latter were treated immediately/very promptly. Farmers tended to wait for a group of mildly lame sheep before providing treatment, delayed treatment of mildly lame sheep to coincide with a future gathering event or brought any planned future gathering event forward. The perception of cause of lameness *e.g.* pasture length; ease of treatment *e.g.* distance to facilities/ease of catching (discussed later), and the potential for negative future outcomes of not acting immediately also effected prioritisation of treatment provision.

4.3.2.6 Identification of individuals for treatment

Having established how farmers recognised and assessed lameness in the field and how they prioritised management of lameness, the researcher asked how farmers identified individual animals that required treatment. Visual identification of individual lame sheep in the field *via* ear tag or ear notching system for subsequent inspection and treatment was done by only three farmers (F9, 0.0%, F16, 15.0% and F17, 5.0%). Two of these farmers had pedigree flocks. Farmer 9 was commercial but distinguished by his meticulous system of ear tagging to improve the genetics of his flock. He always carried a pair of binoculars that he used to read ear tags in the field from a distance. The remaining pedigree farmer (F1, 2.0%) considered himself to have lameness so rarely that identification in the field was not something he considered to be an issue. This farmer had a pedigree flock of Lincoln Long Wools and regularly gathered to trim faecal-matted wool from their tail; during which he treated lame individuals. He stated:

"With the Lincoln long wool breed tail trimming is sort of a constant thing. We call it clagging and I always say to [wife], *if anybody wants me I'm clagging because many days I've spent doing that. While I'd got them in that pen I'd think well that one's probably holding its foot up a bit or it looks a bit tender so I'll treat it."* (F1, 2.0%)

Except farmer 9, all commercial farmers identified only the number of sheep they wished to catch for inspection (see section 4.3.5.4 on catching for treatment). Regarding identification of a lame ewe in the field from a distance one commercial farmer said:

"Could I identify that ewe? Probably not". (F5, 15.0%)

4.3.2.7 Recording lameness in farm records

Three farmers, 2 commercial and 1 both pedigree and commercial, recorded lameness against individual ewe identification numbers in flock records, the latter farmer used EID. In addition, a further 4 commercial farmers used a spray marker to identify the leg treated but did not record a ewe identification number in flock records. The remaining farmers recorded lameness just to comply with the FABBL farm assurance scheme, *i.e.* number of sheep treated and veterinary medicine used in the farm medicine record book. When asked why they didn't record individual identities two farmers said:

"No. there would be too many." (F7, 6.0%)

"It's just another problem. Something else to look at you know. There are so many things to do now ... you almost need a secretary or something to do it." (F14, 5.0%)

4.3.2.8 Culling for lameness

Thirteen of the 17 farmers included lameness within their culling criteria. Repeatedly or chronically lame individuals, and for one farmer, those with granulomas, met the criteria for culling on lameness. However, pardons were commonly mentioned by interviewees for lame ewes that were young, productive or had other favourable traits; although the consequence was also acknowledged:

"Again it's another silly thing… if she is a particularly good looking sheep or she has been good or she's bred something good then she'll stay and get more of a reprieve for being lame than … but then if she's producing others that are going to go on the same then …." (F17, 5.0%)

"We've made the bigger mistake by keeping them and I've done that, I've said she's fine, that's a good ewe she'll be alright and she'd had a problem and then the next year whoosh she's down …. Or your mortality goes high and then you've lost the whole … It's a see saw effect then because they slip right back. So we've learnt again to get shot of them. If you've got one that's persistently lame she's better out of your flock and in the bin somewhere." (F7, 6.0%)

Sheep selected for cull due to lameness did not leave farms immediately. Instead, farmers waited until they were sound enough to be sent to the abattoir.

"You could get [Knackers] *out but that's having it shot and you get nothing towards it. So if you can get it to market just about fit then if you get a tenner for it, it's better than paying* [Knackers] *£18."* (F4, 10.0%)

"If we cull them for lameness they will go when they're walking on all four feet fairly evenly, whenever that may be. Some will be around for a long time while some you can get right and go… When they are right they go otherwise a fortnight later they might have gone back to being lame." (F3, 6.0%)

One farmer's decision to sell cull ewes was also affected by the market price. He said:

"We have a bunch of scrap as it were that I start about now [interviewed February] *… if they can't rear lambs or have got mastitis or whatever then they are given a yellow ear tag and once they have a yellow ear tag that's it. It's just a matter of time until they go. … it obviously depends on the cull ewe price, if we've got a spare paddock that needs grazing down with only 20 ewes or 15 ewes or whatever then we'll kind of keep them all together. But we do, cos obviously you can't sell or send lame sheep to market so we can't, they obviously stay in the local paddocks and then they'll come in more often to go through the baths* [footbath] *to try and get them cured before, to go."* (F13, 5.0%)

Only one farmer felt that the regulations prohibiting the sale of lame sheep were unfair. He said about lame sheep at market:

"The vet comes in there and shoots them on site and throws the carcass away. I think that's just wrong. OK they're lame but they're probably being killed because they are lame and you just can't … It's just a daft thing that some sheep are always going to be lame and they go to the market because they are lame and because we want to kill them. [You feel farmers ought to get a fair price for them? (I)] *Yeah rather than being pulled out, killed and thrown away and charged for it."* (F13, 5.0%)

Farmers who culled on lameness but who did not record the ID of lame ewes (8) did so from their appearance and memory. Farmer's ability to memorise lame sheep did not appear to be affected by increasing flock size:

"If they've been a consistent problem, and you do tend to remember the ones …" (F6, 2.0%, flock size: 250).

"You know the ewes, there's 700 and you know them, you know the dodgy ones." (F8, 5.0%, flock size: 700)

"No I just recognise her. I know it sounds daft with 1200 sheep but I can recognise her if they keep coming back, I've done you 3 times that's enough." (F13, 5.0%, flock size: 1200)

Of the four farmers that did not cull sheep for lameness, two were currently considering it. The remaining two (F1, 2.0% and F14, 5.0%) did not feel there was a need to cull because lame sheep recovered with treatment.

4.3.3 Motivation for treatment of lame sheep

There were several motivations for treating lame sheep and these were categorised into six themes: individual or flock performance; profit; empathy towards sheep; transmission of diseases; public perception; and farmer well-being. In addition, seven farmers commented that they simply disliked seeing lame sheep. All farmers gave more than one motivating factor for the treatment of lame sheep.

4.3.3.1 Performance

"A lame sheep is not productive. You know … if she's just had lambs she won't really milk and it's just not a very nice life. They won't perform so they don't look very nice. And it's not fair, it's cruel really … cruel on the animal … production and then the welfare." (F2, 5.0%)

"It [lameness] *certainly affects the way they finish their lambs. If you've got a lame ewe you will have two thin lambs on her as a rule."* (F6, 2.0%)

"You've got to keep them pretty good on their feet otherwise they'll lose condition and won't have lambs and everything else." (F3, 6.0%)

"*Well no one wants to see a lame sheep in the field do they basically (laughs). You know what I mean, there's nothing worse than seeing something suffer. Plus performance of your flock isn't it. If you've got lame sheep you know … it brings the performance right down that's why basically." (F4, 10.0%)*

All of the farmers agreed that lameness negatively affected production, although one farmer felt that the prevalence of lameness (2.0%) was too low to affect production in his own flock; and another with a prevalence of <1% added that he thought flock performance would be affected "if it were bad". Two farmers had the benefit of regular visits to other farms as part of their sheep group; one said:

"Everybody's system is different but we see other systems and we go onto farms where lameness is a problem and farmers are trying to fatten lambs that are lame and you can see their cut in production is colossal … and you do see other people's sheep and if they are lame they are going backwards basically. Because they are in pain and they are suffering and they're not going to do … and they don't seem to put two and two together. We've got another chap on a farm not far from here and he had a big, big lameness problem and his production for the year was nil basically. Absolutely terrible. And another big estate we do a lot of lambs for had a big foot problem and all sorts of things and because their shepherd is not so keen on too much work if they don't address the problem properly they don't get on top of it and their lameness is colossal. And their loss of production is phenomenal." (F8, 5.0%)

4.3.3.2 Profit

"Erm ... the welfare of the ewe really ... cos it's unproductive which has proved it because the scanning was down. Empty ewes. Not saying it's all down to the feet but the feet were a big problem in that flock. So yeah at the end of the day profit is the main thing because you want your sheep to have two lambs each. ... nobody likes to see, I don't want to see a lame sheep walking around with bad feet to be quite honest. For their good or for my good because I just don't like looking at it." (F5, 15.0%)

"Because a lame sheep doesn't thrive. If it's a lame lamb it won't put on condition and therefore won't be profitable, and a lame ewe will lose condition quicker than anything else. So it's a lot easier to keep the condition on a ewe than it is to, it's more expensive to put it back and invariably a lame ewe won't milk as well, have the same level of colostrum." (F7, 6.0%)

In addition, all farmers agreed that good standards of welfare were profitable for sheep farmers.

"Well if you've got good standards of welfare the sheep will and the lambs will thrive better and the ewes you'll get I think a few more lambs born and they'll have more milk and the lambs will do better more survive and get away quicker for sale whilst the price hopefully holds up." (F3, 6.0%)

One farmer added a proviso:

"Yep ... but the standards have gone down" (F) ["In the past animal welfare was better?" (I)] *"I suppose that a bit of a hard cop out. I think there is less people on the farms to do the work so the animals would ... not have the attention when they*

needed it. So maybe if they wanted footbathing today it might be a week or 10 days before they get to it. You know years ago there was men about all the time to go and do it … well they're not there … the staff are not on the farms to do the job." (F2) ["So because the standards have gone down has this had an effect on profit?" (I)] *"Yeah it does … and performance of the animal. And the other thing is that the profit. The profit hasn't been in the livestock so it does take … it shouldn't do but it does take a step down from when it does, from when it should do. You know if lambs were £100 a piece for a fat lamb you wouldn't see a lame ewe. And the flock would be brilliant. It's only because … its … bar from this year … last year it was like a worthless commodity 2001 the foot and mouth then it was worthless … so something … you know so the animals have suffered from that definitely."* (F2, 5.0%)

4.3.3.3 Empathy for sheep

"Well to relieve their pain really because obviously if they're carrying their foot and they're walking on three legs they're uncomfortable to say the least. … but I mean they're not going to do so well if they're uncomfortable are they (F). If they've got lambs it's their ability to stand up and feed their lambs and that (W)." (F1, 2.0%)

"Because obviously it's hurting them and don't like to see them like that." (F3, 6.0%)

4.3.3.4 Transmission of diseases

This theme included motivation to treat to reduce the transmission of ID and FR but also that of diseases farmers associated with lameness, fly strike.

"If you've got a lame ewe you can guarantee within 6 weeks either one or both her lambs will be lame as well" (F7, 6.0%).

"They do tend to spread it to other sheep or they appear to. If you've got a real persistent lame one you'll get more lame ones and erm there's nothing worse than a permanent lame one in the flock hobbling about because anyone walking across the fields says: "you've got a lame sheep"." (F3, 6.0%)

"Well really with the Lincolns it's a very minor problem. To go back, not to owning mules, but to any sheep that do have a lot of lameness, you see if you're not careful they lie down with a half rotten foot and then they're fly struck all along the side of their body." (F1, 2.0%)

"Well obviously because if they're lame they're not being as efficient as they might be. Certainly they lose condition incredibly quickly because they don't feed as often as they might particularly with a system such as ours where we want them to graze as long and often as possible. If they're off their feet, they don't graze, so they go thin very quickly and during the summer the other one, is the fly strike problem because if they've got badly infected feet the first thing they get is maggots and as soon as they've got maggots they're transferred onto the body and then you've got a serious problem." (F6, 2.0%)

4.3.3.5 Public perception

Public perception also emerged as a theme which motivated farmers to promptly treat lame sheep and was of particular concern where fields were in proximity to a public footpath. A second concept within this theme was that of the perception of farm visitors and included lame sheep being 'hidden' from visitors or buyers.

"Oh just the sight. Just the sight of a lame sheep. I just can't cope with it. And I mean it's just what other people think cos I mean if anyone sort of walked through the farm walks through down the road and sees all these things hopping about I mean it's such a bad reflection on you isn't it. … I mean just basically they're not going to do at all well are they, they're not going to survive and prosper." (F14, 5.0%)

"… we have so many bridle ways and footpaths that you get lots of phone calls. (Farmer puts on posh funny voice) Do you know that you've got a lame sheep? Ahhhh yes!" (F10, 10.0%)

"if you've got people coming to see them, I remember when I was a little lad running around we had this one old boy who used to come to buy his ram and he hadn't got a clue about the sheep but the only thing he could see was 'it's lame'. You know so, any fool can see a lame one can't they. So whether that's my motivation for treating them or not I don't know." (F17, 5.0%)

"Whatever buyer you talk to they've all got very little lameness … but you can guarantee that they've got more lame ones round the corner somewhere." (F13, 5.0%)

Increased effort to treat lame sheep when in proximity to a publicly visible location was mentioned by several farmers. When the researcher asked one farmer whether he had any footpaths, his response was:

"Fortunately we're not in that position but I know the farmer across the road he's got one and he says the villagers are an absolute nightmare." (F17, 5.0%)

He then went on to tell a story (perhaps a fable), also recounted by another farmer, about another farm in which: "The *RSPCA turned up and said that they had received a complaint about a lame sheep from a member of the public. The farmer jumped in his Landrover with the Inspector and asked which one was the lame one. When the inspector pointed it out, he took a rifle out the back of the Landrover, shot it and said 'can you see anymore?" (laughs) (F17, 5.0%)*

4.3.3.6 Farmer well-being

A few farmers commented that staying on top of a low prevalence of lameness made their lives easier:

"You have a plateau that you start at then you can't lose really but it's getting that plateau and keeping it there (laughs). Managing when it's there is half the battle." (F2, 5.0%)

"To get them better (laughs). Well nobody likes a nodding donkey. But if the sheep's walking round fine then it makes my life easier. It's less work for me if I've not got to keep treating everything, and catching everything." (F10, 10.0%)

"We keep on top of our lameness and don't create the problem." (F8, 5.0%)

4.3.4 The importance of managing lameness

Farmers were asked how important management of lameness was in the context of other flock health concerns. The majority (13) of farmers considered lameness very important with four considering it '*one of the biggest causes of lost performance*'.

"Because people don't take it [lameness] *seriously enough that's the trouble. And having gone from places where we've not had a problem to come to here where it is a major problem it is a headache to try and tackle but it is also emphasises how much work load is involved in trying to keep hold of it at a low level. When it's at a high level then it's a time consuming, expensive and frustrating ... just slightly (laughs)."* (F10, 10.0%)

One famer said though lameness was important:

"Footrot always seems to be, cos it's always here, always here all the time, seems to be pushed down the list a bit." (F4, 10.0%)

This was further qualified by another farmer who explained that immediate, visual losses in flock performance/farm profit received greater attention than gradual losses. He said:

"Your lameness and that is difficult to quantify and that ... if she gets mastitis at best she's going to lose a quarter and she's more than likely going to end up dead and you notice that. It's a serious loss and it registers pretty dam quickly. If she's lame she'll hobble about for a while she'll still keep feeding her lambs but ... I'm not saying it's not important at all but it's just how I see it. I don't know for our flock honestly without looking [referring to the production loss from lameness] *but I know that if you get a sheep with mastitis and she dies ... that sticks in there (points to head)."* (F17, 5.0%)

4.3.5 Barriers for treatment of lame sheep

A number of reasons were given by farmers as stumbling blocks in the effective management of lameness but they were not necessarily given freely when the question "*are there any barriers to treatment of lameness*" was directly asked by the researcher. Indeed, two farmers emphatically stated "*none*" until they were probed further by the researcher with reference to earlier discussion in the field. In addition, some farmers were quick to clarify that barriers to treatment were to prompt treatment of mildly lame sheep and not to treatment full stop.

"It doesn't mean to say that we're going to leave them for weeks and weeks." (F1, 2.0%)

"We're not going to leave them lame in the fields … we will make an effort, perhaps not a special journey … but we WILL catch it." (F5, 15.0%)

"We get round to treating them but it's just yeah … not necessarily the same day when you spot them … 50% of the time I'm in the wrong vehicle with the wrong stuff so it normally means I have to come back which will be the following day." (F10, 10.0%)

"They do get handled regularly so it doesn't ever get left for months without being treated … as and when we've got them I'll go through them." (F16, 15.0%)

Five themes of barrier emerged from the interviews. Although separated for the purposes of discussion here, most are interlinked. Themes were: lack of time; availability of labour; distance from handling facilities; difficulties catching in the field; and reluctance to treat during tupping or when heavily pregnant.

4.3.5.1 Availability of time

"*Time*" was repeatedly cited by the majority of farmers as being the principal barrier to prompt treatment of lame sheep. In addition, it was given by 5 farmers as the only impediment to prompt treatment. It should be noted that time as a barrier had a dual connotations; firstly as a physical time constraint associated with work load (thus linked to the availability of assistance or lack thereof) but it also had a seasonal association (thus linked to prioritisation against other farm enterprises).

"Time and effort of getting them in to do it. Yeah, that would be the main reason for not treating them exactly as they needed doing" (F17, 5.0%)

"It takes the best part of an hour to get them in so you've got to justify doing it. You have got to have at least 4 or 5 badly lame that you can't chase around the field and catch." (F6, 2.0%)

"If I just see the one or two they tend to get left until we get a certain amount of numbers and then we tend to get them in and do something about it. But obviously like I say before if there's one who can't walk at all or it's on its knees then you do it straight away. ... Like I say with a flock of this size, if you got a sheep in every time one was lame, it's just time consuming and you cannot do it like. So er basically we wait until there's a certain number then we get them in like and do it that way ... Its time consuming is the thing." (F4, 10.0%)

"Time is a big factor and ... I haven't got time to catch 3 lame sheep which is why if you've got one that you've got to treat twice then ... out [culled]*."* (F7, 6.0%)

Very few of the farmers interviewed in this study had a single responsibility on the farm and therefore their involvement or indeed responsibility for other enterprises took priority over lameness at certain times of the year, in particular, arable obligations and contracting work. This was essentially an issue with regard to the seasonal nature of the farming calendar and was linked to work load/lack of labour.

"Well if there's time I'd do it today but … if there's a whole lot of other things to do then I'd probably leave it until I could get them all in... In the morning's I try and write out a whole list of things that I need to do in the day, you know and there's always far more than I can get round …" (F14, 5.0%)

"When we're combining or someone's crying out they want 250 acres drilled there NOW, sometimes you have to say we'll wait for a rainy day. So yeah in the summer when the weather's bearing down at 90 degrees you have to say they'll have to wait for the next rainy day. So yeah the other part of the business can be a problem." (F5, 15.0%)

"… and if it were in the autumn and I was trying to plant wheat … if we have got several that were very lame you know, I'd make a big effort to drop everything else and do them but if it's just one and we're very busy would have to wait a bit … Harvest time well limits it really to wet days" (F11, 10.0%)

"When we're busy combining or something like that then they will get left for a week." (F15, 1.0%)

"In the summer time the arable and the hay making and forage management would be taking priority over routine sheep work … weather dependant." (F8, 5.0%)

4.3.5.2 Availability of labour

The second most prominent barrier to prompt treatment of lame sheep was the availability of labour, both in general and specifically for moving and gathering sheep; particularly where sheep had to cross roads etc. As mentioned above, many of the farmers were the sole farm labour force (with some unpaid assistance from their wife) and in addition to the sheep, had several other enterprises to run. Workload, availability of labour and time were therefore intricately interlinked.

"As I say they'll follow me in but I want someone to shut the gate you see and when she's [wife] shut the gate she leaves me up there" (F1, 2.0%)

"It's a question of time and labour availability and what have you and what else is on. If you've got the odd one, to spend 2 hours getting the entire flock in to the handling pens to catch one sheep isn't necessarily time well spent … so it's going to be a question of priorities" (F6, 2.0%)

"We have to bring them in via the roads and you can have one in front, one behind and I can't really do that on my own." (F13, 5.0%)

"If you had to pay somebody to look after them you wouldn't keep sheep. I think you'll find most people who keep sheep do the work themselves … cos the figures don't stack up." (F3, 6.0%)

4.3.5.3 Distance to handling facilities

Distance (linked with time) was also a problem when either necessary handling equipment or the flock itself were some distance from one another. This was especially true of farms that weren't ring-fenced, *i.e.* had parcels of land separated by distance. Farmer 5 commented that the furthest parcel of land they farmed was 7 miles away. He said:

"When we were ring-fenced ... it was easier ... less time consuming ... more efficient ... we've got to take all the hurdles down there, set up the race, get the sheep in ... before 70 sheep would be done in an hour now it's a 3, 4 hour job because you've got to go there." (F5, 15.0%)

Indeed ring-fenced farms were viewed by farmers with positivity.

"In effect its 4 farms but they all join, it's all basically ring-fenced so you can just go from one to the other. So you don't have to go along a road or anything like that. Very often you can just go straight from one to the next so it's all very convenient." (F14, 5.0%)

4.3.5.4 Catching in the field

In order to treat lame sheep, farmers either caught individual lame sheep or gathered a group to either catch a lame individual(s) and/or use a whole flock treatment. Another barrier that fell into a rather broad theme of difficulty catching individuals is described below, and is broken down into several concepts.

4.3.5.4.1 Gathering or catching with dogs

Only 5 of the 17 farmers interviewed had sheep dogs to assist with gathering or catching. A sixth farmer, farmer 6, had lost his dog "*to his maker*" several months ago and as yet hadn't replaced him. Well trained sheep dogs appeared to pose a distinct advantage in the ability to catch sheep but were portrayed as a luxury rather than a shepherding essential.

"We've got a good dog and we can catch them …" (F8, 5.0%)

"We are lucky with just the one dog. He will just catch a ewe. I've seen him single out a sheep and just catch it and bring it down for you so you can do whatever you want." (F13, 5.0%)

"That's the thing with the dogs, its lovely having good dogs I mean the one dog out there, he's a trial bred dog, he's the first one I've ever had and he's absolutely exceptional, absolutely wonderful. And when you've got that sort of thing its lovely to see them work." (F14, 5.0%)

One farmer who was aiming to increase his flock size significantly through a breeding programme over the forthcoming years and currently had a small flock of 150 ewes stated:

"Catching them, that's the big problem because we haven't got a large enough flock to have a dog that will bring them down." (F12, 5.0%)

Indeed, farmers were keen to point out the prerequisites of a great sheep dog:

"We've never had a dog that is well enough trained to be able to isolate an individual." (F6, 2.0%)

"I haven't really got the best of dogs, they won't hold them up, … my youngster thinks he'd rather eat them than doing that, he hasn't quite got the grasp of just holding them there as of yet so you have to get all the Prattley out [mobile handling system] and mess about so it [treatment] does … tend to be a group that's lame rather than an individual animal." (F16, 15.0%)

4.3.5.4.1.1 Gathering or catching without a dog

If farmers did not have a dog that could catch individuals or hold a group in the corner of a field, farmers used one of five methods to catch sheep: catching whilst feeding from troughs; gathering in the field using fixed or mobile hurdles; moving sheep to a central handling facility; jumping from vehicles or chasing on foot. Each of these methods was not without its own problems and each presented a barrier to prompt treatment.

4.3.5.4.1.2 Catching at feeding troughs

Farmers were sometimes able to catch individual lame sheep for inspection and treatment as lame ewes/lambs were feeding at troughs in the field. However, sheep were not fed supplements all year round so this tool provided only seasonal assistance.

4.3.5.4.1.3 Identification of individual lame ewes once gathered

Sheep are a prey animal and as with many predator-prey relationships they will mask signs of weakness, including lameness, in the presence of a predator if they perceive a threat. For the majority of farmers, individual identification numbers on ear tags were too small to be read, even at short distances. Once gathered the problem of identification therefore also became a barrier to treatment for many farmers, particularly if the sheep had no distinctive features and was mildly lame.

"... Because as you know as soon as you put sheep into a pen they all get incredibly better." (F6, 2.0%)

"… when you get them in a pen finding it again is the problem. I always find you feel like you want a paint gun so you can shoot them in the field and mark them. Catching them or picking out the one that you want to do when you've got them in the pen. They're my two biggest problems." (F12, 5.0%)

"… because as we discussed earlier, it's a job to even spot them when they're in… so they'd just be treated as a block and if we can catch them as lame they'll be turned over probably sprayed…. But they will be treated if we can find them …" (F5, 15.0%)

4.3.5.4.1.4 Moving to a central handling facility

One farmer commented that it took more or less a whole day to gather the sheep into his central handling facility for treatment and return them to the field and this he felt posed a welfare concern which might be larger than the lameness concern itself and was therefore a barrier. His concern was not mentioned by other farmers.

"… there are no handling facilities for each field but each time you bring them in you are stopping growth … or so we've been told, stopping growth for about 3 or 4 days once they've all come in mixed around and taken back out." (F13, 5.0%)

Central handling facilities were also particularly problematic with large group sizes and also with young lambs. After watching a video clip on the researcher's laptop of a lame sheep with young lambs one farmer stated:

"God it would be a pain in the backside getting those in (laughs). … they're not much more than 3 or 4 weeks old, to get a group like that into the pens would be, yeah, it would take most of the day" (F6, 2.0%)

4.3.5.4.1.5 Age and health of farmer as a barrier

If farmers did not have the convenience of a dog or mobile handling facility or simply needed to catch a lame sheep for inspection without opting to the lengthy process of gathering, they might attempt to catch on foot. However, with an ageing population of sheep farmers (DEFRA, 2010) this was not an easy option. Two farmers noted:

"And as I say if it legged it into the distance and we couldn't catch it, which as we're getting older we now can't (laughs) and we don't have a dog or a quad bike ..." (F6, 2.0%, Age: 54)

"We'd wait until we've got them in the pen to worm them or something like that. Because it is a bit more difficult when you get to my age, you're not quite as nimble. Once upon a time I used to go into a field and I've always been quite active and if there was a sheep I wanted to catch I just used to run after it and it inevitably goes round in a circle, so I took a smaller circle and if you do that for long enough the sheep gets tired and stops. So I could catch any sheep at one time but I can't do it now. I should be the first one to tire." (F1, 2.0%, Age: 82)

4.3.5.4.1.6 Catching from vehicles

Alternatively, if a farm vehicle was available this provided another option for catching, although it posed a further dilemma:

"... one of us will leap out the truck, attempt to pin it to the ground and treat it ... but we figure if its fast enough to run away then it's not that bad." (F6, 2.0%)

"… so long as it will run along by the side of the quad I can kind of jump off and catch it …" (F13, 5.0%)

"… you're driving round the field, you jump out of the truck to jump on a sheep, trim its foot, either the trucks carried on down the hill … or you haven't got your taggers there or anything like that …" (F5, 15.0%)

It was not surprising that farmers expressed welfare concerns about catching lame sheep for inspection even when perhaps more sedate methods of catching were involved.

4.3.5.5 Reluctance to treat during tupping and pregnancy

The condition of the ewes was given by two farmers as a barrier to treatment. One farmer who's early lambing flock was due to start lambing in 4 weeks said:

"At the moment I wouldn't be too keen on getting them in and running them about too much because they're so close to lambing … that's one barrier, tupping another …." (F5, 15.0%)

In the field another farmer commented that he didn't like to tip sheep when the tup was in with the ewes. When the researcher referred to this during the interview he stated:

"Yes I mean they're first of all vulnerable to slipping lambs in the early stages of pregnancy … it doesn't seem sensible to do so when they are heavily pregnant either." (F11, 10.0%)

When asked about barriers to treatment of lame sheep he added that:

"the limitation of the condition of the ewes because they are pregnant ... You have to handle them rather carefully, and big ewes there's no way you could really turn them over very slowly and carefully because they are absolutely enormous." (F11, 10.0%)

Environmental stresses triggered by routine management handling procedures have been shown to cause significant reduction in embryonic implantation (Doney *et al*., 1976) and pregnancy toxemia in ewes (Ferris *et al*., 1969).

However, apprehension concerning pregnancy and stress wasn't perceived to be a problem by other farmers.

"If they're lame they get treated, we haven't noticed that we've lost lambs because we've been turning them over." (F6, 2.0%)

General stress was also a justification given by farmers for not catching mildly lame sheep. After watching a video clip of a locomotion 2 score sheep as said:

"Mildly lame, but I wouldn't stop and mess around with that. Basically because you couldn't catch her without causing too much stress." (F13, 5.0%)

It should be noted here that the list of barriers given by farmers in this study, although large, is not likely to be exhaustive. As one farmer said:

"Yeah that's the only things I can think of that would stop me. I'll probably think of a load more later." (F5, 15.0%)

4.3.6 The purpose of the flock

Two dominant themes emerged as to why farmer's kept sheep. The first was having permanent pasture, parkland, banks or small paddocks that were otherwise unsuitable for other farming enterprises.

"Well basically it's all this grass (laughs). It is all the banks and the waste ground so it's not really productive ground, it isn't highly productive grassland." (F14, 5.0%)

"We've got obligations under all these schemes so it keeps the grass down but I don't want to be a theme park conservation farm. I'm mean my background, I've always been a dickey birder. And I've worked in conservation so I'm interested in a decent landscape BUT (emphasis) the landscape should be producing food as well." (F9, 0.0%)

There's 80 acres of permanent pasture and the sheep utilise that. We can't use it for anything else at the moment so they make best use of that. They're all part of the rotation. We do grow some leys on the main farm here but they're mainly for hay and silage. The sheep are to utilise the permanent pasture which is on the other farm." (F6, 2.0%)

"Basically to keep the grass down and tidy and to keep the estate tidy. In one sense they are not a business venture, although we are trying to push it that way and make it a bit more of a business venture especially with the price of lamb going up. Erm ... but also in this day and age, the last 3 years now, it's become apparent that the rest of the estate has split up in to various aspects and now each area is now accountable for money. So therefore there is more emphasis now that

the sheep must try to become more profitable or be a profitable business rather than just a business. If that makes sense (laughs). Rather than just lawn mowers yeah, although they are cheaper than the diesel (laughs).” (F10, 10.0%)

The second dominant theme was that sheep formed an integrated part of a mixed farming system, following the dairy cattle, putting fertiliser back into the ground, providing a farm income and work for employees all year round.

“We first bought some sheep because we took a farm and it had some grass with it and then it’s another good source of income as well because they do make a bit of money. You know don’t put all your eggs in one basket. And also to keep us busy at this time of year as well, so it’s creating work all the way through the year as well. ... we can lamb sheep in February but we can’t do anything else. You know we’ve got a source of income in June and July then from the early lambs and then a source of income from the later lambs now instead of just having to sell wheat all year round, so it spreads the, it’s ... another product to sell. It’s a good thing to have. We do a bit of spring cropping so we can put stubble turnips on the ground we’re gonna put into a spring crop so then the sheep can utilise that ... or we can fatten lambs on it ... so it’s making a bit more use out of your arable ground as well. But they are very secondary to the arable.” (F5, 15.0%)

“It fits in well with our rotation (W). We’re a mixed farming enterprise and the sheep are a very important part of that mixed enterprise (F). That cog (W). They work well with the cereals; they put fertility back in the ground. We’re feeding a lot of our cereals back through our sheep now and it’s an integrated system.” (F8, 5.0%)

Other reasons for keeping sheep included ensuring survival of rare breeds and personal preference.

"I mean 13 breeds, since the end of the war up to 1970 became extinct in this country I mean it's unbelievable really. And that was one of the reasons for the formation of the rare breeds survival trust. They suddenly alerted people to the fact that our native breeds were all going. Everybody was keeping Texel sheep and Landrace pigs and Charolais and Limousin cattle and our breeds were all going. And so that was one of the, I sort of joined up with that idea purely because once these characteristics of these old breeds have gone, they've gone forever. You can't suddenly say well I go get some because there's none to get." (F1, 2.0%)

"I just prefer to do sheep rather than cattle. Sheep work pretty well around here yeah I just enjoy working with them". (F13, 5.0%)

4.3.7 Social referents

Farmers used a range of social referents for advice on managing lameness. EBLEX (the levy board for the English beef and lamb industry), respected farmers and vets were frequently mentioned as the most influential. Farmers however looked at varied sources including: neighbouring farmers; farmers at market; meetings/seminars; two used a specialist livestock consultant employed as part of an independent farmer's marketing organisation; farming press, texts and literature; and the internet. Many considered themselves to be the expert on their flock and their farm generally and a strong theme emerged that farmers considered each farm to have uniqueness. The application of one system to successfully manage lameness on all farms was not something that appeared realistic. A common approach to a new idea in lameness management was a period of consideration, adaption to their farm circumstances and a trial within part of their flock with undocumented surveillance.

"Well it was sort of, we learn it ourselves ... I'm the sort of father figure. Well I don't like to say that but I mean people do, I get lots of calls asking me what to do (F). At the last AGM he gave a talk (W)." (F1, 2.0%)

"Just chatting to other farmers ... take it off somebody who's done it. I'd rather go to a farmer who's tried something and try his method especially if he's a good farmer and ... you know I respect his views. I'd hope I'd got it all right myself (laughs). ... I think it's just experience really." (F2, 5.0%)

"Other farmers, vets yeah just talking to a few people at different shows stuff like that. Books as well actually. ... You've got to try everything yourself and see how you get on with it." (F5, 15.0%)

4.3.8 The role of the vet

The role of the vet was limited. Not all farmers had a vet. Vets were primarily used when there was a new or increased problem with the flock that the farmer couldn't manage themselves, diagnosis of sudden fatalities, and for obtaining farm medicines. Veterinary involvement in farm flocks was generally limited to necessity, or to comply with retail schemes and was infrequent. One farmer had involved the vet recently to seek advice on CODD and to decrease the prevalence of lameness in his flock. He said:

"I've had the vet out to do examinations on the feet, about twice in the last 6 months actually just to confirm a diagnosis of what I have and what problem I have and b) to make sure I'm doing things right in the sense of what I'm doing. We do have a conflict of interest because I don't think I actually get what I need from the vet, you know, advice wise … you don't get the proactive bit. But I think things are improving because they've got a new vet … he's helping out on the beef side and he's quite proactive with that and now having approached him about the sheep he seems keen … well he's keen to get his hands dirty." (F10, 10.0%)

" … We did a bit of copper testing because they were going on turnips in the winter because you get a lock up in it. But we wouldn't have the vet come in about this foot health which perhaps we ought to. So we wouldn't sit down with the vet and discuss the flock health, we haven't got like a flock health plan done by the vet which might be a good idea yeah. So probably not enough, probably not a lot really. Just somewhere to go and buy your drugs from (laughs). So we probably don't utilise them enough to be quiet honest." (F5, 15.0%)

"In terms of the whole flock and performance we do have an annual meeting with the vet. We've got very good vets actually they are a proper farm animal practice, large animal practice. The senior partner is a good friend of mine so occasionally over a pint of beer gives free advice. (laughs) but we do have an annual meeting with them for both on the sheep and the cattle side of it where we sit down round the table and he has a cup of coffee and charges me a fortune for the advice but err we do have a plan in terms of … because the cattle are for Waitrose so we have to have all sorts of written things and it includes the sheep because they're on the farm as well." (F6, 2.0%)

Those registered with practices that had a large animal section or specific large animal vet were more positive about their vet than those that did not. A few commented that they had struggled to find a large animal vet locally or had not used a vet for years.

"There are no vets around here that treat large animals … it's about 35 miles away … it's so infrequent we just used him to get the Bluetongue vaccine." (F1, 2.0%)

"About 7 or 8 years ago the vets that we had been with since the family had been here … just obviously couldn't make a go of it they couldn't afford to have a large animal specialist on the staff and there was only 4-5 vets in the practice so they sacked all their farmers. I mean we'd been talking about it for some time because the [Vet practice name] vets that we now use had got an increasing good reputation amongst the farmers. Obviously farmers don't change just like that and it was erm somewhat quite fortuitous that they sacked us and we got to the new vets and they've been terrific, absolutely brilliant. And the large animal specialist vets really don't do anything else because they have a small animal department with an animal hospital and what have you and then they have a large animal department with the horses and sheep and cattle. And all their large animal vets don't do anything else. They don't get involved with cats and dogs and budgies. Oh they are very, very good." (F6, 2.0%)

The reasons for limited veterinary involvement in flocks were principally economics. However, a lack of proactive enthusiasm from vets and inexperience in comparison to the farmer was also mentioned. Several farmers felt there was enough '*free*' information out there without needing to use the vet; with the exception of unforeseen problems.

"Apart from anything else a sheep being worth say a ewe commercially say £60-£70. Well it's not worth paying £90 if you think it's going to die anyway." (F1, 2.0%)

"I think what is very disappointing I think our local vets are not very pro-active ... but I went to a very good flock health planning meeting that [ADAS consultant] ran up at Ludlow .... [Vet practice name] local vets were very, very positive, very proactive and if we had vets like that on our doorstep you would use them much more. I think that [name of independent livestock consultant] has been over the 5 or 6 years that we've been working with her, what it costs me I save, more than save, and you know that's in terms of flock health production." (F7, 6.0%)

One of two farmers who used an independent livestock consultant for flock advice said:

"EBLEX books have got some very good pictures in them to be fair and you can work out what you've got wrong and between 2 or 3 of us we work it out a little bit. And go to the vets to get the antibiotics but possibly not go directly to the vet for their advice. I think value for money I think our consultant is the best money we've spent in a year because it makes us all think, it's a different approach. ... the cats and dogs are in the money in the small animal vets practice and not the sheep anymore I'm afraid which is possibly a very dangerous situation to be in. ... profitability out of sheep hasn't been great over the last 20 years. Nobody probably takes a ewe to the vet to lamb it anymore, only possibly your hobby

farmer …. The 500/700 ewe flock doesn't contribute too much to the vets income, yet you buy your drugs off them etc etc but it's better to buy your drugs off the cash and carry sort of programme and get your advice elsewhere. We have involved our local vet with work with our consultancy group and at times it's been reasonable and other times it's been well … The main partner in the practice originally wasn't interested at all. I think, we've invited him up to meetings, it's been damned hard work with him here. … But the younger girl that's the newly qualified vet it's been a good learning curve for her and now if we do a meeting we invite the vets we've had all three of them at the meetings so we've turned a corner a little bit but they realise what we're doing … and realise that we're taking the job forward and they are keen to participate now." (F8, 5.0%)

A couple of farmers did however believe veterinary involvement in sheep flocks to be a two way problem.

"They're only as good as the information you give them. There is a conflict of interest see because … they do the health plans for the herds and the flocks and the first thing the farmer goes and does is go to market and buys a cow and calf because it was the right money so straight away they're going orrghhhhh you know you've bought something so there is a conflict of interest because the farmers got to try and make money and keep the stock up and the vets trying to keep them healthy." (F5, 15.0%)

"We've noticed with our sheep group how difficult it is and how mean farmers are because … you know just because the vet said we should do this (F) … you know needless to say the vet has trained for 7 years and has got all that knowledge and they still back their own judgement and say no, no, we won't do that we'll … (W)

Loyalty in farmers is worth a farthing a time. … You can have the most dynamic person two miles up the road from you with access to their mind and information but you couldn't get anyone to go and take it up because people won't. I mean we've done meetings and education groups. They'll go to a meeting and listen to what you say and they'll go back home and do exactly what they've been doing. You might get the odd one, … might make them think, it might not necessarily change what they are doing at home but it does strike a brain cell somewhere up there that might think oooohhhh perhaps I'm not doing this but the vast majority don't change. And it's like your foot trimming, farmers have always foot trimmed, we still foot trim, you've got a desperate job to convince them it might be a possibility that it mightn't be the right thing. But to stop them doing it, laughs …and some people like to trim their sheep to death realistically. It's just cruel it's like cutting your fingernails up to there isn't it [points to the nail matrix of a finger nail]. It hurt's and that's it that's the mentality I'm afraid. It's a very difficult one but I also think it starts at agricultural colleges." (F8, 5.0%)

4.3.9 The buyer

When directly asked, farmers did not perceive the buyer to influence how they managed their flock either in general or specific to lameness (with the exception of not being able to sell lame sheep for slaughter). However, when probed further many would not consider sending lambs for slaughter at <40+ kilos and had altered their breeding system to obtain larger lambs.

"Well they've got to be healthy to start with and erm normal welfare that's all. They do … alter a bit. It depends. They have sort of changed from wanting smaller lambs to wanting larger lambs. It's now 40 kilos minimum whereas 2 to 3

years ago it was 40 kilos maximum and they penalised you on the weight over that. And now it's probably 48 kilos before they start penalising you at all. They have gone up probably 8-10 kilos live weight that you want. So it does alter it a bit you need to produce slightly larger lambs so it could alter your breeding system to get the larger lambs." (F3, 6.0%)

Farmers did not appear to know where they made or lost money. One farmer who also marketed livestock summed up saying:

"But it's something that everybody, they all talk about how much the lambs are in the market and how much the lambs are in the abattoir but nobody actually questions them. Nobody really knows what the lambs cost to produce anyway and as [wife] will tell you her time doesn't get costed in as much as it should do (F). It's free (W). ... They're producing things that they've always produced and things that they want to produce rather than the fattening. The number of people that say to me well you don't get enough money for your big lambs. Big lambs in [name of market] have made £80, but you know, I don't want big lambs, I want, I will give you £77 for a 22 kilo lamb, I'll still give you £77 for a 23 kilo lamb but it will cost you more money to produce a 24 kilo lamb than it will a 19 kilo lamb. And so we're looking at that cost element. It's not necessarily the best price which gives you the best return at the end of the day." (F7, 6.0%)

In addition, another farmer said:

"A bone of contention because [buyer] just says as long as they're 44 kilos or above that will be fine, it doesn't matter about what they are [conformation] or anything else so whereas I'm a bit the other way around because obviously I've done a lot of EBLEX talks and vets and they're right in one sense when a lamb is

ready its ready whether its 36 or 37 kilos. If its fit then it should go because yeah there is no point in keeping it another 3 months or another month to put 4 or 5 kilos on to make it above 40 kilos because all you're doing is piling fat on. So what's the point in getting it to 42 kilos and coming back at an over grade and you get £2.50 a kilo when a month ago if you sent it at 37 and it came back at an R2 then you get £3 a kilo. It might be 3 or 4 kilos light but you get better money, better value and you've not had to look after it and that in my sense is much better because the quicker they're off here the less chance they'll get lame (laughs)." (F10, 10.0%)

The majority of commercial farmers sent lambs for slaughter at weights of ≥40 Kg to receive the highest price for their lambs rather than to maximise the profit they received. The below comments typify this:

"They go as soon as they are heavy enough which is their conformation, it isn't a problem as a rule because they're at their very best then and so … if you can get them off in late May and once they are up to 40 kilos then you can be sure they won't have too much fat cover and nor too little so… em so that's, there's less need to be identifying the exact conformation." (F11, 10.0%)

"Yeah. I don't know really what profit they make (laughs)." (F14, 5.0%)

One farmer commented that the single farm payment formed a large part of his farm's income. He said:

"We'd be lost without the single farm payment but we work on the principle that if it doesn't roll up one day then … Without it all the enterprises would be seriously under pressure realistically. The single farm payment is basically the profit. And

if you haven't got a single farm payment then you're in a serious situation. And I think that's the same on most farms." (F8, 5.0%)

4.3.10 The future

Farmers' plans for the future of their flock in the forthcoming 5 years were varied. Some planned to increase their flock size, others to decrease and some thought the numbers would remain constant. Factors that influenced their decisions were numerous and were related to: increasing age and decreasing health of the farmer; the profitability of the sheep industry; the market price of arable produce in comparison to the sheep (sheep numbers being easy to quickly change up and down on farms); availability of labour; investment in easy care sheep/low input systems by changing the breed; and improvements to productivity, profit and health of the existing flock.

4.4 Discussion

To the author's knowledge this is the first piece of research to examine sheep farmers' attitudes towards lameness in sheep. Despite effective treatments for the management of lameness, the prevalence in UK sheep flocks has remained at a national average of ~10% since the first recorded survey in 1994 (Grogono-Thomas and Johnston, 1997; Kaler and Green, 2008a). It is not clear why this is the case. This research therefore sought to explore management of lameness from the farmers' perspective.

Interviewees were targeted to include a range of flock sizes, farm enterprises and backgrounds to capture a wide range of opinion. This qualitative approach is a valuable, valid methodology for understanding the range, depth and complexity of opinions (Devine, 1995). The potential for observer bias was minimised through use of a single knowledgeable observer, prior training and the incorporation of non-directive probes, question re-phrasing and diverse prompts within the study design (Rubin and Rubin, 2005; Sarantakos, 2005). The opinions of farmers in this study were not however quantifiable. Although saturation of the data occurred (Rubin and Rubin, 2005) which prompted the interview process to stop, it is possible that other farmers may hold additional opinions not expressed by these farmers. Traditional standardised questionnaires, *i.e.* those that consist of closed questions, cannot capture the depth and complexity of information that a qualitative approach provides. However, their subsequent use may provide useful quantification of opinions obtained from this qualitative study and identify risk factors for managing lameness. A quantitative postal questionnaire was therefore designed to quantify the findings from this study (see Chapter 5).

The farmers who took part in this study were primarily selected from a database of compliant farmers interested in taking part in further research on lameness in sheep. Consequently they may have been more motivated to manage lameness, more open to new ideas in the management of lameness, and accordingly, perhaps have a lower prevalence of lameness than the national average. Indeed, the 2008 period prevalence of lameness in the current study was 5.0%, significantly lower than the national average of 8 and 10.4% reported in 1994 and 2004 respectively (Grogono-Thomas and Johnston, 1997; Kaler and Green, 2008a). However, it was not significantly different from the 5.0% reported in 2006 by Wassink *et al.* (2010b) who surveyed compliant farmers interested in research on lameness in sheep. The difference in sampling strategies (stratified random *cf.* selected compliant) therefore probably accounts for the lower prevalence of lameness in the current study; although it may also be possible that the national average prevalence of lameness in sheep flocks has decreased since 2004.

Farmers in this study considered themselves the best person to make judgements about their flock and farm, and selected information which they perceived to be appropriate to their farm circumstances that they perceived as unique. A one solution fits all guide to the management of lameness was widely snubbed. There was a wide variety of social referents; the most influential and most cited as responsible for bringing about a change in management of lameness being vets, EBLEX and respected farmers. However, veterinary involvement in these farmers' flocks was limited in time and scope; the use of vets was generally only for problems and provision of veterinary medicine. The economics of employing a vet to help manage flock lameness was considered a large limiting factor to uptake of their use; others struggled to find a large animal vet locally; and some were disappointed with the lack of enthusiasm from their vet when advice was sought. Whoever the social referent responsible for bringing about a change in behaviour, most farmers assessed improvements in the prevalence of lameness from memory when adopting new management practices, rather than farm records of lameness; which were for the majority lacking. This makes it difficult for anyone to precisely quantify the benefits of any new management tool/approach. This may provide an insight into why farmers use a variety of management tools, are uncertain of their effectiveness and are reluctant to change.

Farmers were generally quite well informed about managing lameness yet a variety of treatments, both individual and flock based, were used by farmers. The use of unlicensed antibacterials in footbaths was also used to manage or prevent

ID and FR. There was speculation about the efficacy of different footbathing solutions, trimming hoof horn, isolation and vaccination. The latter may be related to evidence provided in interviews indicating that farmers do not always follow instructions provided on vaccination data sheets (and possibly therefore other medicinal products). All the farmers in this study currently had or previously had FR on their farm. However, ID and FR were typically treated as two distinct and separate diseases, with FR receiving greater individual treatment frequently accompanied with parenteral bactericides and one farmer additionally giving painkillers. The aetiology of ID and FR are linked with *D. nodosus* load highest in ID *cf*. FR lesions (Moore *et al*., 2005, Witcomb, 2012). This could indicate a lack of farmer knowledge about the disease, belief that relative pain associated with or productivity lost through these two conditions differs. The provision of literature seeking to improve knowledge transfer should perhaps encompass these details and may perhaps act as incentives for those farmers who are motivated by empathy or productivity to treat lameness and reduce transmission.

Management of lameness was an exercise that was not built in to any management routine. Instead it was unplanned and in response to the occurrence of episodes of lameness. Yet, in contradiction, lameness was acknowledged by farmers as something that occurred all year round, with a peak in late spring, and was frequently seen as one of their biggest concerns. Part of this impasse was because lameness was something that was seen by farmers to have a gradual effect on production compared with that of mastitis or fly strike which had a more visible, immediate and dramatic impact. The priority given to treatment of a mildly lame sheep was always less than that of a sheep with mastitis or flystrike.

It is clear that many farmers do not know what profit their flocks make and where losses and gains are made. Whilst all of the farmers acknowledged that lameness had a negative effect on productivity, they could not quantify the loss. Indeed, following the interview two of the farmers asked the researcher what lameness cost the sheep industry. Farmers have a sufficiently accurate evaluation of the prevalence of lameness on their farm (King and Green, 2011) and it is now known that this is successfully achieved through daily inspections. However, one of the primary reasons that losses through lameness could not be quantified was that lameness was not recorded in the majority of flocks. Furthermore, identification of repeat offenders for culling was achieved by most, from adeptness of farmer memory, impervious to flock size, based on visual identification. Generally, sheep carried some form of numerical management identity (except where tags had been lost and not replaced) and these were in the form of: ear tags; boluses; tattoos; and/or ear notching as required under various schemes/regulations. One farmer said:

"*It's crazy really, our sheep are almost unidentifiable because of their identity. They've got the UK tag number … with an individual number on them, they've got their pedigree number, which is notches in their ears and a tattoo, which is completely different to their UK number. Then up until this year, … when they were in the national scrapie plan, they were bolused. They've got a bolus in them with an electronic number … and that was different again…. (laughs).*"

Only ear notching, a system used by pedigree farmers, was considered of practical use for the farmer to be able to identify, catch or record lame individuals that required treatment. Individual numbers on UK tags were too small to be legible in the field (with the exception of one commercial farmer who used a meticulous ear tagging system and binoculars). This failure to be able to identify individuals in the field by an on farm management ID often led to an inability to treat mildly lame individuals and presented a barrier to prompt treatment for many farmers.

Sheep were kept for a variety of reasons the two most common being to manage land not viable for other enterprises or as part of a mixed farming enterprise. Where sheep were part of a mixed farming enterprise it was clear that they were secondary to the arable and this reason was linked to the relatively small profit margins of the sheep flock and other farming priorities. Sheep farming has been supported by subsidy since 1940. Whilst the extent and range of these have been reduced by the Common Agricultural Policy (CAP) reform and subsequent changes in public policy, it is still currently subsidised by voluntary sign-up to environmental schemes *via* the Single Payment Scheme (SPS). (A historical review of farm animal subsidy is provided by Woods (2011)). Subsidisation of the sheep industry perhaps provides a key explanation as to why sheep farmers do not keep flock records that enable assessment of profit and loss; and consequently perhaps why they were not always motivated to treat lame sheep by financial gain and are less business orientated than pig farmers (Austin *et al*., 2005) who are no longer supported by subsidy. Better flock records would enable the industry to effectively reduce disease, improve flock health and productivity because farmers and their advisors would be able to precisely assess the benefit of any change in management practice. This recommendation is shared and supported by current unpublished work by Kaler and Green (personal communication) examining sheep farmers' opinions of the current and future role of the vet in flock health management.

Farmer motivations for treating lame sheep were varied and embraced more than one theme; farmers' motivations were similar across a range of prevalences of lameness. In addition to the expected motivators (flock performance and profit) empathy towards the sheep emerged as a strong motivating theme. Empathy towards sheep might however, be something less connected with farmers who do not shepherd their sheep every day. Public perception also arose as a motivator, particularly on land with footpaths or when farmers expected visitors. A minority of farmers mentioned farmer-wellbeing acknowledging that it was easier, and more efficient to manage and maintain lameness at a low prevalence than it was to reduce it from a high prevalence of lameness. These farmers had either personal experience of managing flocks with high and low prevalences of lameness or had been fortunate to visit other farms with high and low prevalences of lameness. Past experience has previously been used to explain sheep farmers' diverse opinions of ectoparasite control, with those with the highest incidents of ectoparasites expressing greatest concern and *vice versa* (Morgan-Davies *et al*., 2006). It is plausible that past experience may assist in explanation of farmers' opinion towards management of lameness in sheep. Benchmarking against other farmers was not mentioned in the context of managing lameness and this was similar to the findings of Leach *et al.* (2010b) with lameness in dairy cattle. There were however two farmers that did benchmark against other farmers for the success of their farm generally. Both were farmers who were not from a farming background (a PhD/qualified chartered surveyor) and felt they had something to prove, specifically due to the type of enterprise they were running: a conservational system with forage legumes heavily incorporated into pastures, and livestock marketing.

Farmers were quick to explain that barriers to treatment, were to prompt treatment of mildly lame sheep and not to treatment full stop. All but one of the barriers were physical difficulties (lack of time; difficulty identifying and catching; distance to facilities and lack of labour) and these barriers were shared by farmers with low (≤2%) and higher prevalence of lameness. Two of these barriers the author believes could to some large extent be alleviated with the use of a visually useful management tag such as the '*leaf tag'* (Ritchey™ sheep tags); as used with other livestock. An ageing population of sheep farmers and the reduction in labour force on farms is not likely to change and these are barriers that need to be incorporated into an effective lameness management plan if it is to be successful. Sheep are a labour intensive enterprise as acknowledged by farmers in this study, therefore any management plan needs to devise an efficient use of the shepherd/farmer's time.

Farmers are legally required to keep minimum standards for the care and husbandry of their stock. The Animal Welfare Act, 2006 makes it an offence to cause or allow unnecessary suffering of any animal and sets out a duty of care. In addition, the Welfare of Farmed Animals (England) Regulations 2007 sets out minimum requirements for the care and husbandry of livestock and is supported by the *Code of Recommendations for the Welfare of Livestock: Sheep* produced in accordance with Section 3 of the Agriculture (Miscellaneous Provisions) Act 1968. Furthermore, under the SPS, cross compliance legislation sets out minimum requirements for good agricultural and environmental conditions and minimum standards for the care and husbandry of livestock in order to receive the full environmental subsidy payment. Additional legislation relating to livestock welfare covers transport (Welfare of Animals (Transport) (England) Order 2006), markets (Welfare of Animals at Markets Order 1990; Welfare of Animals at Markets (Amendment) Order 1993) and slaughter (European Union Regulation 1099/2009; Welfare of Animals (Slaughter or Killing) Regulations 1995, and its' amendments: 1999, 2000, 2001, 2003, 2006, 2007 and 2012). The Welfare of Farmed Animals (England) Regulations 2007 makes it a requirement for livestock to be inspected daily in "*husbandry systems in which their welfare depends on frequent human attention*" or "at *intervals sufficient to avoid any suffering*" in other husbandry systems; with "*ill or injured*" livestock "*cared for appropriately and without delay*". In addition the Code of Recommendations for the Welfare of Sheep states: "*a significant percentage of sheep with chronic lameness may be indicative of poor overall welfare standards within the flock*"; although it does not state a recommended ceiling of acceptability. Husbandry systems for sheep are not defined within the legislation and farmers' interpretations of the wording of legislation may vary; it may reasonably explain why the majority of farmers inspected daily, with some inspecting more or less frequently dependant on season. The reluctance to treat heavily pregnant lame ewes and lame ewes during tupping requires further investigation; both in the proportion of farmers avoiding treatments during this time and whether there is any evidence to support an increased risk of spontaneous abortion/infertility from stress induced *via* gathering/catching. Delayed treatment of these ewes breaches the legislative requirement to provide appropriate care but a moral dilemma is also present from the potential for stress to induce poor health and productivity. Current evidence suggests that the benefits of treating even mildly lame ewes when heavily pregnant outweighs the potential risk of spontaneous abortion/pregnancy toxemia (Wassink *et al.*, 2010a). The Wassink *et al.* (2010a) study monitored but did not treat lame ewes during tupping because the study farm considered gathering and treatment to pose a risk to successful implantation. Aversive human interactions with pigs and dairy cattle have been demonstrated to reduce productivity due to fear and stress (Hemsworth *et al*., 1989; Hemsworth and Barnett, 1991; Seabrook, 1972). Calm and frequent handling, perhaps from twice weekly/weekly routine treatments for lameness, where ewes are exposed to seeing other ewes handled would however reduce the environmental stress caused to individuals (as has been demonstrated in chickens (Jones, 1993; Barnett *et al*., 1994)), and perhaps therefore the risk of reduced implantation and increased spontaneous abortion/pregnancy toxemia (Doney *et al*., 1976; Ferris *et al*., 1969). Farmers' reluctance to catch individuals based on a cost/benefit welfare exercise, which lacks supporting evidence perhaps highlights the need for further research in this area.

A quantitative analysis of farmers' attitudes compared with the prevalence of lameness was impractical due to the range of response and relative sample size; neither was it an objective of the current study. It would be useful to quantify which barriers and which motivators are associated, if at all, with low and high prevalences of lameness. This information could then be used to assist with successful knowledge transfer based on targeted message framing.

4.5 Conclusions

The aim of this study was to qualitatively investigate the motivators and barriers for treatment of lame sheep and to use these findings to develop a quantitative postal questionnaire. Several motivators and barriers to the prompt treatment of mildly lame sheep were identified from the analysis that could usefully be tested in a quantitative questionnaire to establish their importance. In addition, the study provided a useful understanding of farmers' perceptions of lameness in their sheep flock that is currently absent from the literature and provided context to the motivators and barriers identified. The motivators and barriers in this study require further investigation in the form of a quantitative study to examine associations between farmer opinion and the prevalence of lameness and this is the subject of the next chapter (Chapter 5).

Chapter 5 Farmers’ behaviours and attitudes towards management of lameness in their sheep flocks in England: a quantitative study

5.1 Introduction

The qualitative results from Chapter 4 suggested several motivators and barriers to the prompt treatment of lame sheep and additionally provided useful contextual understanding of them. However, a limitation of this study was the small sample size which did not permit quantitative exploration of the prevalence of lameness with these barriers and motivators. A larger study would also enable validation of the study’s findings and reliably suggest possible ways of motivating sheep farmers to make sustained changes to reduce lameness in their flock.

This chapter presents findings of a stratified random postal questionnaire, developed from Chapter 4, used to quantify farmer attitude towards management of lameness in sheep.

5.1.1 Study aims

There were two aims to this chapter. Firstly to quantitatively investigate the motivators and barriers for treatment of lame sheep and understand what lameness means to sheep farmers. Secondly to assess farmer perceptions and behaviour in relation to routine foot trimming of sheep and to understand the evidence required by the end user to change behaviour, should there be a detrimental effect from routine foot trimming.

5.2 Materials and methods

Ethical approval for the research project was sought and granted in accordance with the University of Warwick's ethics approval procedures. The interviews from Chapter 4 were used to develop a twelve page questionnaire to obtain detailed data about the respondent's farm, their flock and their opinions towards prevention and treatment of lameness in their own flock. Precise estimates of the prevalence of lameness and the severity of lameness that farmers recognised, reported and caught for inspection were also included in the questionnaire; these were developed from Chapter 3.

The pilot questionnaire was tested with research colleagues and a sheep farmer and adjustments were made. The final pilot was sent to 10 randomly selected sheep farmers obtained from EBLEX (the organisation for the English beef and sheep meat industry) with a cover letter and a pre-paid self-addressed return envelope. Their comments were used to adjust and modify the questionnaire.

5.2.1 Study population

Using Win Episcope 2.0, it was estimated that a sample size of 385 farmers were needed. The calculation assumed a population of 35,300 sheep farmers (DEFRA, 2012), with a precision of ±5.0% and a confidence level of 95%. A response rate of 50% was assumed because the address list was known to contain redundancy.

A stratified random sample of 1000 sheep farms was obtained from EBLEX, stratified by county and flock size. Ten (1%) of the names and addresses supplied were unusable. Of these, seven were duplicates with two names for the same addresses; the remaining three were not farm premises (a slaughter house and two breed societies). A further 18 addresses were excluded because they were located outside England (Wales, Scotland and Ireland).

5.2.2 The questionnaire

The final questionnaire (Appendix 10) requested information about the shepherd, the flock, and specific details on the current number of ewes, the number lame, treated, untreated, and the number lame enough to treat and too mildly lame to treat, in order to estimate the point prevalence of lameness precisely for each respondent. Where farmers had more than one flock they were asked to select one, and answer questions based on this one flock. Questions included the lowest locomotion score each farmer recognised, inspected and reported sheep lame (see Chapter 3). Information was gathered on the use of their vet in the preceding 12 months, attendance at meetings on lameness in sheep between lambing 2010 and lambing 2011, any resulting changes to their management practice and their belief on the effect of those changes. Farmers were also given a number of statements on potential motivations and obstacles to immediate treatment of lame sheep. They were asked to state the extent to which they currently agreed or disagreed with each statement by drawing a cross on a visual analogue scale (VAS) located immediately beneath it. Each VAS was identical, 100mm in length (Wewers and Lowe, 1990), of horizontal orientation (Scott and Huskisson, 1976) and contained descriptive numeric and verbal bipolar anchors (Nyren, 1988) (*e.g.* '0 never' and '100 always') that were placed beyond the ends of the scale (Huskisson, 1983). Clear, concise instruction and an example question were provided in the questionnaire at the start of this section (Price *et al.*, 1983). Farmers were also asked whether they felt that the Farm Animal Welfare Committee (FAWC) (2011) target of ≤2% for the prevalence of lameness in Great Britain flocks by 2021 was reasonable and achievable. Finally, farmers were asked a series of questions about their use of routine foot trimming in the preceding 12 months and their beliefs about its role in management of lameness in sheep.

5.2.3 Data collection

Each questionnaire was printed with the name and address of the farmer and a unique reference number. The questionnaires were sent with a covering letter (Appendix 11) and pre-paid self-addressed return envelope on 10/11/2011 to the 972 useable sheep farmer addresses obtained from EBLEX. A reminder postcard (Appendix 13) was sent out to all non-responders on 08/12/2011. A second and final reminder letter (Appendix 12), which included a copy of the questionnaire and a pre-paid self-addressed return envelope, was sent out to all remaining non-respondents on 17/01/2012. An acknowledgement postcard (Appendix 14) was sent to all respondents as completed questionnaires were received thanking them for their time and participation. The unique reference number was used to enter returns into a database and enabled the date and reason for return to be recorded as well as removal of respondents from reminder lists. The return database was managed by Selin Cooper.

5.2.4 Data input, preparation and management

Data entry for the questionnaire was done by PECS Data Services Limited (Midland House, 95a The Green, Darlaston, West Midlands, WS10 8JP). The company was selected for its experience, client testimonials, price and ability to deliver a UK based service. Data were entered manually by the company personnel into Microsoft Access® 2010 (Microsoft®, USA) using a key and verify process that guaranteed data entry to be 99.98% accurate (PECS Data Services, 2010). Once data entry was complete, the database and paper questionnaires were returned to the University of Warwick. A series of quality control checks on data entry were subsequently made by EMK: queries were used to check for anomalies and these were checked against the original paper record for errors. In addition, random checks were made on the database compared with the paper records for 10% of the questionnaires. In preparation for analysis, where possible, data from open questions were coded by EMK.

Data were extracted from the database and checked for anomalies before exporting directly, or *via* an intermediary spreadsheet (Excel® 2010, Microsoft®, USA) to one of three statistical analysis programmes (Stata SE 10.0, StataCorp, USA; IBM® SPSS® statistics 20, IBM Corp, USA; and GenStat® 13th edition, VSN International Ltd, UK). The geographical locations of respondents and non-respondents were plotted using ArcMap (ArcGIS 10.1. Environmental Research Institute Inc.).

5.2.5 Statistical analysis

Bivariate and covariate analysis were carried out using Stata SE 10.0 (StataCorp, USA). Data were non-parametric, therefore medians were compared using a Wilcoxon rank-sum test, more than two medians with a Kruskal-Wallis test and correlations between variables were performed using a Spearman's rank correlation coefficient (Rho) test (Petri and Watson, 2000). The VAS data were treated as ordinal and non-parametric (Wewers and Lowe, 1990). Tests for significance were set at $p \leq 0.05$ with p values above 0.05 but ≤ 0.10 considered trends.

Multivariate analysis was used to investigate farmer attitudes using dimension reduction techniques. Principle component analysis (PCA) and biplots were used to investigate the underlying structure within the VAS data in SPSS® statistics 20 (IBM Corp, USA). The number of components to retain was assessed using a combination of four methods: Cattell's scree test; the Kaiser criterion along with assessment of the loadings; the percentage of variance criterion (Hair *et al*., 2009); and parallel analysis (O'Connor, 2000). Procrustes rotation analysis was used to determine the best of three alternative substitutes for missing VAS values based on the dataset (Marshall Brown *et al*., 2012); the mean, the median and 49 (the mid-point of the VAS scale). PCA was re-run and the reduced components compared with the period prevalence of lameness. Canonical variates analysis (CVA) was used to examine the ratio of between-group to within-group variation of the VAS attitude data by low (≤2.0%), medium (>2.0 and <7.0%) and high (≥7.0%) period prevalence's of lameness. CVA was then repeated for VAS attitude data by the five frequency categories for prompt treatment of lame sheep with antibacterials for: ID; FR; and ID and FR combined.

5.2.5.1 Multivariate analysis tools

PCA is a dimension reduction technique that uses orthogonal transformation to convert the number of variables in a data set into an equal number of uncorrelated components which account for successively less variation in the dataset (Hotelling, 1933). The number of components is then reduced with minimal loss of variation so that the data can be visualised, summarised or explored in subsequent analysis (Jolliffe, 1986). Four techniques for component reduction were used: Kaiser criterion, scree test, percentage of variance and parallel analysis, and are described below.

The Kaiser (1960) criterion is the most well-known and commonly used technique (Fabrigar *et al*., 1999) whereby only components with eigenvalues ≥1 are retained. The logic behind the technique is based on the knowledge that each variable contributes a value of 1 to the total eigenvalue. If a component is to be retained, it should comprise the variance of at least one of the original variables. The test however has been widely criticised because of its subjective nature; a component with an eigenvalue of 1.00 would be retained but not 0.99 (Fabrigar *et al*., 1999). It has also been documented to lead to both over and under estimation (Zwick and Velicer, 1986) being most precise when the number of variables is between 20 and 50 (Hair *et al*., 2009).

The scree test proposed by Cattell (1966) is a visual assessment of the plotted eigenvalues against the number of components in order of their extraction. The last substantial drop, or '*elbow*' is used to determine a cut-off point for the optimum number of components to be retained. The '*elbow*' determines the point at which common variance is dominated by unique variance (Cattell, 1966). The scree test has also been criticised. The interpretation of scree plots is subjective, can be difficult and can vary between researchers, and with training (Zwick and Velicer, 1986).

The percentage of variance criterion examines the total cumulative variance extracted by each successive component. It ensures retained factors explain at least a defined quantity of variance; solutions of ≥60% are considered satisfactory for the social sciences (Hair *et al*., 2009).

Parallel analysis (PA) is a Monte-Carlo test for determining significant eigenvalues and is a modification of Cattell’s scree test and Kaiser’s criterion (O’Connor, 2000). A dataset with the same number of observations and variables is created from either normally distributed data generated randomly, or data generated from simulations of the original data. When data are not normally distributed, the latter is more precise because it takes account of the distribution in the original data. Its correlation matrix and eigenvalues are calculated and compared with the original PCA. Original PCA components with eigenvalues greater than their respective PA components are retained. Unlike the aforementioned tests for determining the number of components to retain, it is widely recommended and has been validated by statisticians (Franklin *et al*., 1995). However, popular statistical packages are not able to run PA without additional programming. Fortunately, researchers have created and made programme files which can be incorporated into some common statistical packages. Brian O’Connor’s ‘*rawpaw.sps’* programme was downloaded and pasted as a syntax file into SPSS (O’Connor, 2000). It was customised to run 5000 simulations of the raw data with a 95% confidence interval.

Procrustes rotation analysis rotates, translates and scales one matrix to best conform to another minimising the residual sums of squares between two configurations. PCA was applied to four datasets (the original and three substitute datasets) using GenStat® 13th edition (VSN International Ltd, UK) and the principal component scores were saved as matrices. Scores for respondents with missing and substituted data were subsequently removed from all four matrices before running Procrustes rotation analysis. The fitted configuration (substitute) which most closely matched the fixed configuration (original) was used to determine the optimum substitute for missing VAS values in subsequent analysis.

Canonical variates analysis is a tool used to discriminate between groups of individuals. It maximises the ratio of between-group to within-group variation by finding linear combinations of the variables that maximise this ratio.

To assist the reader, four brief summaries of segments of results are provided in sections 5.3.5.1 (page 222), 5.3.6.4 (page 284), 5.3.7.1 (page 302) and 5.3.8.1 (page 318).

5.3 Results

5.3.1 Response to the questionnaire

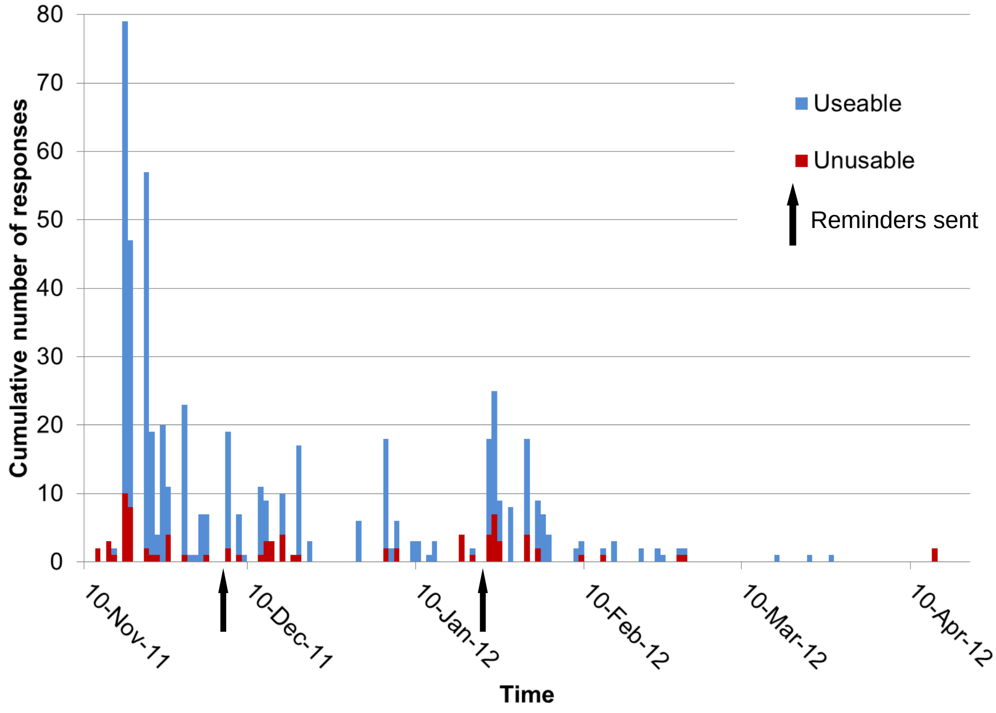
Of the 972 questionnaires sent to farmers in England, a total of 534 (54.9%) were returned, 449 (84.1%) were useable for the analysis; giving a useable response rate of 46.2%. The survey response pattern was categorised (Table 39).

Table 39: Survey response pattern from 972 English sheep farmers in 2011/12

Types of response	Number	Percentage (%)
Useable	449	46.2
No sheep in 2010	55	5.7
Addressee unknown/deceased	8	0.8
Non-participation	9	0.9
Unknown reason	13	1.3
Non-response	438	45.1
Total	972	100.0

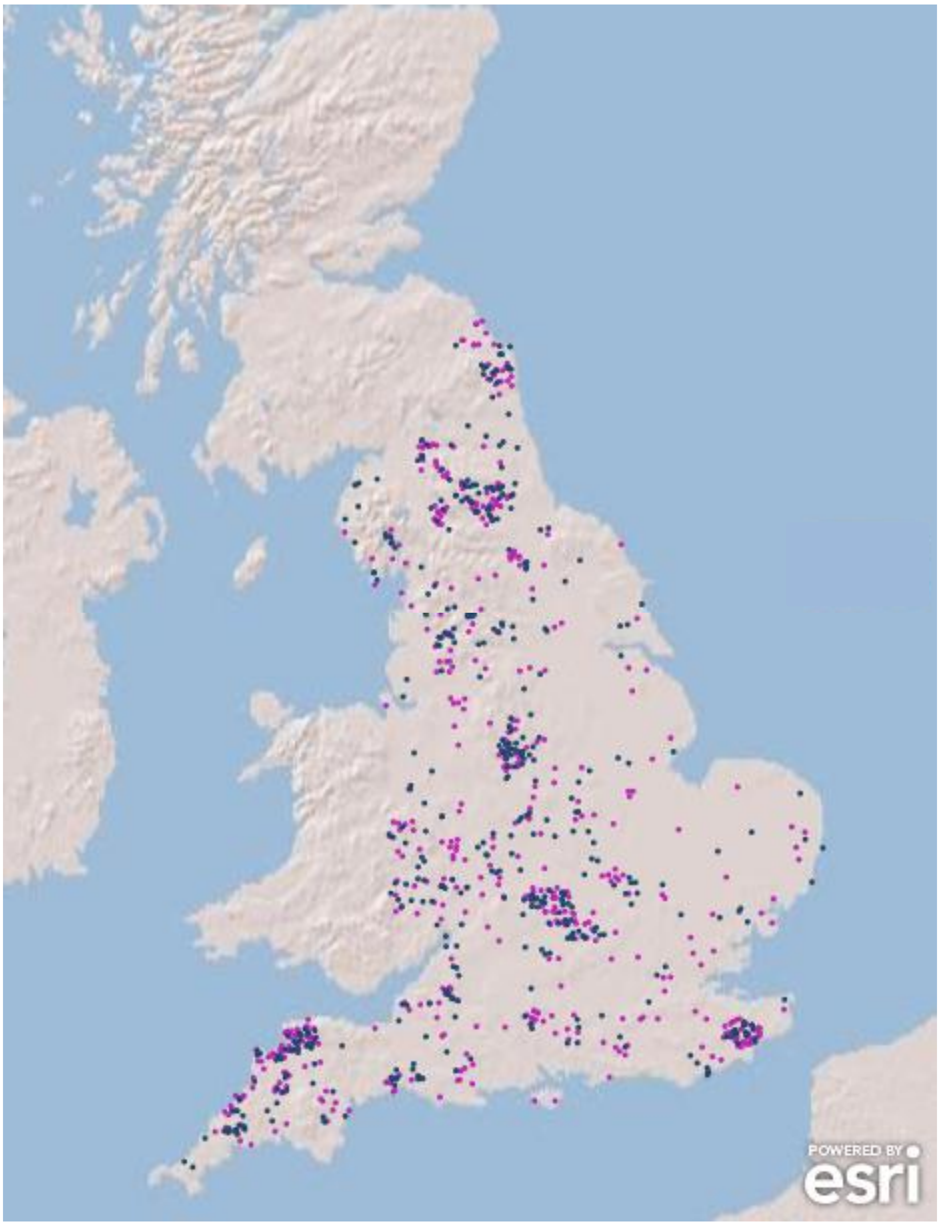
Of the 534 responses received, 310 (58.0%) were received in response the initial mailshot. A further 33 (6.2%) were received in response to the reminder postcard and a further 191 (35.8%) received in response the second reminder which included a second copy of the questionnaire (Figure 10). The final response was received on 14/04/2012, five months after the initial mailshot.

Figure 10: Cumulative number of useable and unusable responses received between 10/11/2011 and 14/04/2012



There were no obvious differences in the geographical locations of respondents and non-respondents (Figure 11). The latitudes and longitudes of respondent's and non-respondent's postcodes were compared with a Wilcoxon rank-sum test and were not significantly different ($p = 0.24$ and 0.94 respectively).

Figure 11: Geographical location of 534 respondents (pink) and 438 non-respondents (blue) in England



5.3.2 Background statistics on respondents, their farms and their flocks

Of the 449 useable responses, 362 (80.6%) respondents were male, 75 (16.7%) respondents female with a further 12 (2.7%) not stated. The median age category of all respondents (n = 446), male respondents (n = 358) and female respondents (n = 75) was 46-55 (IQR: 46-55, 56-65) equally (Table 40) and was not significantly different between sexes (p = 0.87).

Table 40: Frequency distribution of respondents' age and by sex

Age category (years)	Total respondents Number (%)	Male respondents Number (%)	Female respondents Number (%)
≤ 25	12 (2.7)	10	2
26-35	22 (4.9)	20	1
36-45	60 (13.4)	47	13
46-55	138 (30.7)	110	25
56-65	115 (25.6)	94	19
>65	97 (21.6)	77	15
unwilling to say	2 (0.4)	1	0
not stated	3 (0.7)	78	0
N	449	437	75
Median	45-55	45-55	45-55
IQR	45-55, 56-65	45-55, 56-65	45-55, 56-65

N = number; IQR = interquartile range

Overall, respondents (n = 430) had a median of 30 years farming experience (IQR: 20, 40) with males (n = 350) farming for significantly longer than females (n = 71) with a median of 30 years (IQR: 22, 40) compared with 20 (IQR: 11, 30) (p <0.01).

Three hundred and twenty one (71.5%) respondents farms were lowland, 94 (21.0%) upland, 27 (6.0%) hill, 1 (0.2%) both upland and hill, 1 (0.2%) all three and a further 5 (1.1%) not stated. Three hundred and fifty one respondents

(78.2%) had commercial flocks, 87 (19.4%) pedigree flocks, 5 (1.1%) both pedigree and commercial flocks, and 6 (1.3%) not stated.

The median period prevalence of lameness over the preceding 12 months as given by 390 (86.9%) respondents was 5% (IQR: 2, 8) and spanned a period November 2010 to March 2012. It included 2 respondents that reported a very high period prevalence of lameness (75% and 90%), both of which had a small number of ewes (21 and 1 respectively). They were excluded from all subsequent analysis that used period prevalence of lameness. The IQR and median period prevalence of lameness following their exclusion remained unchanged. The period prevalence of lameness was not significantly different by farm type (p = 0.41), respondent sex (p = 0.80) and did not vary significantly by the age category of the respondent (p = 0.32) or years of farming experience (Rho = 0.05, p = 0.38). It was however, significantly higher in commercial flocks compared with pedigree flocks (p <0.01) (Table 41).

Table 41: The number of respondents, the median, interquartile range and range of the period prevalence of lameness (%) by respondents' farm and flock type, sex and age (years).

Respondent	Number	Median	IQR	Range
Lowland	227	5.0	2.0, 8.0	0.0 – 25.0
Upland	86	5.0	3.0, 8.0	0.0 – 25.0
Hill	21	3.0	2.0, 5.0	0.0 – 15.0
Commercial	308	5.0	3.0, 8.0	0.0 – 25.0
Pedigree	74	3.0	2.0, 5.0	0.0 – 25.0
Male	316	5.0	2.0, 8.0	0.0 – 25.0
Female	64	5.0	2.0, 10.0	0.0 – 25.0
≤ 25	10	5.5	5.0, 8.0	0.0 – 14.0
26-35	22	5.0	3.0, 10.0	0.0 – 15.0
36-45	54	5.0	3.0, 8.0	0.0 – 25.0
46-55	113	5.0	2.0, 5.0	0.0 – 25.0
56-65	100	5.0	2.5, 9.0	0.0 – 25.0
>65	85	4.0	2.0, 6.0	1.0 – 15.0

5.3.3 Management of lameness in respondents' flocks

When asked when they last checked their flock for lameness, 439 (97.8%) farmers responded. Of those that responded, 215 (49.0%) checked their flock '*today*', 89 (20.3%) '*yesterday*', 75 (17.1%) '*three or more days ago*' and 60 (13.6%) checked their flock for lameness '*over a week ago*'. There was no significant difference between the last check for lameness and respondents age or years of farming experience ($p = 0.51$ and 0.28 respectively). However, female respondents checked their flocks for lameness more recently than male respondents ($p <0.01$) (Table 42). Similarly, pedigree farmers checked their flocks for lameness more recently than commercial respondents ($p <0.01$) (Table 42). There was also significant variability within farm types ($p <0.01$) with lowland farmers checking their flocks significantly more recently than either upland or hill farmers ($p <0.01$ and 0.01 respectively) (Table 42). Finally both the period prevalence in the preceding 12 months and the point prevalence of lameness were significantly different by respondent's last flock check (p = 0.03 and <0.01) with respondents who had checked their flocks '*today*' with a significantly lower period and point prevalence of lameness compared with those who checked their flock '*yesterday*' and '*three or more days ago*' (p = 0.01; <0.01; 0.03 and <0.01 respectively) (Table 42).

Table 42: Most recent inspection by respondent on flock lameness by respondent sex, flock and farm type and the period and point prevalence of lameness

Respondent	Number	Median	IQR	Range
Male	354	*2*	*1, 3*	*1 - 4*
Female	74	*1*	*1, 2*	*1 - 4*
Commercial	343	*2*	*1, 3*	*1 - 4*
Pedigree	85	*1*	*1, 2*	*1 - 4*
Lowland	314	*1*	*1, 3*	*1 - 4*
Upland	91	*2*	*1, 3*	*1 - 4*
Hill	27	*2*	*1, 3*	*1 - 4*
Period Prevalence				
1	185	4.0%	2.0, 6.0%	0.0 – 25.0%
2	82	5.0%	3.0, 9.0%	0.0 – 25.0%
3	61	5.0%	3.0, 10.0%	0.0 – 25.0%
4	53	5.0%	3.0, 10.0%	0.0 – 20.0%
Point prevalence				
1	196	1.5%	0.1, 3.8%	0.0 – 25.0%
2	8	2.9%	1.4, 4.6%	0.0 – 15.0%
3	72	2.6%	1.1, 4.8%	0.0 – 19.5%
4	58	2.4%	0.6, 4.0%	0.0 – 15.4%

1 = 'today'; 2 = 'yesterday', 3 = 'three or more days ago'; 4 = 'more than a week ago'

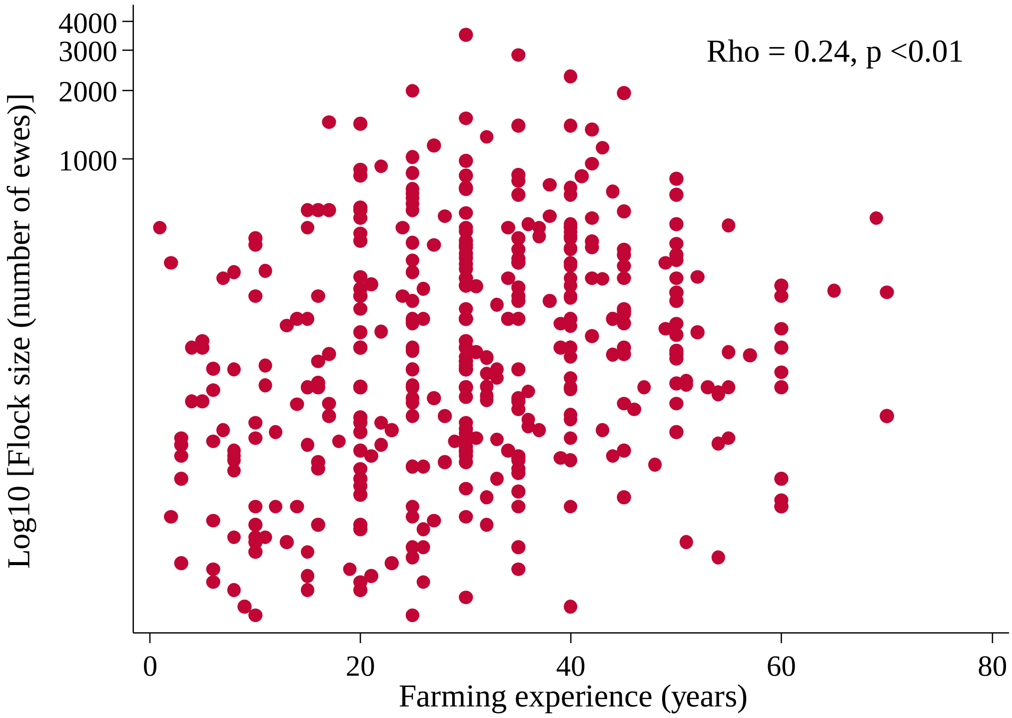
The median number of ewes in 440 (98.0%) respondents' flocks was 120 (IQR: 48.5, 300; Range: 0, 3500). There were 6 (1.3%) respondents with no ewes in their flock and a further 18 (4.0%) with between 1 and ≤9 ewes (possibly farmers who reared replacement ewe lambs, had rams only or hobby farmers). Subsequent analysis with flock size excluded respondents with <10 ewes. The amended median number of ewes in 416 (92.7%) respondents' flocks was 136 (IQR: 56.5, 327; Range: 10, 3500).

Pedigree farmers had smaller flocks than commercial farmers and this was significant ($p < 0.01$) (Table 43). Flock size also varied significantly by farm type ($p < 0.01$), with significantly smaller flock sizes for lowland compared with upland flocks ($p < 0.01$) (Table 43). Female farmers had significantly smaller flocks than male farmers ($p < 0.01$) (Table 43). Flock size also varied significantly with the age of the respondent ($p < 0.01$) with significantly smaller flocks for respondents over 65 compared with those aged between 26-45 ($p \leq 0.03$). In addition, there was a trend for respondents ≤25 years to have a smaller flock size compared with those aged 36-45 ($p = 0.06$) (Table 43). Finally, flock size was significantly positively correlated with respondents farming experience (Rho = 0.24, $p < 0.01$) (Figure 12) but was not significantly correlated with either the period or point prevalence of lameness (Rho <0.01 and 0.07, $p > 0.1$).

Table 43: The median, interquartile range and range of ewe flock size by respondent sex, age, flock and farm type.

Respondent	Number	Median	IQR	Range
Male	341	155	65, 360	11 - 3500
Female	65	50	19, 120	10 - 470
Commercial	333	162	75, 370	10 - 3500
Pedigree	73	40	19, 84	10 - 500
Lowland	295	120	50, 277	10 – 1950
Upland	90	245	85, 460	10 – 2850
Hill	24	139.5	95, 327.5	17 - 670

Figure 12: Scatter plot comparing respondents flock size with the number of years of farming experience



The point prevalence of lameness was calculated for 411 (91.5%) respondents who had ≥10 ewes in their flock and then for 353 (78.6%) respondents that had answered all 6 questions about the number of ewes, the number lame, lame and treated, lame and untreated, too mildly lame and lame enough to treat (Table 44). These respondents completed the questionnaire between 10/11/2011 and 19/03/2011 (median completion date: 19/11/2011, IQR: 14/11/2011, 17/12/2011) and the median number of ewes for these respondents was 120 (IQR: 53, 300: Range; 10, 3500).

Table 44: Estimates of the point prevalence of lameness between November 2011 and March 2012 given by 353 respondents

Point prevalence of lameness of ewes:	Median	IQR	Range
Treated and untreated	2.2	0.6, 4.2	0.0 – 25.0
Previously treated	0.4	0.0, 1.6	0.0 – 15.4
Untreated	0.6	0.0, 2.1	0.0 – 22.2
Too mildly lame to treat	0.0	0.0, 1.5	0.0 – 22.2
Lame enough to treat	1.0	0.0, 3.0	0.0 – 22.2

The point prevalence of lameness of treated and untreated ewes (abbreviated to point prevalence of lameness from here on) was significantly lower than the period prevalence of lameness over the preceding 12 months ($n = 359$, $p < 0.01$) but they had good correlation ($Rho = 0.60$, $p < 0.01$) (Figure 13). The point prevalence of lameness did not vary significantly with the time of year (November 2011 – March 2012) that respondents completed the questionnaire ($Rho = <-0.01$, $p = 0.92$); a logarithm transformation was applied to the data and an S-curve fitted to aid visualisation (Figure 14).

Figure 13: Scatter plot comparing the period prevalence of lameness in the preceding 12 months with the point prevalence of lameness as estimated by respondents

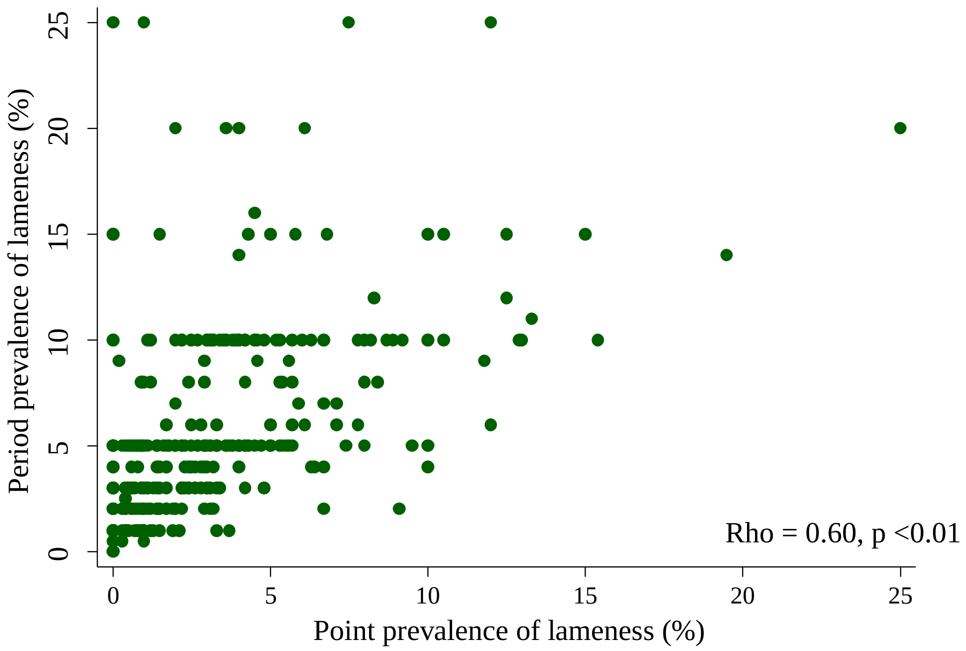
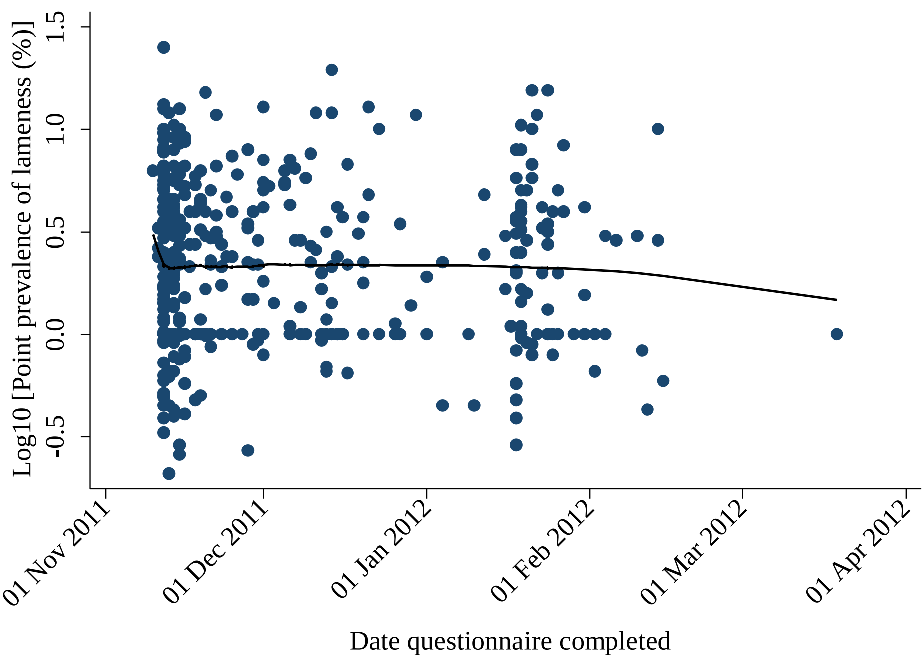


Figure 14: Scatter plot comparing the point prevalence of lameness with the date of completion of the questionnaire



In addition, the point prevalence of lameness did not vary significantly by respondent age (p = 0.13), sex (p = 0.95) or farm type (p = 0.35) and was not significantly correlated with the number of years of farming experience (Rho = 0.04, p = 0.48). The point prevalence was however, significantly lower for pedigree compared with commercial farmers (p <0.01) with medians of 1.4 *cf.* 2.4% (Table 45).

Table 45: The median, interquartile range and range of the point prevalence of lameness (%) by number of respondents by farm and flock type, sex and age.

Respondent	Number	Median	IQR	Range
Lowland	290	2.2	0.6, 4.6	0.0 – 25.0
Upland	90	2.5	0.9, 3.5	0.0 – 13.3
Hill	24	1.4	0.7, 2.6	0.0 – 12.5
Commercial	330	2.4	0.8, 4.2	0.0 – 25.0
Pedigree	72	1.4	0.0, 3.3	0.0 – 12.5
Male	337	2.2	0.7, 4.0	0.0 – 25.0
Female	65	2.4	0.0, 5.0	0.0 – 15.4
Age in years				
≤ 25	12	4.0	2.4, 6.1	0.0 – 11.8
26-35	22	2.4	1.1, 4.6	0.0 – 12.9
36-45	56	2.4	0.9, 4.4	0.0 – 15.4
46-55	123	2.2	0.9, 4.0	0.0 – 15.4
56-65	106	2.2	0.6, 4.2	0.0 – 25.0
>65	88	1.5	0.0, 3.9	0.0 – 13.3

Between lambing and weaning 2011, 112 (24.9%) respondents '*always*' used parenteral and topical antibacterials within 3 days of becoming lame to treat adult ewes lame with footrot (FR). A further 106 (23.6%) did this '*most of the time*', 128 (28.5%) '*sometimes*', 46 (10.3%) '*never*', 40 (8.9%) stated '*not applicable*' and 17 (3.8%) respondents did not answer this question. In comparison, this method was used to treat adult ewes lame with interdigital dermatitis (ID) during the same period '*always*' by 86 (19.2%) respondents, '*most of the time*' by 91 (20.3%), '*sometimes*' by 137 (30.5%), '*never*' by 74 (16.5%), was stated '*not applicable*' by 35 (7.8%) and was not answered by 26 (5.8%) respondents. Significantly more respondents '*always*' treated adult ewes lame with FR with parenteral and topical antibacterial than compared with ID ($p = 0.04$). In addition, more respondents '*never*' treated adult ewes lame with ID with parenteral and topical antibacterial compared with FR and this was significant ($p <0.01$).

When responses to the two diseases were combined, 58 (12.9%) respondents '*always*' used parenteral and topical antibacterials to treat lame sheep with ID and FR within 3 days of becoming lame. A further 56 (12.5%) respondents did this '*most of the time*', 78 (17.4%) '*sometimes*', 38 (8.5%) '*never*', and 19 (4.2%) stated '*not applicable*'. There were also 165 (36.7%) respondents that differed in their management of ID compared with FR; a further 35 (7.8%) respondents did not answer either one or both questions on the management of these two conditions.

The median period prevalence of lameness over the preceding 12 months varied by treatment type for FR, ID and both diseases combined ($p <0.01$). The period prevalence of lameness was significantly lower for those respondents who '*always*' treated adult ewes lame with FR within 3 days with parenteral and topical antibacterials than those who did this '*most of the time*' or '*sometimes*' ($p \leq 0.01$). This was also the case for respondents who '*always*' treated adult ewes lame with ID compared with those who did this '*most of the time*' or '*sometimes*' ($p <0.01$); and also for ID and FR combined ($p = 0.02$ and <0.01 respectively)

(Table 46). Interestingly, the median period prevalence of lameness was also significantly lower for those respondents who '*never*' treated adult ewes lame with FR, and with ID and FR combined with parenteral and topical antibacterials within 3 days compared to respondents who did this '*most of the time*' ($p = 0.05$ and <0.01 respectively) (with a trend just for ID alone, $p = 0.10$) and '*sometimes*' ($p < 0.01$). Also of interest were those respondents who stated '*not applicable*'. They had a lower median period prevalence of lameness over the preceding 12 months than any other category of treatment frequency for ID, FR, and ID and FR combined and this was significant ($p \leq 0.01$) (Table 46).

Table 46: The median period prevalence of lameness over the preceding 12 months reported by respondents by use of parenteral and topical antibacterials for treatment of adult ewes lame with footrot and interdigital dermatitis both separately and combined.

Use	N	Median	IQR	Range
Footrot				
Always	93	4.0	2.0, 5.0	0.0 - 20.0
Most of the time	96	5.0	3.0, 9.0	0.0 - 20.0
Sometimes	110	5.0	4.0, 10.0	1.0 - 25.0
Never	41	3.0	2.0, 5.0	1.0 – 25.0
Not applicable	32	1.0	1.0, 4.0	0.0 – 10.0
Interdigital dermatitis				
Always	71	4.0	2.0, 5.0	0.0 - 20.0
Most of the time	84	5.0	3.0, 10.0	0.0 - 20.0
Sometimes	119	5.0	3.0, 8.0	0.0 – 25.0
Never	63	5.0	2.0, 7.0	1.0 – 25.0
Not applicable	32	2.0	1.0, 5.0	0.0 – 15.0
Interdigital dermatitis and footrot combined				
Always	48	4.5	2.0, 5.0	0.0 - 20.0
Most of the time	52	5.0	3.5, 10.0	0.0 - 20.0
Sometimes	66	5.0	5.0, 10.0	1.0 – 25.0
Never	33	4.0	2.0, 6.0	1.0 – 25.0
Not applicable	18	1.0	0.0, 5.0	0.0 – 10.0

Similarly, when the median point prevalence of lameness was compared, it was significantly lower for those respondents who '*always*' treated adult ewes lame with FR and ID separately and combined within 3 days with parenteral and topical antibacterials than those who did this '*most of the time*' or '*sometimes*' (FR: $p < 0.02$) (ID: $p < 0.01$) (FR and ID combined: $p \leq 0.01$) (Table 47). It was also significantly lower for those respondents who '*never*' treated adult ewes lame with FR (but not ID alone or in combination with FR) with parenteral and topical antibacterials within 3 days compared to respondents who did this '*sometimes*' (FR: $p < 0.02$; ID: $p = 0.37$; FR and ID combined: $p = 0.09$). In addition, those respondents who stated '*not applicable*' had a lower median point prevalence of lameness than any other category of treatment frequency for FR, ID and ID and FR combined and this was significant ($p < 0.02$) for all except FR alone in comparison with '*always*' ($p = 0.09$) (Table 47).

Table 47: The median point prevalence of lameness by use of parenteral and topical antibacterials for treatment of adult ewes lame with footrot and interdigital dermatitis both separately and combined.

Use	N	Median	IQR	Range
Footrot				
Always	102	1.4	0.4, 3.3	0.0 – 12.0
Most of the time	101	2.5	0.9, 4.2	0.0 – 25.0
Sometimes	118	3.0	1.3, 5.0	0.0 – 19.5
Never	40	2.1	0.0, 3.5	0.0 – 15.4
Not applicable	35	0.8	0.0, 3.3	0.0 – 11.8
Interdigital dermatitis				
Always	77	1.4	0.0, 3.3	0.0 - 12.0
Most of the time	86	2.8	1.1, 4.0	0.0 - 25.0
Sometimes	129	2.7	1.0, 5.2	0.0 – 19.5
Never	68	2.7	0.7, 4.2	0.0 – 15.4
Not applicable	30	0.4	0.0, 1.7	0.0 – 10.0
Interdigital dermatitis and footrot combined				
Always	52	1.4	0.2, 3.7	0.0 – 11.8
Most of the time	54	2.9	1.5, 4.0	0.0 - 25.0
Sometimes	74	2.95	1.1, 5.6	0.0 – 19.5
Never	34	2.6	0.0, 4.2	0.0 – 15.4
Not applicable	16	0.2	0.0, 1.7	0.0 – 5.0

There was no significant difference in the use of parenteral and topical antibacterials for treatment of adult ewes lame with ID, FR or both diseases combined by categories for respondents last check for lameness ($p \geq 0.44$).

5.3.4 Respondents and their veterinary advisors

A total of 402 (89.5%) respondents used their vets to provide medicine, 266 (59.2%) for advice, 115 (25.6%) for flock health planning, 131 (29.2%) seminars, meeting or events; 33 (7.4%) did not use their vet, 3 (0.7%) did not have a vet, 17 (3.8%) used their vet for other reasons and 2 (0.5%) did not answer this question (Table 48).

Table 48: Number and percentage of respondents by services accessed from their veterinary advisor(s) over a 12 month period

Service accessed from veterinary advisor	Number (%) of respondents
Medicine	402 (89.5)
Advice	266 (59.2)
Flock health planning	115 (25.6)
Seminars, courses, meetings or events	131 (29.2)
None	33 (7.4)
No veterinary advisor	3 (0.7)
Other reason	
Lambing assistance	7 (1.6)
Ram fertility testing	3 (0.7)
Ram vasectomy	1 (0.2)
Ram de-horning	1 (0.2)
Export checks	1 (0.2)
Post mortem	1 (0.2)
Dog attack	1 (0.2)
Sheep event subsidy	1 (0.2)
Non-sheep related	1 (0.2)
Not stated	2 (0.5)

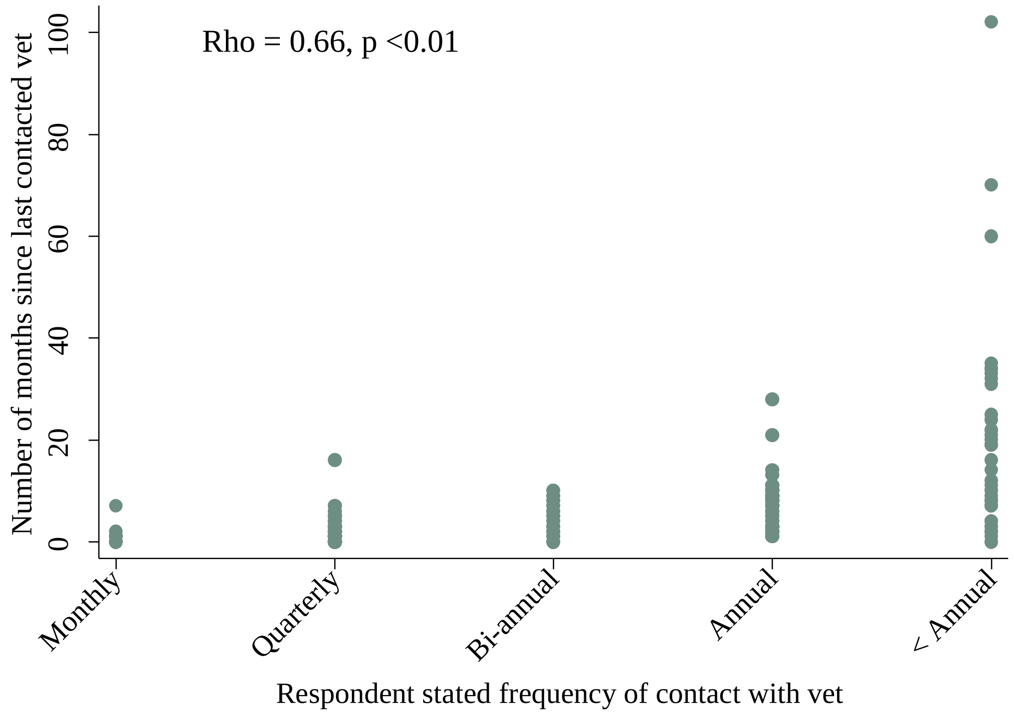
There was no significant difference in respondents' frequency of use of parenteral and topical antibacterials for respondents who did not use their vet for medicine ($p>0.05$). Respondents most frequently contacted their veterinary advisors twice per year (IQR: quarterly, annually) (Table 49).

Table 49: Number and percentage of respondents by frequency of contact with their veterinary advisor

Contact frequency with veterinary advisor	Number (%) of respondents
Monthly	37 (8.2)
Quarterly	90 (20.1)
Bi-annually	142 (31.6)
Annually	85 (18.9)
Less than annually	71 (15.8)
Not stated	24 (5.4)

The difference between the date the questionnaire was completed (dd/mm/yyyy) and the date of last veterinary contact (mm/yyyy) was calculated in months for 366 (81.5%) respondents. The number of months since last contact with vet had good correlation with the frequency of veterinary contact as stated by the respondent which was significant (Rho = 0.66, p <0.01) (Figure 15).

Figure 15: Scatter plot comparing the number of months between questionnaire completion date and respondents last contact with their vet by the respondent self-stated frequency of contact with vet



There was a trend for significant difference in the period prevalence of lameness with differences in respondent's frequency of contact with their vet ($p = 0.09$). Respondents who stated that they contacted their vet less than annually had a significantly lower period prevalence of lameness than those who contacted their vet bi-annually, with a trend for quarterly and annually ($p <0.01$; 0.10 and 0.08) (Table 50). There was however significant variability in the point prevalence of lameness with differences in respondent's frequency of contact with their vet ($p <0.01$). Again, respondents who stated that they contacted their vet less than annually had a significantly lower point prevalence of lameness than those who contacted their vet monthly, quarterly, bi-annually and annually ($p \leq 0.03$) (Table 50).

Table 50: The number of respondents, the median, interquartile range and range of the period and point prevalence of lameness by respondents' stated frequency of contact with their vet

Frequency of contact	N	Median	IQR	Range
Period prevalence of lameness				
Monthly	31	5.0	2.0, 5.0	0.5 – 15.0
Quarterly	78	5.0	2.0, 6.0	0.0 – 20.0
Bi-annually	122	5.0	3.0, 10.0	0.0 – 25.0
Annually	76	5.0	3.0, 10.0	0.0 – 20.0
< Annually	62	3.0	2.0, 5.0	0.0 – 20.0
Point prevalence of lameness				
Monthly	36	2.3	0.9, 3.3	0.0 – 8.4
Quarterly	81	2.4	0.9, 4.6	0.0 – 12.0
Bi-annually	130	2.5	0.6, 4.0	0.0 – 19.5
Annually	77	3.0	0.5, 5.5	0.0 – 15.4
< Annually	66	1.1	0.0, 2.5	0.0 – 25.0

N = number of respondents; IQR = interquartile range

There was also significant variability in flock size by contact frequency with their vet ($p < 0.01$), with respondents with larger flock sizes having more contact (Table 51). Farmers in monthly contact with their vet had significantly larger flock sizes than those in bi-annual, annual and less than annual contact ($p < 0.01$) with a trend for quarterly contact ($p = 0.06$). Those who contacted their vet quarterly had a significantly larger flock size than those in bi-annual, annual ($p \leq 0.05$) and less than annual contact ($p < 0.01$). In addition, farmers who contacted their vet bi-annually had a significantly larger flock size than those who contacted their vet less than annually ($p = 0.05$).

Table 51: The number of respondents, the median, interquartile range and range of flock size by respondents' stated frequency of contact with their vet

Contact frequency	Number	Median	IQR	Range
Monthly	36	332	136.5, 654	27 - 3500
Quarterly	82	200	65, 460	14 - 1950
Bi-annually	132	127.5	60, 270	11 - 1400
Annually	77	100	50, 250	10 - 2300
< annually	68	79.5	33, 275	10 - 1980

IQR = interquartile range

5.3.5 Educational events on management of lameness attended by respondents

One hundred and eight respondents (24.1%) had attended at least one meeting, seminar or course on lameness in sheep between lambing 2010 and lambing 2011. These events were mainly organised by vets (72.2%) or EBLEX (42.6%) (Table 52).

Table 52: Number and percentage of respondents attending lameness in sheep educational events between lambing 2010 and lambing 2011 by event organiser

Organiser	Number (%) respondents
Vet	78 (72.2)
EBLEX	46 (42.6)
ADAS	2 (1.9)
RDA	3 (2.8)
Unknown	4 (3.7)
Other	
Sheep group	4 (3.7)
College	2 (1.9)
Pharmaceutical company	2 (1.9)
Breed society	1 (0.9)
Monitor farm	1 (0.9)
Rural hub	1 (0.9)

There was a trend for both the period and point prevalence of lameness to be higher for those who attended a meeting compared with those that did not ($p = 0.09$) (Table 53).

Table 53: The number of respondents and median, interquartile range and range of the period and point prevalence of lameness by respondents who did and did not attend an event on the management of lameness between lambing 2010 to lambing 2011.

Event attendance	N	Median	IQR	Range
Period prevalence				
Attended	91	5.0	3.0 , 8.0	0.0 – 25.0
Did not attend	297	5.0	2.0, 7.0	0.0 – 25.0
Point prevalence				
Attended	98	2.5	0.9, 4.5	0.0 – 15.4
Did not attend	311	2.2	0.5, 4.0	0.0 – 25.0

N = number of respondents; IQR = interquartile range

After attending the event(s) 45 (41.6%) respondents made changes to management of lameness in their flock. There was a trend for respondents who made changes to have a higher period and point prevalence of lameness compared with those who did not make changes ($p \leq 0.08$ equally) (Table 54).

Table 54: The median, interquartile range and range of the point and period prevalence of lameness for the preceding 12 months by the number of respondents who did and did not make changes to management of lameness in their sheep flock after attending a meeting on lameness in sheep.

Management practice	N	Median	IQR	Range
Period prevalence				
No change	50	5.0	2.0, 8.0	0.5 – 25.0
Changed practice	35	5.0	5.0, 10.0	0.0 – 20.0
Point prevalence				
No change	50	1.6	0.9, 3.6	0.0 – 13.0
Changed practice	40	3.2	1.6 – 5.2	0.0 – 15.0

N = number of respondents; IQR = interquartile range

When asked whether changes made had reduced the prevalence of lameness in their flock, 32 (71.1%) said yes, 2 (4.4%) said no, 8 (17.8%) did not know, and 3 (6.7%) did not give an answer to this question.

5.3.5.1 Summary of results sections 5.3.1-5.3.5

The majority of respondents were male (80.6%), lowland (71.5%) and commercial (78.2%) farmers. Over 75% of respondents were >45 years old with male farmers having more experience than females.

The median ewe flock size was 136 ewes, was positively correlated with farming experience, with male, commercial and upland farmers holding larger flock sizes. Farmers that were >65 and ≤25 years had smaller flocks.

The median period prevalence of lameness was 5.0% (IQR: 2-8) and the median point prevalence of lameness was 2.2% (IQR: 0.6 - 4.2%); lower but positively correlated (Rho = 0.60). Both were higher in commercial *cf.* pedigree flocks. The period and point prevalence of lameness were lower for respondents (49.0%) who had checked their flock '*today*'. Female, pedigree and lowland respondents checked their flocks more recently compared with male, commercial and upland/hill respondents respectively.

More respondents '*always*' and fewer respondents '*never*' promptly treated FR with parenteral and topical antibacterials compared with ID (25% *cf.* 20% and 10.3 *cf.* 16.5% respectively); with 36.7% of respondents treating FR and ID at different frequencies.

The period and point prevalence of lameness were lower for respondents who '*always*' promptly treated ID, FR and both diseases combined with parenteral and topical antibacterials compared with '*most of the time*' and '*sometimes*'. They were also both lower for respondents who stated '*not applicable*' for this treatment for ID, FR and both diseases combined compared with all other frequencies of treatment. In addition, respondents had a lower period prevalence of lameness when they '*never*' treated ID, FR and both diseases combined with parenteral and topical antibacterials than those who did this '*most of the time*'. The point prevalence of lameness was lower for respondents who '*never*' treated FR and both disease combined in this way compared with '*sometimes*'.

Veterinary involvement in the flock was principally provision of medicines (89.5%) and advice (59.2%); 8.1% of respondents did not use or did not have a vet. The median frequency of veterinary contact was bi-annual (IQR: quarterly – annual). The flock size, period and point prevalence of lameness were higher for respondents in more frequent contact with their vet.

The majority of educational events on lameness attended by respondents were organised by vets and EBLEX. Those respondents that attended events, and that made changes after attending events, had higher period and point prevalence's of lameness; with the majority (71.1%) of respondents believing changes made were successful in reducing lameness.

5.3.6 Farmers' views on lameness in their sheep flock

5.3.6.1 Lowest locomotion score recognised, reported and caught for treatment

A table of locomotion scores with associated verbal descriptions of lameness with increasing severity was given in the questionnaire (Appendix 10). Locomotion score 2 is regarded by researchers as the lowest score that has good inter and intra observer reliability and therefore used to classify a sheep as '*lame*' (Kaler *et al*., 2009). Of farmers who answered questions on locomotion, 112 (27.5%) respondents stated that they reported lameness above locomotion score 2 and a further 122 (30.0%) respondents reported below locomotion score 2 (p = 0.44) (Table 55). The median lowest locomotion score that 445 (99.1%) respondents recognised, 446 (99.3%) caught with the intention of treating and 407 (90.6%) reported as lame in postal surveys was 1, 2, and 2 respectively.

Table 55: The lowest locomotion score that respondents recognised, caught and reported lameness in sheep.

Locomotion score	Recognised N (%)	Caught N (%)	Reported N (%)
0	0 (0.0)	0 (0.0)	0 (0.0)
1	256 (57.0)	127 (28.3)	122 (27.2)
2	140 (31.2)	182 (40.5)	173 (38.5)
3	42 (9.4)	120 (26.7)	82 (18.3)
4	6 (1.3)	16 (3.6)	18 (4.0)
5	1 (0.2)	1 (0.2)	9 (2.0)
6	0 (0.0)	0 (0.0)	3 (0.7)
N	445 (99.1)	446 (99.3)	407 (90.6)
Median	1	2	2
IQR	1, 2	1, 3	1, 3
Range	1 - 5	1 - 5	1 - 6

Responses from 405 (90.2%) respondents answering all three questions were compared and varied significantly (p <0.01). Respondents reported a significantly lower minimum locomotion score for recognised than caught lame ewes for treatment or reported in postal surveys (p <0.01). However, these were significantly correlated (Rho = 0.55 and 0.57 respectively, p <0.01) (Figure 16 and Figure 17). The minimum locomotion score given by respondents for lame ewes caught compared with lame ewes reported was not significantly different (p = 0.57); the correlation coefficient was lower (Rho = 0.45) but was again significant (p <0.01) (Figure 18).

Figure 16: Scatter plot to compare the minimum locomotion score respondents recognised as lame with the minimum locomotion score they caught for inspection and treatment, weighted by frequency of the minimum locomotion score caught

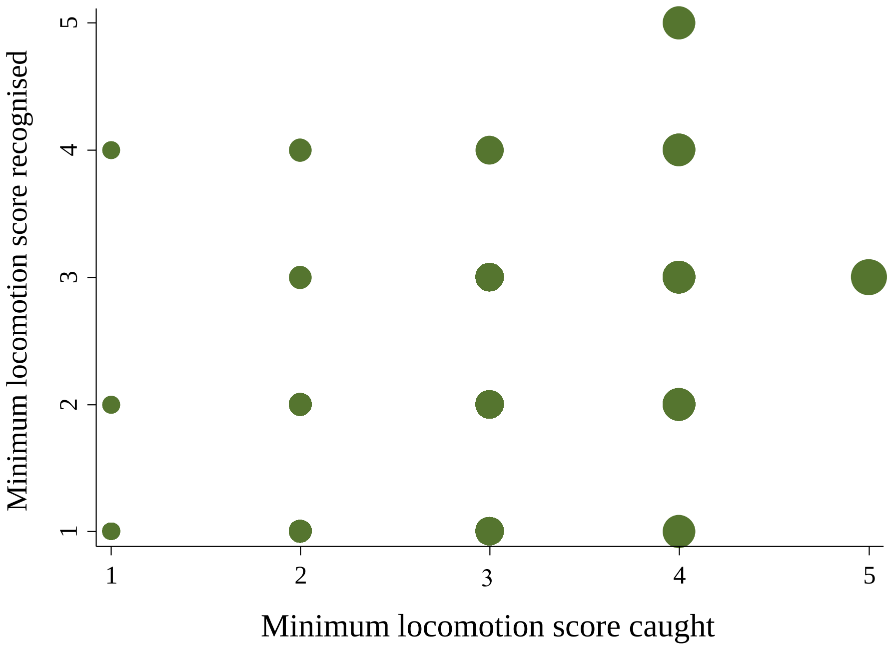


Figure 17: Scatter plot to compare the minimum locomotion score respondents recognised as lame with the minimum locomotion score they reported as lame in postal surveys, weighted by frequency of the minimum locomotion score reported

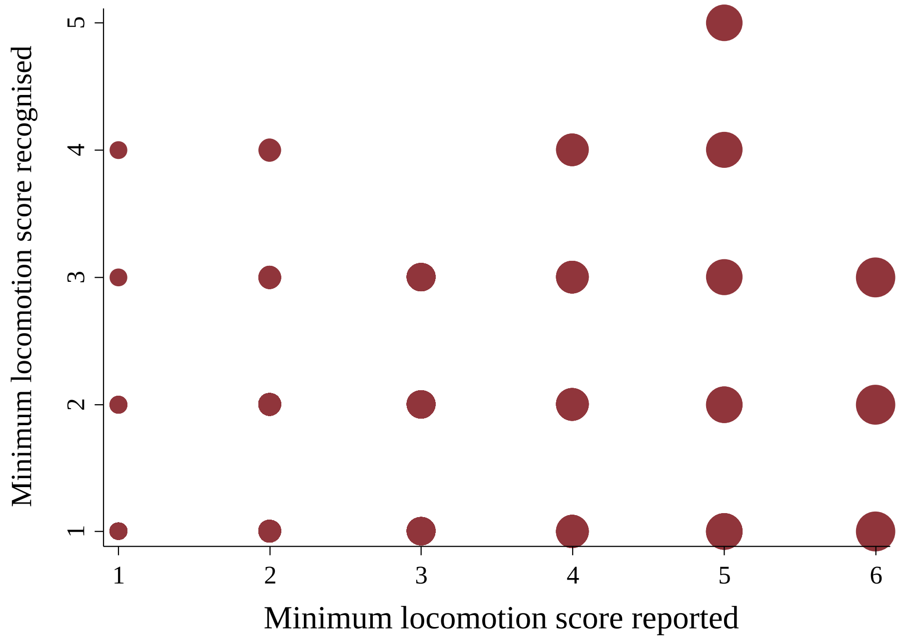
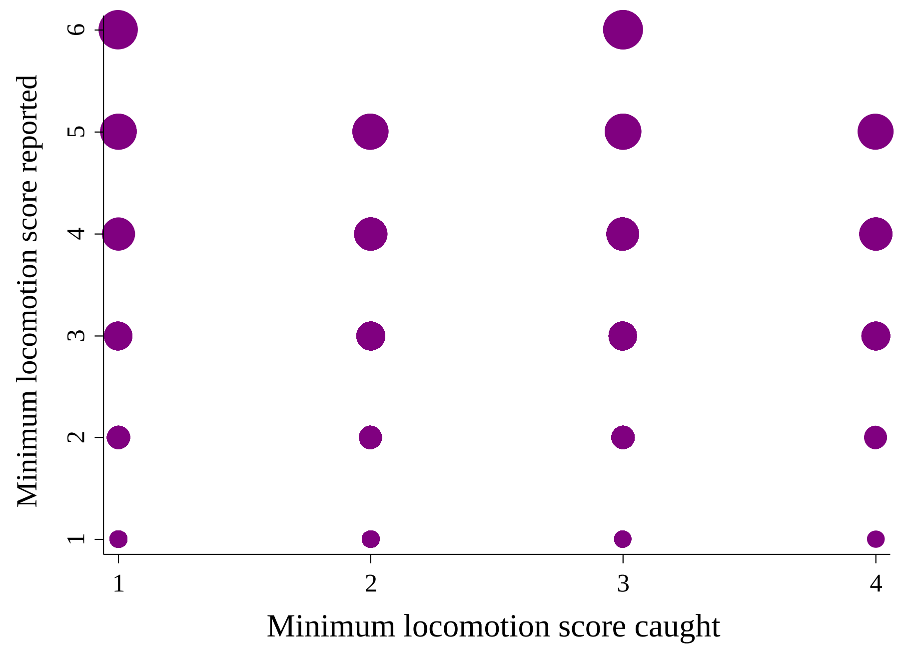


Figure 18: Scatter plot to compare the minimum locomotion score respondents reported as lame in postal surveys with the minimum locomotion score they caught as lame for inspection and treatment, weighted by frequency of the minimum locomotion score reported



There was significant variability in the prevalence of lameness by the minimum number of lame ewes needed in a group to prompt individual investigation with the intention of providing treatment; and also by the lowest locomotion score that respondents caught for treatment (Table 56). The period (but not point) prevalence of lameness varied significantly for respondents who caught the first lame ewe in a group by the minimum locomotion score they caught ($p = 0.02$). Respondents who caught at locomotion score 1 had a significantly lower period prevalence than those that caught at locomotion scores ≥3 ($p <0.01$); with a trend in comparison with those that caught at locomotion score 2 ($p = 0.07$). There was however no significant variability in the period or point prevalence of lameness by the minimum locomotion score caught for those that waited for either 2-5 or ≥6 ewes to be lame in a group before investigating ($p >0.2$) (Table 56).

In addition, there was significant variability in both the period and point prevalence of lameness by the minimum number of lame ewes needed in a group to prompt inspection, for respondents that caught at locomotion scores 1 and 2; and ≥3 for the point prevalence only ($p <0.03$) (Table 56). For respondents that caught lame sheep at locomotion score 1, the period prevalence of lameness was significantly lower for those that caught the first lame sheep in a group compared with those who waited for 2-5 lame sheep ($p <0.01$); with a trend in comparison with respondents who waited for ≥6 lame sheep ($p = 0.07$). Similarly the point prevalence of lameness was significantly lower for those that caught the first lame ewe in a group compared with those who waited for 2-5 lame ewes ($p <0.01$), and for ≥6 lame ewes ($p = 0.05$). For respondents who caught lame sheep at locomotion score 2, the period prevalence of lameness was significantly lower for those that caught the first lame sheep in a group compared with those who waited for ≥6 lame sheep ($p = 0.02$); with a trend in comparison with respondent s who waited for 2-5 lame sheep ($p = 0.07$). Again, similarly the point prevalence of lameness was significantly lower for those that caught the first lame ewe in a group compared with those who waited for ≥6 lame ewes ($p < 0.01$), and for 2-5 lame sheep ($p = 0.02$). In addition, the point prevalence was also significantly lower for those who waited for 2-5 sheep to be lame in a group before investigating compared with ≥6 lame sheep ($p < 0.01$). For respondents who caught at locomotion score ≥3, the point prevalence of lameness was significantly lower for those that caught the first lame ewe in a group compared with those who waited for 2-5 lame ewes ($p < 0.01$), and for ≥6 lame sheep ($p = 0.03$) (Table 56).

Table 56: Number and percentage of 443 respondents that reported the lowest locomotion score they would catch a lame ewe by the minimum number of ewes needed with this score to prompt individual investigation with the intention of treatment provision. The median (with interquartile range) point and period prevalence of lameness over the last 12 months is shown for each category where provided by (n) respondents.

Number of lame ewes required	Minimum locomotion score lame ewes caught		
	1	2	≥3
1	100 (22.6%)	94 (21.2%)	81 (18.3%)
Period prevalence: Median (n)	3.0% (84)	4.0% (78)	5.0% (71)
IQR	1.0, 5.0	2.0, 5.0	2.0, 10.0
Point prevalence: Median (n)	1.1% (87)	1.8% (80)	1.8% (77)
IQR	0.0, 2.9	0.5, 3.7	0.0, 3.9
2-5	22 (5.0%)	73 (16.5%)	47 (10.6%)
Period prevalence: Median (n)	7.0% (20)	5.0% (65)	5.0% (43)
IQR	4.0, 10.0	3.0, 10.0	3.0, 10.0
Point prevalence: Median (n)	3.7% (20)	2.9% (69)	3.1% (47)
IQR	1.9, 7.6	1.4, 4.2	1.1, 5.7
≥ 6	4 (0.9%)	13 (2.9%)	8 (1.8%)
Period prevalence: Median (n)	7.5% (4)	6.0% (12)	5.0% (5)
IQR	4.5, 11.5	5.0, 9.5	5.0, 6.0
Point prevalence: Median (n)	4.9% (4)	5.6% (13)	3.8% (8)
IQR	2.0, 10.9	3.5, 6.8	2.7, 5.5
Do not catch individuals	0 (0.0%)	1 (0.2%)	0 (0.0%)
Period prevalence: Median (n)	-	-	-
IQR			
Point prevalence: Median (n)	-	5.0% (1)	-
IQR		-	

- = no data; IQR = interquartile range; n = number of respondents; % = percentage;

One hundred and ninety one respondents (42.5%) gave a lower minimum locomotion score for ewes they recognised as lame compared with the minimum locomotion score that they would catch with the intention of treating. Of these, 77.0% (147) provided a reason why they did not catch sheep which they recognised lame (Table 57). The most common reason given by 56 (38.1%) respondents was that lower locomotion scores (locomotion scores ≤2) were likely to be temporary. As a consequence no intervention was necessary because the cause would probably correct itself. Any mildly lame ewes that did not recover spontaneously after a few days or worsened would then be investigated. These respondents, along with others, sometimes additionally listed a probable cause for cases of transient lameness: a physical injury, such as a sprain (20, 13.6%); or a problem with '*mud*', '*stones*' or other debris '*stuck between the cleats*' (15, 10.2%). A lack of time, workload and distance to handling facilities were also given as reasons for not treating all sheep they recognised lame by 35 (23.8%), 7 (4.8%) and 8 (5.4%) respondents. Difficulties catching mildly lame ewes, identifying mildly lame ewes once gathered and the stress caused *vs.* the benefit to the ewe were also given by 14 (9.5%), 9 (6.1%) and 8 (5.4%) respondents. Sixteen (10.9%) respondents stated that for milder cases of lameness (locomotion score ≤2) footbathing the flock was usually sufficient treatment and catching individuals at these scores was unnecessary (Table 57).

Table 57: Reasons given by 147 respondents for not catching sheep with locomotion scores that they recognise as lame.

Reason	Number (%) of respondents
Temporary lameness, might resolve unaided	56 (38.1)
Time	35 (23.8)
Lower scores likely to be a physical injury *e.g.* a sprain	20 (13.6)
Lower scores likely to be a problem with mud or stones	15 (10.2)
Foot bathing lower locomotion scores is sufficient	16 (10.9)
Difficulty catching lower locomotion scores in field	14 (9.5)
Difficulty finding lower locomotion scores once gathered	9 (6.1)
Stress of catching *vs.* benefit gained	8 (5.4)
Stress in gathering pregnant ewes and or young lambs	4 (2.7)
Other enterprises and or workload	7 (4.8)
Requirement of > 1 lame ewe	5 (3.4)
Convenience	4 (2.7)
Distance to or lack of penning and handling facilities	8 (5.4)
Lower scores not severe enough to prompt investigation	5 (3.4)
Would be treated at routine gatherings	3 (2.0)
Depends on time of year, season or weather	3 (2.0)
Depends on mood of sheep or behaviour of sheep dog	2 (1.4)
Not necessary, lameness rare in my flock	2 (1.4)
Gathering increases lameness	1 (0.7)
I don’t catch all lame sheep	1 (0.7)
Not practical to catch lower locomotion scores	1 (0.7)
I wait for symptoms to develop	1 (0.7)
Not necessary, change of pasture usually sufficient	1 (0.7)
Lack of help	1 (0.7)
Good question, I should	1 (0.7)

5.3.6.2 Farmers' opinions on individual treatments for lameness and lameness targets

The majority of respondents (362, 80.6%) regarded catching and treating individual lame sheep rather than waiting until the flock was next gathered, as an effective practice to manage lameness. Only 31 (6.9%) respondents believed it to be ineffective, with 45 (10.0%) undecided and a further 11 (2.4%) respondents abstaining from answering. The period prevalence of lameness in the preceding 12 months was not significantly different between those that felt it ineffective (n = 27), effective (n = 310) or undecided (n = 41) with medians of 5.0, 5.0 and 4.0% (IQR: 2.0, 8.0; 3.0, 5.0; 2.0, 10.0% and range: 0.0 – 25.0; 2.0 – 10.0; 0.0 – 25.0% respectively) (p = 0.93). Similarly, the point prevalence of lameness was also not significantly different between those that felt it ineffective (n = 29), effective (n = 332) or undecided (n = 40) with medians of 2.7, 2.2 and 2.1% (IQR: 1.0, 4.2; 0.7, 4.1; 0.4, 4.8% and range: 0.3 – 15.4; 0.0 – 25.0; 0.0 – 12.9% respectively) (p = 0.47).

Twenty-six of the 31 farmers that considered catching individual lame sheep an ineffective practice gave at least one explanation. The most common reasons were difficulty catching or identifying individuals in the field (6); time and logistics (6); stress caused to the sheep (5); and catching individuals in the field was unnecessary because sheep were gathered frequently enough (4). Less common reasons included: increased risk of disease transmission through frequent gatherings (3); whole flock treatments/treating at routine gathering were already effective (2); circumstances unique to each farm (2); and age of farmer (1).

The majority of respondents (329, 73.3%) felt that targets of ≤5% by 2016 and ≤2% by 2021 for levels of sheep lameness in Great Britain given by the Farm Animal Welfare Committee (FAWC) were reasonable. Forty-two (9.4%) respondents felt these targets were unreasonable, 63 (14.0%) were unsure, with a further 15 (3.3%) abstaining. The period prevalence for the preceding 12 months was significantly lower for those respondents who felt the target reasonable compared with those who felt it unreasonable or were unsure ($p < 0.01$) (Table 58). When asked whether these targets were achievable, 220 (49.0%) stated '*yes*' with '*already achieved*' stated by a further 97 (21.6%). Only 39 (8.7%) respondents felt it was unachievable. Uncertainty was expressed by 73 (16.3%) respondents with the remaining 20 (4.5%) respondents abstained. Those respondents who felt the targets achievable had a significantly lower period prevalence of lameness in the preceding 12 months compared to those that felt them unachievable or were uncertain ($p < 0.01$). In addition, respondents who considered themselves to have already met the FAWC targets had a significantly lower period prevalence of lameness than those who felt them achievable, unachievable or were uncertain ($p < 0.01$) (Table 58).

Table 58: The period prevalence of lameness for the preceding 12 months by respondents' feelings towards the farm animal welfare committee's 10 year target for lameness.

	N	Median	IQR	Range
Reasonable	289	5.0	2.0, 5.0	0.0 – 25.0
Unreasonable	37	6.0	4.0, 10.0	0.0 – 15.0
Unsure	49	8.0	5.0, 10.0	1.0 – 25.0
Already achieved	83	2.0	1.0, 4.0	0.0 – 15.0
Achievable	197	5.0	3.0, 7.0	0.0 – 25.0
Unachievable	35	6.0	5.0, 10.0	0.0 – 15.0
Unsure	57	5.0	5.0, 10.0	1.0 – 25.0

N = number

Similarly, the point prevalence was significantly lower for those respondents who felt the target reasonable compared with those who felt it unreasonable or were unsure (medians: 1.7 *cf.* 3.6 and 3.5% respectively) ($p < 0.01$) (Table 59). Again, those respondents who felt the targets achievable had a significantly lower point prevalence of lameness compared to those that felt them unachievable or were uncertain (medians: 2.2 *cf.* 3.9 and 3.4%) ($p < 0.01$). Once more, respondents who considered themselves to have already met the FAWC targets had a significantly lower point prevalence of lameness than those who felt them achievable, unachievable or were uncertain (medians: 0.9 *cf.* 2.2, 3.9 and 3.4%) ($p < 0.01$) (Table 59).

Table 59: The point prevalence of lameness by respondents' feelings towards the farm animal welfare committee's 10 year target for lameness.

	N	Median	IQR	Range
Reasonable	301	1.7	0.5, 3.6	0.0 – 25.0
Unreasonable	38	3.6	2.0, 5.0	0.0 – 12.0
Unsure	59	3.5	1.9, 7.5	0.0 – 19.5
Already achieved	84	0.9	0.0, 1.9	0.0 – 11.8
Achievable	220	2.2	0.7, 4.2	0.0 – 25.0
Unachievable	32	3.9	2.5, 6.2	1.0 – 12.0
Unsure	68	3.4	2.1, 5.7	0.0 – 13.3

Of the 39 farmers that considered the FAWC target unachievable 33 gave at least one reason. The most common reasons were: wet or otherwise unfavourable ground (7); time (6); the weather (3) and have tried but impractical (3). Other less common reasons included: large flocks (2); old sheep (2); treatments considered ineffective (2); risks associated with buying in stock (1); not possible to adhere to the target with lambs (1); not plausible with small flock sizes (*e.g.* 1/30 sheep lame is >2%) (1); target could not be met 100% of the time (1); breeds prone to lameness (1); FAWC target too low (1); inability to see mildly lame ewes once gathered (1); because '*>5% of humans are lame, 2% would be putting sheep above humans'* (1); and '*not dedicated enough*' (1).

5.3.6.3 Farmer attitudes to lameness obtained from visual analogue scales

Although the length of visual analogue scales was set at 100mm, the printing process reduced the actual length of the line to 98mm. The maximum VAS score for all VAS questions was therefore 98.0 and not 100.0. Bipolar anchors for the VAS questions were 0 (never/disagree) and 98 (always/agree). A table summarising the distribution of farmer responses and histograms, in intervals of 10, for 18 VAS questions are presented below (Table 60, Figure 19 to

Figure 36). Interestingly, farmer attitude towards pain and welfare scored more highly than that of profit and productivity. Reluctance to catch heavily pregnant ewes also scored highly (Table 60). There was however a high degree of multi-collinearity within farmer attitudes towards lameness as measured by these 18 VAS questions (Table 61).

Table 60: Farmer attitudes toward management of lameness in their flock: the number of respondents, the median, interquartile range and range of each visual analogue scale (0 = never/disagree and 98 = always/agree)

VAS measure of attitude toward treatment of lame sheep:	Number	Median	IQR	Range
Motivations to treat lame ewes in their flock				
Improve profit	427	74.0	27.0 , 93.0	0.0 – 98.0
Reduce pain	437	94.0	86.0 , 97.0	4.0 – 98.0
Improve welfare	438	94.0	89.0 , 97.0	3.0 – 98.0
Reduce disease transmission	436	92.0	76.0 , 96.0	0.0 – 98.0
Proximity to a public location	419	50.0	8.0, 92.0	0.0 – 98.0
Obstacles to the prompt treatment of mildly lame ewes in their flock				
Difficulty identifying in the field	440	43.0	7.0, 67.5	0.0 – 98.0
Difficulty catching in the field	434	47.0	11.0, 80.0	0.0 – 98.0
Distance from handling facilities	435	19.0	3.0, 56.0	0.0 – 98.0
Lack of an assistant	435	15.0	3.0, 51.0	0.0 – 98.0
Lack of a trained dog	420	6.0	1.0, 46.0	0.0 – 98.0
Lack of time	435	24.0	7.0, 48.0	0.0 – 98.0
Need >1 ewe lame in a group	435	17.0	3.0, 69.0	0.0 – 98.0
Reluctance to treat at tupping	434	15.0	3.0, 68.0	0.0 – 98.0
Reluctance to treat when pregnant	434	72.5	18.0, 91.0	0.0 – 98.0
Other				
Believe lameness a minor problem	437	78.0	44.0, 91.0	0.0 – 98.0
Belief in scale of productivity loss	427	89.0	74.0, 95.0	0.0 – 98.0
Never catch individuals	435	3.0	1.0, 9.0	0.0 – 98.0
Would stop routine foot trimming	321	13.0	3.0, 47.0	0.0 – 98.0

Where visual analogue scale score of 0 = never/disagree and 98 = always/agree; number = number of observations; IQR = interquartile range.

Figure 19: Farmer attitude to: "I treat lame ewes to improve my profit"

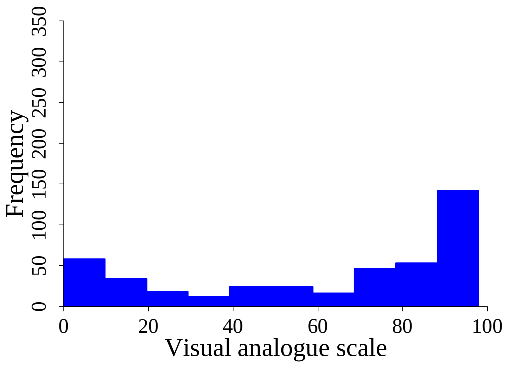


Figure 22: Farmer attitude to: "I treat lame ewes to prevent the spread of lameness"

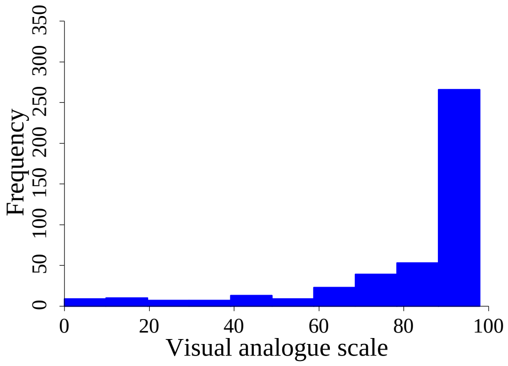


Figure 20: Farmer attitude to: "I treat lame ewes to relieve their pain"

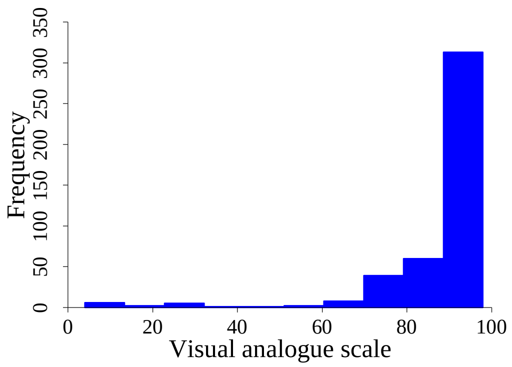


Figure 23: Farmer attitude to: "I make a special effort to catch and treat a lame ewe if it were near a footpath, bridleway or other public place"

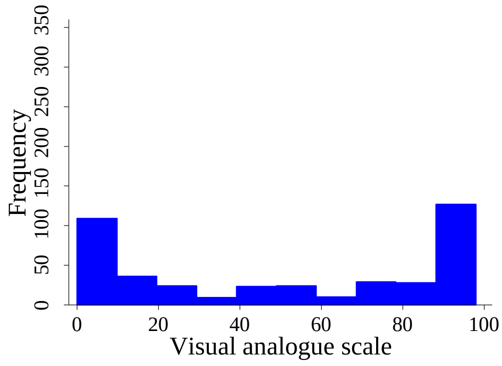


Figure 21: Farmer attitude to: "I treat lame ewes to improve their welfare"

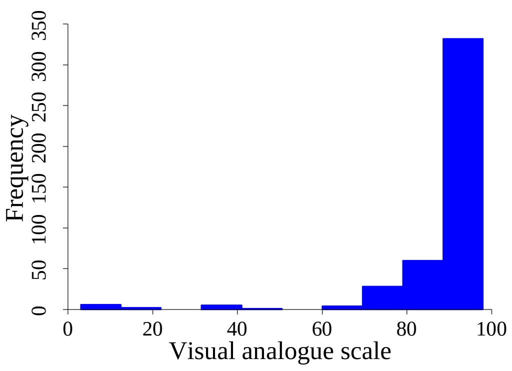


Figure 24: Farmer attitude to: "I have difficulty finding and identifying a mildly lame ewe once the flock is gathered"

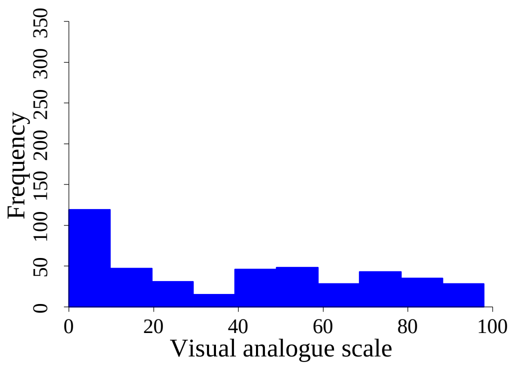


Figure 25: Farmer attitude to: "I have difficulty catching a mildly lame ewe in the field for treatment"

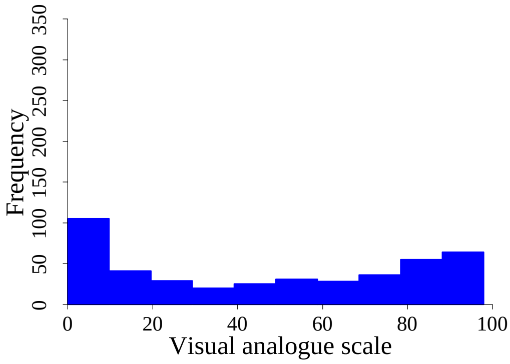


Figure 26: Farmer attitude to: "The distance of the flock from suitable handling facilities prevents me from treating a lame ewe immediately"

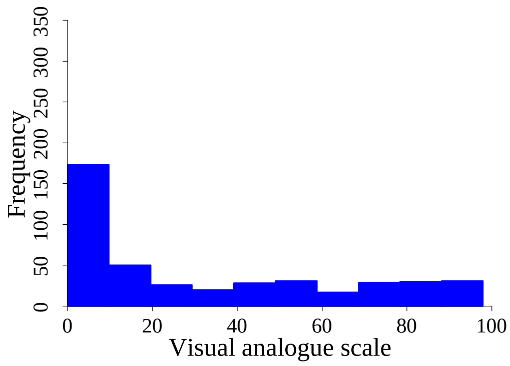


Figure 27: Farmer attitude to: "Lack of an assistant to help gather ewes prevents me from treating a lame ewe immediately"

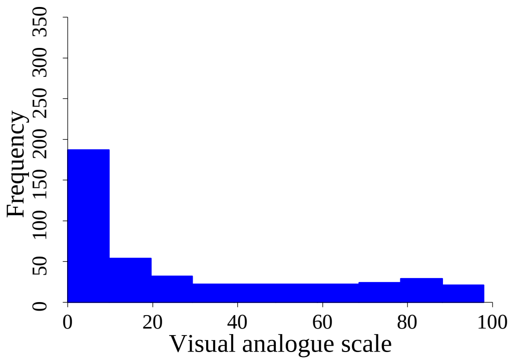


Figure 28: Farmer attitude to: "Lack of a trained dog to gather ewes prevents me from treating a lame ewe immediately"

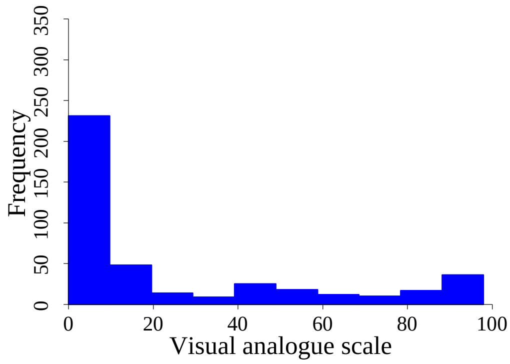


Figure 29: Farmer attitude to: "Lack of time prevents me from treating a lame ewe immediately"

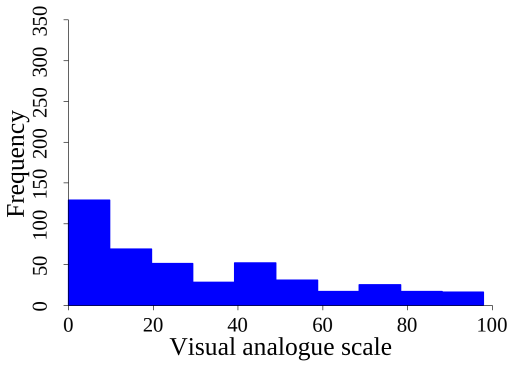


Figure 30: Farmer attitude to: "It is too time consuming to catch a ewe for treatment every time one is lame. I have to wait until there is more than one in a group"

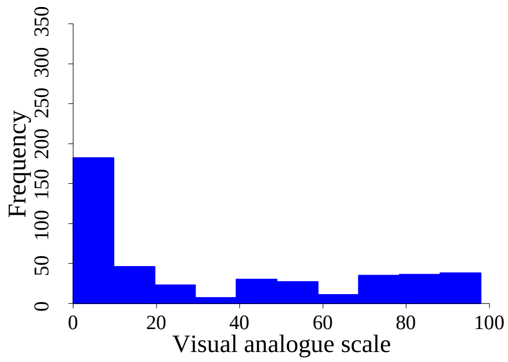


Figure 31: Farmer attitude to: "I am reluctant to catch and turn a lame ewe during tupping for inspection and treatment"

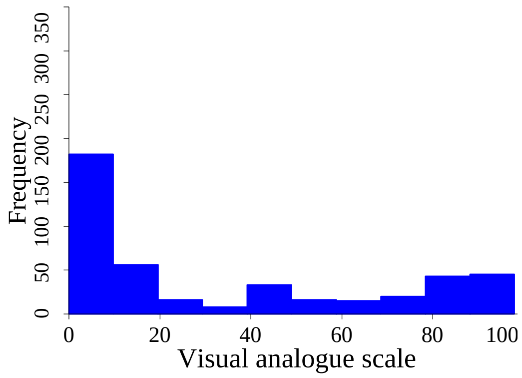


Figure 32: Farmer attitude to: "I am reluctant to catch and turn a lame ewe that is heavily pregnant for inspection and treatment"

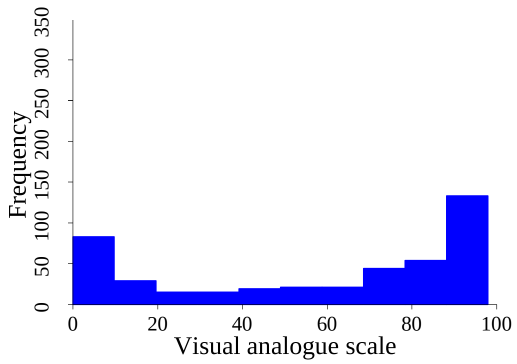


Figure 33: Farmer attitude to: "Lameness is a minor problem in my sheep flock"

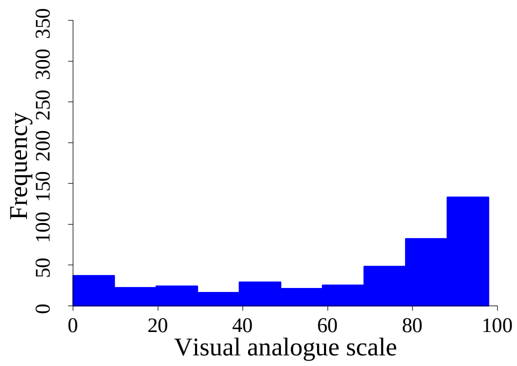


Figure 34: Farmer attitude to: "Levels of lameness of 2% or less result in fewer barren ewes, fewer ewe deaths, ewes with more milk, greater lamb survival and lambs that finish earlier"

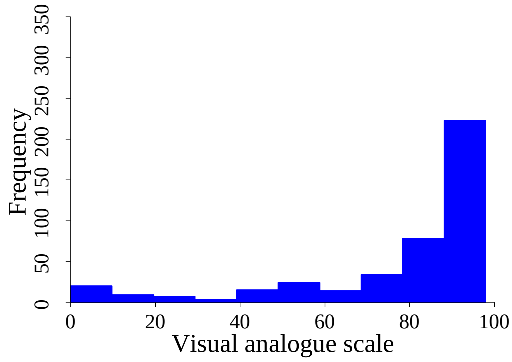


Figure 35: Farmer attitude to: "I never catch individual lame ewes for treatment"

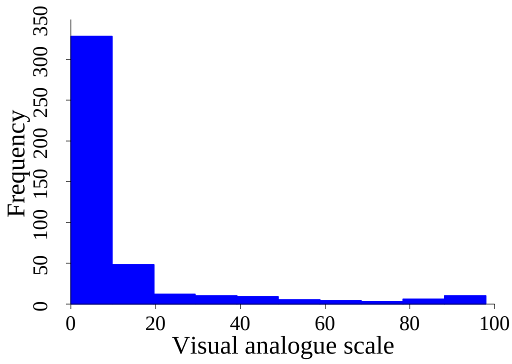


Figure 36: Farmer attitude to: "How likely are you, on a scale of 0 – 100, to stop routine foot trimming?"

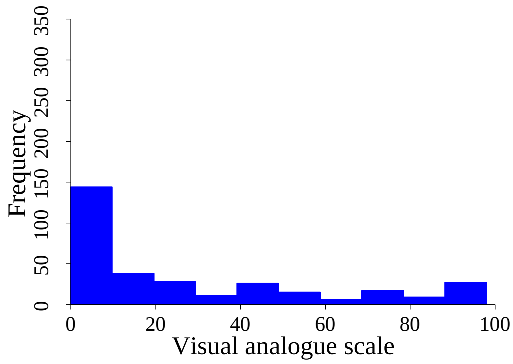


Table 61: Spearman's rank correlation coefficient matrix of visual analogue scale variables of farmer attitudes towards lameness

VAS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
A	1.00																	
B	0.24	1.00																
C	0.25	0.86	1.00															
D	0.32	0.52	0.56	1.00														
E	0.31	0.13	0.12	0.21	1.00													
F	-0.03	-0.19	-0.17	-0.21	0.06	1.00												
G	-0.12	-0.23	-0.27	-0.33	-0.07	0.51	1.00											
H	-0.04	-0.30	-0.31	-0.32	<0.01	0.40	0.57	1.00										
I	-0.13	-0.35	-0.37	-0.32	0.03	0.38	0.50	0.64	1.00									
J	-0.07	-0.29	-0.32	-0.25	0.10	0.30	0.38	0.51	0.69	1.00								
K	-0.01	-0.27	-0.27	-0.29	0.01	0.37	0.43	0.58	0.48	0.35	1.00							
L	0.04	0.19	0.17	0.05	-0.02	-0.15	-0.14	-0.20	-0.18	-0.13	-0.25	1.00						
M	0.23	0.23	0.28	0.26	0.03	-0.07	-0.11	-0.14	-0.24	-0.24	-0.11	0.27	1.00					
N	-0.03	-0.38	-0.39	-0.32	0.03	0.35	0.44	0.54	0.48	0.35	0.49	-0.20	-0.20	1.00				
O	0.01	-0.26	-0.26	-0.18	<0.01	0.22	0.22	0.34	0.33	0.26	0.25	-0.09	-0.16	0.36	1.00			
P	-0.15	-0.09	-0.11	-0.18	-0.02	0.12	0.14	0.15	0.22	0.16	0.06	<0.01	-0.07	0.17	0.28	1.00		
Q	-0.07	-0.38	-0.34	-0.27	0.14	0.30	0.28	.032	0.39	0.41	0.22	-0.18	-0.30	0.46	0.33	0.16	1.00	
R	0.03	-0.21	-0.21	-0.09	0.05	0.23	0.17	0.28	0.25	0.24	0.33	-0.18	-0.08	0.27	0.25	0.12	0.28	1.00

VAS = visual analogue scale; red = not significant (p >0.10); green = trend (p >0.05 and ≤0.10); white = significant (p ≤0.05)

A = Improve profit
B = Relieve pain
C = Improve welfare
D = Reduce disease transmission
E = Importance of public location
F = Difficulty identifying in the field
G = Difficulty catching in the field
H = Distance to handling facilities
I = Lack of an assistant
J = Lack of a trained dog
K = Lack of time
L = Believes lameness is a minor problem
M = Belief in scale of productivity loss
N = Require >1 lame ewe in a group
O =Reluctant to treat at tupping
P = Reluctant to treat pregnant ewes
Q = Provision of individual treatment
R = Likely to stop routine foot trimming

5.3.6.3.1 Motivation: to improve profit

Commercial farmers (n = 337) were significantly more likely to treat lameness to improve their profit than pedigree farmers (n = 79) ($p < 0.01$) with medians of 76.0 (IQR: 39.0, 93.0) *cf.* 50.0 (IQR: 9.0, 90.0). In addition, male respondents (n = 348) were significantly more likely to treat lame ewes to improve their profit than female respondents (n = 68) ($p < 0.01$) with median VAS scores of 76.0 (IQR: 39.5, 93.0) *cf.* 48.5 (IQR: 9.0, 86.5). Treatment to improve profit was significantly positively correlated with the number of years of farming experience (Rho = 0.12, $p = 0.02$) and flock size (Rho = 0.36, $p < 0.01$) and negatively but not significantly associated with period or point prevalence of lameness (Rho = -0.03, and - 0.02; $p \geq 0.56$).

There was significant variation in respondents VAS scores for profit as a motivating factor between different frequencies of contact with vets ($p < 0.01$). Respondents in monthly contact with their vet were significantly more motivated by profit than those in bi-annual contact ($p = 0.02$). Similarly, respondents who were in quarterly contact with their vet were significantly (and a trend for those in monthly contact) more motivated by profit than those who contacted their vet less than annually ($p = 0.02$ and 0.07 respectively). In addition, those in quarterly contact with their vet were significantly more motivated by profit than those in bi-annual or annual contact ($p \leq 0.02$) (Table 62).

Table 62: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to improve profit by contact frequency with vet.

Frequency of contact with vet	N	Median	IQR	Range
No vet	3	85.0	22.0, 95.0	22.0, 95.0
Monthly	35	80.0	45.0, 96.0	1.0, 98.0
Quarterly	89	83.0	63.0, 94.0	0.0, 98.0
Bi-annually	136	60.5	20.0, 90.0	0.0, 98.0
Annually	80	72.0	23.0, 90.0	0.0, 98.0
< annually	65	66.0	14.0, 93.0	0.0, 98.0

In addition, there was a trend for variability in respondents VAS scores between different age categories ($p = 0.08$) with farmers ≤25 and 36-45 years old significantly more likely to treat for profit than those aged >65 years ($p = 0.05$ and <0.01). There was also a trend for farmers aged 36-45 to be more motivated by profit than those aged 46-55 and 56-65 years ($p = 0.08$ and 0.09) (Table 63).

Table 63: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to improve profit by age category of the respondent.

Age category (years)	N	Median	IQR	Range
≤25	12	87.0	58.0, 94.0	30.0, 98.0
26-35	22	78.5	40.0, 94.0	2.0, 98.0
36-45	59	81.0	50.0, 96.0	2.0, 98.0
46-55	136	73.5	22.5, 93.0	0.0, 98.0
56-65	109	76.0	30.0, 92.0	0.0, 98.0
>65	86	62.0	14.0, 89.0	0.0, 98.0

Similarly, there was a trend for variability in respondents VAS scores for motivation by profit within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with ID alone (but not for FR alone or ID and FR combined) (see Section 5.3.3) ($p = 0.09$) (Table 64). Those who '*always*' treated ID in this way were significantly more motivated to treat lameness to increase profit than those who '*never*' did this or stated '*not applicable*' ($p \leq 0.05$). In addition, there was a trend for those who did this '*most of the time*' to be more motivated by profit than those who stated '*not applicable*' ($p = 0.10$) (Table 64).

Table 64: Number, median, interquartile range and range of respondents visual analogue scores for motivation to treat lame ewes to improve profit by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Always	80	82.5	23.0, 94.5	0.0 – 98.0
Most of the time	88	77.5	40.0, 92.0	0.0 – 98.0
Sometimes	131	72	40.0, 90.0	0.0 – 98.0
Never	72	62.5	14.5, 89.0	0.0 – 98.0
Not applicable	32	47.5	8.0, 93.5	0.0 – 98.0

5.3.6.3.2 Motivation: to relieve pain

Female respondents ($n = 71$) were significantly more likely to treat lame ewes to relieve pain than male respondents ($n = 354$) ($p = 0.03$) with medians of 95.0 (IQR: 90.0, 97.0; Range: 74.0 – 98.0) *cf.* 94.0 (IQR: 85.0, 97.0 and range: 4.0 – 98.0). There was also significant variability in respondents VAS scores for motivation to relieve pain between age categories of respondents ($p = 0.03$). Farmers aged >65 years were significantly less motivated to relief pain than farmers in age categories between 26-65 years ($p \leq 0.02$) (Table 65).

Table 65: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to relieve pain by age category of the respondent.

Age category (years)	N	Median	IQR	Range
≤25	12	97.0	84.0, 98.0	31.0, 98.0
26-35	22	96.0	90.0, 97.0	15.0, 98.0
36-45	59	95.0	85.0, 97.0	10.0, 98.0
46-55	138	94.0	87.0, 97.0	25.0, 98.0
56-65	113	94.0	89.0, 97.0	4.0, 98.0
>65	88	91.0	85.0, 95.0	8.0, 98.0

In addition, there was significant variability in VAS score for motivation by pain with differences in the minimum locomotion score that respondents caught for inspection and treatment ($p < 0.01$). Those than caught lame sheep for inspection and treatment at locomotion score 1 were significantly more motivated to relieve pain than those that caught at locomotion score 2 or ≥3 ($p \leq 0.02$). This was also true of those that caught at locomotion score 2 compared with those that caught at locomotion score ≥3 ($p = 0.02$) (Table 66).

Table 66: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to relieve pain by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	124	95.0	82.0, 97.5	4.0, 98.0
2	177	94.0	86.0, 97.0	11.0, 98.0
≥3	134	92.0	82.0, 96.0	10.0, 98.0

Treatment to relieve pain was significantly, negatively associated with the number of years of farming experience (Rho = -0.14, $p < 0.01$) and the point prevalence of lameness (Rho = -0.11, $p = 0.03$). There was also significant variability in respondents VAS scores for motivation by pain within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with FR alone or FR in combination with ID (but not ID alone) ($p = 0.03$ and 0.02 respectively). Farmers that '*always*' treated lame ewes with within 3 days with topical and parenteral antibacterials, were more motivated to treat to relieve pain than those that did this '*most of the time*' (FR: $p = 0.06$; ID and FR: $p = 0.02$) or '*sometimes*' (FR: $p < 0.01$; ID and FR: $p = 0.02$). Interestingly, respondents that stated '*not applicable*' to the use of antibacterials within 3 days of becoming lame for sheep with FR and FR and ID combined, were also significantly more motivated to treat lame ewes for reasons of pain than those who did this '*most of the time*' (FR: $p = 0.07$; ID and FR: $p = 0.02$) or '*sometimes*' (FR: $p = 0.02$; ID and FR: $p = 0.01$) (Table 67).

Table 67: Number, median, interquartile range and range of respondents visual analogue scores for motivation to treat lame ewes to relieve pain by respondents frequency of treatment of lame ewes diagnosed with footrot and interdigital dermatitis and footrot combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Footrot				
Always	110	95.0	90.0, 97.0	4.0 – 98.0
Most of the time	104	93.0	86.5, 97.0	8.0 – 98.0
Sometimes	124	93.0	83.0, 96.0	11.0 – 98.0
Never	46	93.5	86.0, 97.0	32.0 – 98.0
Not applicable	38	96.0	89.0, 97.0	19.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	56	95.0	91.5, 97.0	4.0 – 98.0
Most of the time	56	92.0	85.5, 96.0	10.0 – 98.0
Sometimes	75	92.0	84.0, 96.0	24.0 – 98.0
Never	38	93.5	86.0, 97.0	65.0 – 98.0
Not applicable	17	97.0	94.0, 97.0	76.0 – 98.0

5.3.6.3.3 Motivation: to improve welfare

There was significant variation in respondents VAS scores for treatment to improve welfare for differences in respondents age categories (p = 0.02). Respondents >65 years old were significantly less inclined to treat to improve welfare than those in age categories between 26 and 65 (p = 0.01; 0.05; <0.01 and 0.03 respectively); but not significantly different from those ≤25 years old (p = 0.11) (Table 68).

Table 68: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to improve welfare by age category of the respondent.

Age category (years)	N	Median	IQR	Range
≤25	12	97.0	86.0, 98.0	38.0, 98.0
26-35	21	94.0	93.0, 98.0	71.0, 98.0
36-45	59	94.0	90.0, 96.0	60.0, 98.0
46-55	138	95.0	90.0, 97.0	35.0, 98.0
56-65	114	94.0	90.0, 97.0	3.0, 98.0
>65	90	92.0	84.0, 95.0	3.0, 98.0

There was also significant variability in respondents VAS scores for motivation to improve welfare by frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with FR (but not ID) and ID and FR combined (p <0.01 and 0.02 respectively). Those farmers who '*always*' treated ewes lame with FR within 3 days with topical and parenteral antibacterials, were significantly more likely to treat lame ewes to improve welfare than those that did this '*most of the time*', '*sometimes*' or '*never*' (p = 0.04; <0.01; and 0.03) but scores were not significantly different from those who stated '*not applicable*' (Table 69). Interestingly, those respondent that stated '*not applicable*' to frequency of treatment of ewes lame with FR, were also significantly more likely to treat lame ewes to improve welfare than those who did this '*sometimes*' and '*never*' (p <0.01 and 0.04) with a trend in comparison to those who did this '*most of the time*' (p = 0.07). This pattern was similar for farmers treating ewes with ID and FR combined. Those that '*always*' treated ID and FR within 3 days with antibacterials scored significantly higher for motivation by welfare than those who did this '*sometimes*' (p <0.01); with a trend for '*most of the time*' and '*never*' (p =

0.10 and 0.06). Again, those respondents that stated ‘*not applicable*’ to frequency of treatment of ewes lame with FR and ID combined, were also significantly more likely to treat lame ewes to improve welfare than those who did this ‘*sometimes*’(p = 0.02); with a trend for those who ‘*never*’ did this (p = 0.08) (Table 69).

Table 69: Number, median, interquartile range and range of respondents visual analogue scores for motivation to treat lame ewes to improve welfare by respondents frequency of treatment with topical and parenteral antibacterials within 3 days of becoming lame ewes diagnosed with footrot, and interdigital dermatitis and footrot combined.

Frequency of treatment	N	Median	IQR	Range
Footrot				
Always	119	95.0	91.0, 97.0	3.0 – 98.0
Most of the time	106	94.0	89.0, 96.0	4.0 – 98.0
Sometimes	123	92.0	84.0, 96.0	3.0 – 98.0
Never	46	92.5	87.0, 97.0	32.0 – 98.0
Not applicable	38	95.0	92.0, 98.0	20.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	57	95.0	92.0, 98.0	3.0 – 98.0
Most of the time	56	93.5	88.5, 96.0	70.0 – 98.0
Sometimes	75	91.0	84.0, 96.0	3.0 – 98.0
Never	38	92.5	87.0, 97.0	71.0 – 98.0
Not applicable	17	96.0	92.0, 98.0	81.0 – 98.0

There was also significant variation in respondents VAS scores for motivation by welfare with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Respondents who caught lame sheep at locomotion score 1 were significantly more motivated by welfare than those who caught at either locomotion score 2 or ≥3 (p ≤0.02). Although, there was no significant difference between those who caught at locomotion score 2 and ≥3 ($p > 0.10$) (Table 70).

Table 70: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to improve welfare by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	125	95.0	92.0, 98.0	3.0, 98.0
2	176	93.0	87.5, 97.0	8.0, 98.0
≥3	135	93.0	86.0, 96.0	4.0, 98.0

Treatment to improve welfare was also significantly negatively associated with the number of years of farming experience (Rho = -0.17, $p < 0.01$) and the point prevalence of lameness (Rho = -0.12, $p = 0.02$).

5.3.6.3.4 Motivation: to reduce transmission

Pedigree farmers (n = 82) were significantly more likely to treat lame sheep to prevent transmission than commercial farmers (n = 343) ($p = 0.04$) with medians of 94.0 (IQR: 82.0, 97.0) *cf.* 91.0 (IQR: 75.0, 96.0). There was significant variability in respondents VAS scores for motivation to reduce transmission within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with FR (but not ID) and ID and FR combined ($p < 0.01$ and 0.02). Again those farmers who '*always*' treated lame ewes with FR alone within 3 days with antibacterials were significantly more likely to treat to reduce transmission than those who did this '*most of the time*', '*sometimes*' or '*never*' ($p < 0.01$ respectively) (Table 71). Similarly, those farmers who '*always*' treated lame ewes with ID and FR combined within 3 days with antibacterials were significantly more likely to treat to reduce transmission than those who did this '*sometimes*' or '*never*' (p = 0.01 respectively) with a trend in comparison with those who did this '*most of the time*' (p = 0.08) (Table 71).

Table 71: Number, median, interquartile range and range of respondents visual analogue scores for motivation to treat lame ewes to improve welfare by respondents frequency of treatment with topical and parenteral antibacterials within 3 days of becoming lame of lame ewes diagnosed with footrot, and interdigital dermatitis and footrot combined.

Frequency of treatment	N	Median	IQR	Range
Footrot				
Always	108	95.0	89.0, 97.0	3.0 – 98.0
Most of the time	105	91.0	81.0, 96.0	10.0 – 98.0
Sometimes	123	90.0	72.0, 95.0	1.0 – 98.0
Never	46	89.0	61.0, 95.0	5.0 – 98.0
Not applicable	38	92.0	63.0, 97.0	0.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	55	95.0	89.0, 97.0	3.0 – 98.0
Most of the time	56	92.0	80.0, 96.0	15.0 – 98.0
Sometimes	75	91.0	70.0, 95.0	15.0 – 98.0
Never	38	88.0	61.0, 95.0	5.0 – 98.0
Not applicable	17	91.0	46.0, 97.0	16.0 – 98.0

Similarly, there was significant variation in respondents VAS scores for transmission with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Those that caught lame ewes for inspection and treatment at locomotion score 1 were significantly more likely to treat lame ewes to reduce transmission than those that caught at locomotion score 2 or ≥3 (p <0.01 respectively) (Table 72).

Table 72: Number, median, interquartile range and range of respondents visual analogue scale scores for motivation to treat lame ewes to reduce transmission by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	124	95.0	83.0, 98.0	3.0, 98.0
2	179	91.0	74.0, 96.0	0.0, 98.0
≥3	131	89.0	75.0, 96.0	1.0, 98.0

Treatment to reduce transmission was negatively and significantly associated with the point and period prevalence of lameness (Rho = -0.16, $p < 0.01$; Rho = -0.11, p = 0.04). There was also a positive non-significant trend (p = 0.07, Rho = 0.09) between increased flock size and a likelihood to treat lame ewes to reduce transmission.

5.3.6.3.5 Motivation: lame sheep in an exposed public location

There was significant variation in respondents VAS scores for motivation by public location with differences in age categories of the respondents (p = 0.04). Respondents aged >65 were significantly less likely to treat for reasons of location than those aged between 26 – 35, 36 - 45 and 46 – 55 years (p = 0.04; 0.01; and 0.02 respectively). In addition, there was a trend for those aged 56 – 65 to be less motivated by location than those aged 36 – 45 (p = 0.10) (Table 73).

Table 73: Number, median, interquartile range and range of respondents' visual analogue scale scores for motivation to treat lame ewes in an exposed public location by age category of the respondent.

Age category (years)	N	Median	IQR	Range
≤25	12	84.5	34.5, 97.5	0.0, 98.0
26-35	22	74.5	48.0, 94.0	0.0, 98.0
36-45	58	64.0	30.0, 94.0	0.0, 98.0
46-55	133	50.0	11.0, 92.0	0.0, 98.0
56-65	111	45.0	7.0, 92.0	0.0, 98.0
>65	79	18.0	2.0, 89.0	0.0, 98.0

There was a significant positive association between increased flock size and increased effort to treat lame ewes in a site proximate to a public place (Rho = 0.19, p <0.01). There was also a trend (p = 0.06) for commercial farmers (n = 330) to be more likely to treat lame ewes in public areas than pedigree farmers (n = 78) with medians of 52.0 (IQR: 10.0, 92.0) *cf.* 22.5 (IQR: 3.0, 92.0). Similarly, there was also an increased trend for respondents who had attended a course on lameness in sheep in the last 12 months (n = 316) to make a special effort to catch lame ewes in proximity to a public place than those who had not attended a course (n = 105) (p = 0.06) (medians: 65.0 (IQR: 19.0, 93.0) *cf.* 50.0 (IQR: 6.0, 92.0). Finally, there was a trend (p = 0.07) for variation in respondents VAS scores for sites in proximity to public location to differ between frequency of treatment for ewes lame with FR alone but not for ID alone or ID and FR combined (Table 74). Respondents who '*never*' treated lame ewes with FR with antibacterials within 3 days of becoming lame were less likely to be motivated by location than those who did this '*always*', '*most of the time*' and '*sometimes*' (p = 0.02; <0.01; and 0.04) (Table 74).

Table 74: Number, median, interquartile range and range of respondents visual analogue scores for motivation to treat lame ewes in proximity to a public place (*e.g.* a footpath) by respondents frequency of treatment of lame ewes diagnosed with footrot with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Always	105	70.0	7.0, 95.0	0.0 – 98.0
Most of the time	102	68.5	28.0, 90.0	0.0 – 97.0
Sometimes	119	47.0	14.0, 90.0	0.0 – 98.0
Never	42	35.0	2.0, 76.0	0.0 – 98.0
Not applicable	36	21.0	3.0, 95.5	0.0 – 98.0

5.3.6.3.6 Obstacle: identification for treatment

Commercial respondents (n = 344) were significantly more likely to have difficulty identifying a mildly lame ewe for treatment than pedigree respondents (n = 85) (p <0.01) with medians of 45.0 (IQR: 12.0, 71.0) *cf.* 15.0 (3.0, 49.0). Difficulty identifying a mildly lame ewe once the flock was gathered was positively and significantly associated with both the point prevalence of lameness (Rho = 0.16, p <0.01) and flock size (Rho = 0.14, p <0.01). Those respondents who attended a course on lameness in the previous 12 months were also significantly more likely to have difficulty identifying a mildly lame ewe once the flock was gathered that those who did not attend a course (p =0.02) (medians: 48.0 (IQR: 12.0, 72.0) *cf.* 32.0 (IQR: 7.0, 65.0).

In addition, there was significant variation in respondents VAS scores for difficulty with identification with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Scores for difficulty identifying mildly lame individuals once gathered were significantly higher for those respondents who caught lame ewes for inspection at locomotion score 2 and ≥3 compared with those that caught at locomotion score 1 ($p < 0.01$ respectively). Scores for difficulty identifying a lame ewe were not significantly different between those that caught at locomotion score 2 compared with locomotion score ≥3 ($p = 0.18$) (Table 75).

Table 75: Number, median, interquartile range and range of respondents visual analogue scale scores for difficulty finding and identifying a mildly lame ewe once gathered by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	123	15.0	2.0, 49.0	0.0, 98.0
2	179	45.0	12.0, 68.0	0.0, 98.0
≥3	135	50.0	14.0, 73.0	0.0, 97.0

There was a trend for variability in respondents VAS scores for difficulty identifying lame ewes once gathered between farm types ($p = 0.08$). Hill farmers ($n = 27$) had less difficulty identifying mildly lame ewes once gathered than lowland ($n = 315$) or upland ($n = 91$) respondents with medians of 18.0 (IQR: 3.0, 49.0) *cf.* 44.0 (IQR: 8.0, 65.0) and 43.0 (IQR: 11.0, *cf.* 75.0) ($p = 0.04$ respectively). There was also significant variability in respondents VAS scores for identification within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with FR; and a trend for ID and FR combined ($p = 0.03$ and 0.08). Respondents reported less difficulty identifying mildly lame ewes where they stated '*not applicable*' to the frequency of treatment of ewes lame with FR alone with antibacterials within 3 days of becoming lame than those that did this '*sometimes*' (significant) or '*never*' (trend) (Table 76) ($p < 0.01$ and 0.07). In addition there was a trend for those who '*sometimes*' did this in comparison to those who did this '*most of the time*' to have greater difficulty identifying a mildly lame ewe once gathered (p = 0.10). Respondents also reported significant less difficulty identifying mildly lame ewes once gathered when they '*always*' caught lame ewes with ID or FR combined within 3 days and treated with antibacterials compared with '*sometimes*' (p = 0.01); and a trend in comparison with '*never*' (p = 0.06). There was also a trend for those who '*sometimes*' caught ewes with ID and FR to have greater difficulty identifying mildly lame ewes once gathered than those who sated '*not applicable'* (p = 0.09) (Table 76).

Table 76: Number, median, interquartile range and range of respondents visual analogue scores for difficulty finding and identifying a mildly lame ewe once gathered by respondents frequency of treatment of lame ewes diagnosed with footrot and interdigital dermatitis and footrot combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Always	109	43.0	3.0, 62.0	0.0 – 98.0
Most of the time	106	39.0	10.0, 70.0	0.0 – 98.0
Sometimes	124	45.0	15.5, 74.0	0.0 – 97.0
Never	45	47.0	12.0, 66.0	0.0 – 98.0
Not applicable	40	15.0	3.0, 54.0	0.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	56	34.0	3.0, 59.0	0.0 – 94.0
Most of the time	56	42.5	12.5, 63.5	0.0 – 97.0
Sometimes	75	45.0	22.0, 73.0	0.0 – 97.0
Never	38	47.5	12.0, 66.0	0.0 – 89.0
Not applicable	19	15.0	7.0, 56.0	0.0 – 98.0

Finally there was a trend for VAS scores to differ by categories of contact frequency with the vet (p = 0.08). Respondents who contacted their vet less than annually had less difficulty identifying mildly lame ewes once gathered than those who contacted their vet bi-annually (p <0.01) (Table 77).

Table 77: Number, median, interquartile range and range of respondents visual analogue scale scores for difficulty finding a mildly lame ewe once gathered by contact frequency with vet.

Frequency of contact with vet	N	Median	IQR	Range
No vet	3	2.0	0.0, 61.0	0.0, 61.0
Monthly	37	40.0	8.0, 62.0	0.0, 97.0
Quarterly	87	43.0	9.0, 64.0	0.0, 97.0
Bi-annually	140	48.5	14.0, 72.0	0.0, 98.0
Annually	83	36.0	5.0, 72.0	0.0, 95.0
< annually	69	24.0	3.0, 58.0	0.0, 85.0

5.3.6.3.7 Obstacle: difficulty catching mildly lame ewes

Commercial respondents (n = 339) reported a significantly greater median VAS score for difficulty catching mildly lame ewes than pedigree respondents (n = 84) (p <0.01) with medians of 52.0 (IQR: 14.0, 81.0) *cf.* 19.0 (IQR: 5.0, 71.5). Difficulty catching mildly lame ewes in the field was also positively and significantly associated with both the period and point prevalence of lameness (Rho = 0.13, p = 0.01 and Rho = 0.14, p <0.01 respectively); and there was a positive associated trend with flock size (Rho = 0.08, p = 0.09). In addition, there was significant variation in respondents VAS scores for difficulty catching mildly lame ewes with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). The median VAS scores were significantly higher for those respondents who caught lame ewes for inspection at locomotion score 2 and ≥3 compared with locomotion score 1 (Table 78) (p <0.01 respectively).

Table 78: Number, median, interquartile range and range of respondents visual analogue scale scores for difficulty catching a mildly lame ewe in the field by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	122	20.0	5.0, 65.0	0.0, 98.0
2	177	54.0	17.0, 81.0	0.0, 98.0
≥3	133	55.0	20.0, 83.0	0.0, 98.0

Finally there was also significant variability within VAS scores for difficulty catching mildly lame ewes within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with ID, FR and both ID and FR combined (p = 0.02; <0.01; and 0.01 respectively) (Table 79). Respondents who '*always*' and '*most of the time*' treated cases of ID within 3 days with antibacterials had significantly less difficulty catching mildly lame ewes compared with respondents who did this '*sometimes*' or '*never*' (always: p <0.01 and 0.02; most of the time: p = 0.02 and 0.05). Respondents that '*always*' treated cases of FR within 3 days with antibacterials had significantly less difficulty catching mildly lame ewes compared with respondents who did this '*most of the time*', '*sometimes*' or '*never*' (p = 0.03; <0.01 and <0.01 respectively). In addition, respondents who did this '*most of the time*' had significantly less difficultly catching mildly lame ewes than respondents who did this '*sometimes*' (p = 0.04), with a trend in comparison with those who did '*never*' did this (p = 0.10). Respondents that '*always*' treated cases of ID and FR within 3 days with antibacterials had significantly less difficulty catching mildly lame ewes compared with respondents who did this, '*sometimes*', '*never*' or stated '*not applicable*' (p <0.01; 0.02 and 0.04). In addition, respondents who did this '*most of the time*' had significantly less difficultly catching mildly lame ewes than respondents who did this '*sometimes*' (p = 0.02) (Table 79).

Table 79: Number, median, interquartile range and range of respondents visual analogue scores for difficulty catching mildly lame ewes in the field by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis, footrot and both interdigital dermatitis and footrot combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Interdigital dermatitis				
Always	82	34.5	5.0, 78.0	0.0 – 98.0
Most of the time	89	42.0	13.0, 68.0	0.0 – 97.0
Sometimes	132	57.5	17.0, 83.5	0.0 – 98.0
Never	74	57.5	16.0, 84.0	0.0 – 98.0
Not applicable	32	44.0	16.5, 82.5	0.0 – 98.0
footrot				
Always	107	20.0	3.0, 73.0	0.0 – 98.0
Most of the time	106	50.0	13.0, 75.0	0.0 – 97.0
Sometimes	122	65.5	20.0, 85.0	0.0 – 98.0
Never	45	61.0	20.0, 84.0	3.0 – 98.0
Not applicable	38	27.0	13.0, 81.0	0.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	54	34.5	3.0, 80.0	0.0 – 98.0
Most of the time	56	50.0	16.5, 76.5	0.0 – 97.0
Sometimes	74	67.0	35.0, 85.0	2.0 – 98.0
Never	38	65.5	25.0, 84.0	3.0 – 98.0
Not applicable	18	48.5	18.0, 95.0	9.0 – 98.0

5.3.6.3.8 Obstacle: distance to handling facilities

Male respondents (n = 351) were significantly more likely to consider distance an obstacle to the immediate treatment of lame ewes than female respondents (n = 71) (p = 0.02) with medians of 21.0 (IQR: 3.0, 55.0) *cf.* 8.0 (IQR: 2.0, 47.0). Similarly, 340 commercial respondents considered distance more of an obstacle than 84 pedigree respondents (p <0.01) with medians of 22.5 (IQR: 4.0, 64.5) *cf.* 7.0 (IQR: 1.0, 40.5). Distance of the flock from suitable handling facilities was positively and significantly associated with the period and point prevalence of lameness and flock size (Rho = 0.13, p = 0.01; Rho = 0.24 and 0.18, p <0.01 respectively). There was also significant variation in respondents VAS scores for distance to handling facilities as an obstacle with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Median VAS scores for distance of the flock from handling facilities as an obstacle to the immediate treatment of lame ewes was significantly higher for those respondents who caught lame ewes for inspection and treatment at locomotion score 2 and ≥3 than compared with locomotion score 1 (p <0.01 respectively) (Table 80).

Table 80: Number, median, interquartile range and range of respondents visual analogue scale scores for distance of the flock from suitable handling facilities as an obstacle to immediate treatment of a lame ewe by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	122	6.0	1.0, 34.0	0.0, 98.0
2	177	23.0	5.0, 55.0	0.0, 98.0
≥3	134	46.0	6.0, 72.0	0.0, 97.0

Finally there was also significant variability in VAS scores for distance of the flock from handling facilities as an obstacle to immediate treatment of a lame ewe within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with ID, FR and both ID and FR combined ($p = 0.02$; <0.01; and <0.01 respectively) (Table 81). Respondents who '*always*' treated cases of ID within 3 days with antibacterials reported distance significantly less of an obstacle compared with respondents who did this '*most of the time*' or '*sometimes*' ($p \leq 0.01$ respectively). Interestingly, in addition, those who did this '*most of the time*' also reported distance significantly more of an obstacle than those who '*never*' did this ($p = 0.04$). Respondents that '*always*' treated cases of FR within 3 days with antibacterials reported distance as significantly less of an obstacle compared with respondents who did this '*most of the time*' and '*sometimes*' ($p <0.01$ respectively). In addition, respondents who did this '*most of the time*' reported distance significantly more of an obstacle that respondents who '*never*' did this or stated '*not applicable*' ($p = 0.02$ and 0.04). Furthermore, respondents who '*sometimes*' treated lame ewes with FR within 3 days with antibacterials reported distance as more of an obstacle than those who '*never*' did this ($p = 0.05$), with a trend in comparison with those who stated 'not applicable' ($p = 0.08$). Respondents that '*always*' treated cases of ID and FR within 3 days with antibacterials reported distance significantly less of an obstacle compared with respondents who did this, '*most of the time*' or '*sometimes*' ($p <0.01$ respectively). In addition, respondents who '*never*' did this reported distance significantly more of an obstacle than respondents who did this '*most of the time*' and '*sometimes*' ($p <0.01$and 0.02) (Table 81).

Table 81: Number, median, interquartile range and range of respondents visual analogue scores for distance of the flock from suitable handling facilities as an obstacle to the immediate treatment of a lame ewe by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis, footrot and both diseases combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Interdigital dermatitis				
Always	83	1.0	1.0, 48.0	0.0 – 96.0
Most of the time	89	34.0	7.0, 70.0	0.0 – 98.0
Sometimes	133	25.0	4.0, 56.0	0.0 – 98.0
Never	73	14.0	3.0, 51.0	0.0 – 97.0
Not applicable	32	11.0	2.0, 68.0	0.0 – 98.0
footrot				
Always	108	9.0	1.0, 50.0	0.0 – 96.0
Most of the time	106	35.5	6.0, 70.0	0.0 – 98.0
Sometimes	122	25.0	5.0, 67.0	0.0 – 98.0
Never	45	7.0	2.0, 41.0	0.0 – 97.0
Not applicable	38	13.0	2.0, 47.0	0.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	55	6.0	1.0, 47.0	0.0 – 96.0
Most of the time	56	47.5	11.5, 75.5	0.0 – 98.0
Sometimes	75	32.0	8.0, 66.0	0.0 – 98.0
Never	38	7.0	2.0, 41.0	0.0 – 97.0
Not applicable	18	17.0	2.0, 62.0	0.0 – 98.0

5.3.6.3.9 Obstacle: lack of an assistant to help gather the flock

Commercial respondents (n = 340) reported a significant higher median score for lack of an assistant as an obstacle to immediate treatment of lame ewes than pedigree farmers (n = 84) ($p < 0.01$) (medians of 18.5 (IQR: 3.0, 56.5) *cf.* 5.5 (IQR: 1.5, 28.5). There was significant variation in respondents VAS scores for lack of an assistant as an obstacle with differences in farm type ($p = 0.02$). Upland farmers (n = 90) reported lack of an assistant as a significantly greater obstacle to treating lame ewes immediately than lowland (n = 311) or hill farmers (n = 27) with scores of 29.0 (IQR: 5.0, 70.0) *cf.* 16.0 (2.0, 50.0) and 4.0 (IQR: 1.0, 24.0) ($p \leq 0.02$). Scores were also significantly higher for those respondents who caught lame ewes for inspection and treatment at locomotion score 2 and ≥3 than those who caught at locomotion score 1 ($p < 0.01$) (Table 82).

Table 82: Number, median, interquartile range and range of respondents visual analogue scale scores for lack of an assistant to help gather ewes as an obstacle to immediate treatment of lame ewes by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	122	5.0	1.0, 27.0	0.0, 97.0
2	178	19.5	3.0, 53.0	0.0, 98.0
≥3	133	21.0	5.0, 68.0	0.0, 97.0

In addition both the period and point prevalence were significantly and positively correlated with lack of an assistant as an obstacle to immediate treatment of lame ewes (Rho = 0.12, p = 0.02 and Rho = 0.23, $p < 0.01$). Finally there was also significant variability in VAS scores for lack of an assistant to help gather ewes as an obstacle to immediate treatment of lame ewes within frequency of treatment of lame ewes with parenteral and topical antibacterials within 3 days for ewes with FR (but not ID alone) and both ID and FR combined (p = 0.03 and <0.01 respectively) (Table 83). Respondents who '*always*' treated cases of FR within 3 days with antibacterials reported lack of an assistant less of an obstacle compared with respondents who did this '*most of the time*' (trend) or '*sometimes*' (significant) (p = 0.08 and <0.01). Interestingly, in addition, those who stated '*not* *applicable*' also reported lack of an assistant significantly less of an obstacle than those who did this '*sometimes*' (p = 0.01), with a trend in comparison to those who did this '*most of the time*' (p = 0.07). Respondents that '*always*' treated cases of ID and FR within 3 days with antibacterials reported lack of an assistant significantly less of an obstacle compared with respondents who did this, '*most of the time'* or '*sometimes'* (p ≤0.01). In addition, there was a trend for respondents who '*sometimes*' did this to report lack of an assistant more of an obstacle than respondents who '*never*' did this or had stated '*not applicable*' (p = 0.06 and 0.08) (Table 83).

Table 83: Number, median, interquartile range and range of respondents visual analogue scores for lack of an assistant as an obstacle to the immediate treatment of lame ewes by respondents frequency of treatment of lame ewes diagnosed with footrot and interdigital dermatitis and footrot combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
footrot				
Always	108	8.0	1.0, 47.5	0.0 – 98.0
Most of the time	106	15.0	3.0, 64.0	0.0 – 96.0
Sometimes	123	22.0	4.0, 64.0	0.0 – 97.0
Never	45	19.0	2.0, 47.0	0.0 – 92.0
Not applicable	38	6.5	1.0, 37.0	0.0 – 95.0
Interdigital dermatitis and footrot combined				
Always	55	6.0	1.0, 43.0	0.0 – 96.0
Most of the time	56	29.5	5.0, 68.5	0.0 – 95.0
Sometimes	75	32.0	8.0, 65.0	0.0 – 97.0
Never	38	19.0	5.0, 36.0	0.0 – 80.0
Not applicable	18	9.0	1.0, 53.0	0.0 – 95.0

5.3.6.3.10 Obstacle: lack of a trained sheep dog

As an obstacle to the immediate treatment of lame ewes, the lack of a trained dog was positively and significantly correlated with both the period and point prevalence of lameness (Rho = 0.12, p = 0.02 and Rho = 0.21, p <0.01 respectively). Those respondents who had attended a course on lameness in sheep in the previous 12 months (n = 317) reported a significantly higher score (*i.e.* lack of a trained dog as more of an obstacle) than those who had not attended a course (n = 101) (p = 0.01) (medians of 14.0 (IQR: 3.0, 51.0) *cf.* 5.0 (IQR: 1.0, 43.0). There was also significant variation in respondents VAS scores for lack of a trained dog with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Lack of a dog was a significantly greater obstacle for those respondents who caught lame ewes for inspection and treatment at increasing locomotion scores (LS 1 *cf.* 2: p <0.01; LS 2 *cf.* ≥3: p = 0.04) (Table 84).

Table 84: Number, median, interquartile range and range of respondents visual analogue scale scores for lack of trained sheep dog help gather ewes as an obstacle to immediate treatment of lame ewes by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	116	3.0	0.0, 12.0	0.0 - 98.0
2	171	6.0	1.0, 48.0	0.0 - 98.0
≥3	132	15.0	3.0, 53.5	0.0 - 97.0

5.3.6.3.11 Obstacle: lack of time

Male respondents (n = 353) considered lack of time significantly more of an obstacle to prompt treatment of lame sheep than female respondents (n = 71) with median scores of 26.0 (IQR: 8.0, 50.0) *cf.* 14.0 (IQR 4.0, 30.0) ($p < 0.01$). There was significant variability in respondents VAS scores for lack of time between age categories of the respondents ($p = 0.03$) (Table 85). Those aged ≤25 considered lack of time significantly more of an obstacle than those in age categories 36-45, 46-55, 56-65 and >65 years ($p \leq 0.02$). Similarly, those aged 26-35 considered time significantly more of an obstacle than those aged 56-65 and >65 ($p = 0.03$ respectively); with a trend for those aged 26-35 to consider it more of an obstacle than those aged 45-55 ($p = 0.01$).

Table 85: Number, median, interquartile range and range of respondents visual analogue scale scores for lack of time as an obstacle to the immediate treatment of a lame ewe by age category of the respondent.

Age category (years)	N	Median	IQR	Range
≤25	12	64.5	20.5, 78.5	7.0 - 88.0
26-35	22	45.0	12.0, 59.0	0.0 - 96.0
36-45	59	20.0	11.0, 49.0	0.0 - 97.0
46-55	138	25.0	5.0, 49.0	0.0 - 98.0
56-65	113	18.0	7.0, 46.0	0.0 - 86.0
>65	87	22.0	4.0, 44.0	0.0 - 97.0

Commercial respondents (n = 340) also considered time more of a limiting factor than pedigree farmers (n = 84) and gave significant higher scores ($p < 0.01$) (medians of 28.0 (IQR: 9 – 51) *cf.* 12.0 (IQR: 3.0, 27.5). Lack of time was also significantly positively correlated with the period and point prevalence of lameness and also flock size (p <0.01 and Rho = 0.19, 0.26, 0.21 respectively). There was also significant variation in respondents VAS scores for lack of time with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Farmers that caught lame ewes with locomotion scores 1 compared with 2 or ≥3 for treatment also considered lack of time less of an obstacle and this was significant (p <0.01) (Table 86).

Table 86: Number, median, interquartile range and range of respondents visual analogue scale scores for lack of time as an obstacle to immediate treatment of a lame ewe by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	121	12.0	3.0, 36.0	0.0 - 98.0
2	178	28.5	10.0, 54.0	0.0 - 95.0
≥3	134	30.0	10.0, 50.0	0.0 - 96.0

Finally, there was significant variation in respondents VAS scores for lack of time where farmers treated lame ewes with ID, FR and ID and FR combined with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies (p ≤0.01 respectively) (Table 87). Respondents who '*always*' treated cases of ID within 3 days with antibacterials reported lack of time significantly less of an obstacle compared with respondents who did this '*most of the time*', '*sometimes*' or '*never*' p <0.01 respectively). Interestingly, in addition, those who stated '*not applicable*' also reported lack of time significantly less of an obstacle than those who did this '*most of the time*', '*sometimes*' and '*never*' (p ≤0.04 respectively). Respondents who '*always*' treated cases of FR within 3 days with antibacterials reported lack of time significantly less of an obstacle compared with respondents who did this '*sometimes*' (p <0.01). In addition, those who '*sometimes*' did this reported lack of time significantly more of an obstacle than those who '*never*' did this (p = 0.02); and a trend for more of an obstacle when those who stated '*sometimes*' was compared with those who stated '*not applicable*' (p = 0.06). Respondents that '*always*' treated cases of ID and FR within 3 days with antibacterials reported lack of time significantly less of an obstacle compared with respondents who did this, '*most of the time*', '*sometimes*' and '*never*' (p <0.01; <0.01; and 0.04). In addition, there was a trend for respondents who '*sometimes*' did this to report lack of time more of an obstacle than respondents who '*never*' did this or had stated '*not applicable*' (p = 0.10 and 0.07) (Table 87).

Table 87: Number, median, interquartile range and range of respondents visual analogue scores for lack of time as an obstacle to the immediate treatment of a lame ewe by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis, footrot and both diseases combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Interdigital dermatitis				
Always	82	12.0	3.0, 34.0	0.0 – 93.0
Most of the time	89	30.0	14.0, 51.0	0.0 – 96.0
Sometimes	133	32.0	9.0, 48.0	0.0 – 98.0
Never	74	21.5	12.0, 49.0	0.0 – 96.0
Not applicable	32	11.0	3.0, 45.0	0.0 – 95.0
footrot				
Always	107	17.0	3.0, 46.0	0.0 – 95.0
Most of the time	106	25.0	8.0, 50.0	0.0 – 97.0
Sometimes	123	33.0	16.0, 50.0	0.0 – 98.0
Never	45	15.0	10.0, 45.0	0.0 – 92.0
Not applicable	38	19.0	6.0, 48.0	0.0 – 91.0
Interdigital dermatitis and footrot combined				
Always	54	10.0	2.0, 36.0	0.0 – 93.0
Most of the time	56	33.0	9.0, 55.0	0.0 – 96.0
Sometimes	75	37.0	11.0, 52.0	1.0 – 98.0
Never	38	15.5	10.0, 49.0	1.0 – 92.0
Not applicable	18	9.0	4.0, 59.0	0.0, 91.0

5.3.6.3.12 Obstacle: Waiting for a more than one ewe in a group to be lame

Waiting for more than one ewe to be lame was positively and significantly correlated with years of farming experience (p = 0.03, Rho = 0.10). It was also significantly positively correlated with the period and point prevalence of lameness and the flock size (Rho = 0.22, 0.37 and 0.29; p <0.01). Male respondents (n = 352) were significantly more likely to wait for more than one ewe to be lame before catching than female respondents (n = 71) (p <0.01) with medians of 20.0 (IQR: 3.0, 71.5) *cf.* 5.0 (IQR: 1.0, 36.0). Similarly, commercial respondents (n = 341) were more likely to wait for more than one ewe to be lame than pedigree respondents (n = 83) (p <0.01) (medians of 24.0 (IQR: 5.0, 72.0) *cf.* 4.0 (IQR: 1.0, 20.0). There was also a trend for variability within farm types (p = 0.07) with upland farmers significantly more likely to wait for more than one ewe in a group to be lame before investigating compared with lowland farmers (p = 0.03) (Table 88).

Table 88: Number, median, interquartile range and range of respondents visual analogue scale scores for the need to wait for more than one ewe in a group to be lame before catching by respondents farm type.

Farm type	N	Median	IQR	Range
Lowland	313	13.0	3.0, 57.0	0.0, 98.0
Upland	90	43.5	5.0, 75.0	0.0, 98.0
Hill	25	10.0	2.0, 59.0	0.0, 93.0

There was also significant variation in respondents VAS scores for postponing investigation until more than one ewe was lame where farmers treated lame ewes with ID, FR and ID and FR combined with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies (p <0.01 respectively) (Table 89). Respondents who '*always*' treated cases of ID within 3 days with antibacterials reported were significantly less likely to wait for more than one ewe to be lame compared with respondents who did this '*most of the time*' and '*sometimes*' (p <0.01 respectively). Interestingly, in addition, those who stated '*not applicable*' were also significantly less likely to wait for more than one ewe in a group to be lame than those who did this '*most of the time*' and '*sometimes*' (p = 0.02 respectively). Similarly, respondents who '*always*' treated cases of FR within 3 days with antibacterials were significantly less likely to wait for more than one ewe to be lame compared with respondents who did this '*most of the time*' and '*sometimes*' ($p \leq 0.01$ respectively). Interestingly and conversely, there was also a trend for those who stated '*not applicable*' to be less likely to wait for a group to be lame before treatment than those who '*always*' did this ($p = 0.08$). In addition, respondents who '*never*' treated cases of FR within 3 days with antibacterials were significantly less likely to wait for more than one ewe to be lame compared with respondents who did this '*most of the time*' and '*sometimes*' ($p = 0.05$ and <0.01 respectively). This was also the case for respondents who stated '*not applicable*' in comparison to those who did this '*most of the time*' and '*sometimes*' ($p <0.01$ respectively). Likewise, respondents who '*always*' treated cases of ID and FR combined within 3 days with antibacterials were significantly less likely to wait for more than one ewe to be lame compared with respondents who did this '*most of the time*' and '*sometimes*' ($p <0.01$ respectively). Again, interestingly respondents who '*never*' treated cases of ID and FR combined within 3 days with antibacterials were significantly less likely to wait for more than one ewe to be lame compared with respondents who did this '*most of the time*' and '*sometimes*' ($p = 0.03$ and 0.04 respectively). Again, this was also the case for respondents who stated '*not applicable*' in comparison to those who did this '*most of the time*' and '*sometimes*' ($p \leq 0.01$ respectively) (Table 89).

Table 89: Number, median, interquartile range and range of respondents visual analogue scores waiting for more than one ewe to be lame by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis, footrot and both diseases combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Interdigital dermatitis				
Always	83	6.0	2.0, 48.0	0.0 – 98.0
Most of the time	90	42.0	6.0, 75.0	0.0 – 98.0
Sometimes	132	24.0	5.0, 74.0	0.0 – 98.0
Never	73	16.0	3.0, 65.0	0.0 – 97.0
Not applicable	33	6.0	2.0, 43.0	0.0 – 93.0
footrot				
Always	108	10.0	2.0, 49.0	0.0 – 98.0
Most of the time	106	23.0	7.0, 72.0	0.0 – 98.0
Sometimes	122	47.5	5.0, 79.0	0.0 – 98.0
Never	45	9.0	2.0, 50.0	0.0 – 95.0
Not applicable	38	3.5	1.0, 13.0	0.0 – 94.0
Interdigital dermatitis and footrot combined				
Always	55	6.0	2.0, 49.0	0.0 – 95.0
Most of the time	56	47.5	8.5, 79.0	0.0 – 98.0
Sometimes	73	45.0	5.0, 77.0	0.0 – 98.0
Never	37	11.0	3.0, 50.0	0.0 – 95.0
Not applicable	18	5.0	2.0, 40.0	0.0, 92.0

Interestingly, respondents who had attended a course on lameness in sheep in the previous 12 months (n = 328) were significantly more likely to wait for more than one ewe in a group to be lame than those who had not attended a course (n = 105) ($p < 0.01$) (medians of 45.0 (IQR: 5.0, 77.0) *cf.* 12.0 (IQR: 2, 58.5). There was also significant variation in respondents VAS scores for waiting for more than one ewe in a group to be lame before investigation with differences in the minimum locomotion score that respondents caught for inspection and treatment ($p < 0.01$).

Respondents who caught lame ewes at locomotion score 1 for inspection were significantly less likely to wait for more than one ewe in a group to be lame than those who caught at locomotion scores 2 and ≥3 (p <0.01 respectively) (Table 90).

Table 90: Number, median, interquartile range and range of respondents visual analogue scale scores waiting for more than one ewe to be lame compared with the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	123	5.0	1.0, 31.0	0.0 - 98.0
2	176	24.0	4.0, 70.0	0.0 - 98.0
≥3	134	35.5	5.0, 75.0	0.0 - 98.0

5.3.6.3.13 Obstacle: Reluctance to treat lame ewes during tupping

There was significant variability of VAS scores for reluctance to catch lame ewes during tupping within farm types (p = 0.04) with hill farmers significantly less reluctant to catch a lame ewe during tupping than lowland or upland farmers (p = 0.04 and 0.02) (Table 92).

Table 91: Number, median, interquartile range and range of respondents visual analogue scale scores for reluctance to catch and turn a lame ewe during tupping by respondents farm type.

Farm type	N	Median	IQR	Range
Lowland	312	15.0	3.0, 66.0	0.0 - 98.0
Upland	90	18.5	3.0, 81.0	0.0 - 98.0
Hill	25	4.0	2.0, 18.0	0.0 - 95.0

The point prevalence of lameness was significantly positively correlated with reluctance to catch ewes during tupping (Rho = 0.17, p <0.01). There was also significant variation in respondents VAS scores for reluctance to catch and turn lame ewes during tupping with differences in the minimum locomotion score that respondents caught for inspection and treatment (p <0.01). Respondents who caught lame ewes at locomotion score 1 for inspection were significantly less reluctant to catch and turn lame ewes during tupping than those who caught at locomotion scores 2 and ≥3 (p <0.01 respectively) (Table 92).

Table 92: Number, median, interquartile range and range of respondents visual analogue scale scores for reluctance to catch and turn lame ewes during tuppiung by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	122	6.0	2.0, 48.0	0.0 - 98.0
2	176	19.5	3.5, 72.5	0.0 - 98.0
≥3	134	18.0	4.0, 72.0	0.0 - 98.0

Finally, there was a trend for variation in respondents VAS scores for reluctance to catch and turn lame ewes during tupping where farmers treated lame ewes with FR (but not ID alone or ID and FR combined) with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies (p = 0.08) (Table 93). Respondents who '*always*' treated cases of FR within 3 days with antibacterials were significantly less reluctant to catch and turn a lame ewe during tupping than those who did this '*most of the time*' or '*sometimes*' (p = 0.03 and 0.02 respectively) (Table 93).

Table 93: Number, median, interquartile range and range of respondents visual analogue scores reluctance to catch lame ewes during tupping by respondents frequency of treatment of lame ewes diagnosed with footrot with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Always	108	10.5	1.5, 55.0	0.0 – 96.0
Most of the time	106	18.5	4.0, 75.0	0.0 – 98.0
Sometimes	121	17.0	4.0, 76.0	0.0 – 98.0
Never	46	10.0	2.0, 60.0	0.0 – 97.0
Not applicable	38	11.5	2.0, 62.0	0.0 – 93.0

5.3.6.3.14 Obstacle: Reluctance to treat lame ewes when heavily pregnant

Female farmers (n = 72) were significantly more concerned about catching heavily pregnant lame ewes for inspection and treatment than male farmers (n = 350) ($p = 0.02$) with medians of 80.0 (IQR: 47.5, 93.0) *cf.* 69.5 (IQR: 14.0, 91.0). The period and point prevalence of lameness were significantly positively correlated with reluctance to catch heavily pregnant lame ewes for treatment (Rho = 0.16 and 0.23, $p < 0.01$). In addition, the flock size was significantly negatively correlated with reluctance to catch heavily pregnant lame ewes (Rho = -0.13, $p < 0.01$). There was significant variation in respondents VAS scores for reluctance to catch and turn a heavily pregnant lame ewe with differences in the minimum locomotion score that respondents caught for inspection and treatment ($p < 0.01$). Respondents who caught lame ewes at locomotion score 1 for inspection were significantly less reluctant to catch and turn a heavily pregnant lame ewe than those who caught at locomotion scores 2 and ≥3 ($p = 0.05$ and <0.01 respectively) (Table 94).

Table 94: Number, median, interquartile range and range of respondents visual analogue scale scores for reluctance to catch and turn a heavily pregnant lame ewe by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	122	56.0	7.0, 91.0	0.0 - 98.0
2	175	74.0	22.0, 91.0	0.0 - 98.0
≥3	134	79.5	40.0, 93.0	0.0 - 98.0

Finally, there was a trend for variation in respondents VAS scores for reluctance to catch and turn heavily pregnant lame ewes for inspection and treatment where farmers treated lame ewes with FR, and ID and FR combined (but not ID alone) with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies (p = 0.09 and 0.07) (Table 95). Respondents who stated '*not applicable*' to treating cases of FR within 3 days with antibacterials were significantly less reluctant to catch and turn a heavily pregnant lame ewe than those who did this '*most of the time*' and '*never*' (p = 0.02); with a trend in comparison with those who did this '*sometimes*' (p = 0.10). In addition, respondents who stated '*not applicable*' to treating cases of ID and FR combined within 3 days with antibacterials were significantly less reluctant to catch and turn a heavily pregnant lame ewe than those who did this '*always*', '*most of the time*' '*sometimes*' and '*never*' (p = 0.05; 0.01; 0.03; and <0.01 respectively) (Table 95).

Table 95: Number, median, interquartile range and range of respondents visual analogue scores reluctance to catch lame ewes when heavily pregnant by respondents frequency of treatment of lame ewes diagnosed with footrot and both diseases combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Footrot				
Always	110	70.0	12.0, 91.0	0.0 – 98.0
Most of the time	106	75.5	24.0, 93.0	0.0 – 98.0
Sometimes	119	65.0	20.0, 88.0	0.0 – 98.0
Never	46	83.5	40.0, 92.0	0.0 – 98.0
Not applicable	38	41.5	4.0, 87.0	0.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	57	74.0	19.0, 91.0	0.0 – 98.0
Most of the time	56	77.0	40.0, 93.0	0.0 – 98.0
Sometimes	71	63.0	20.0, 91.0	1.0 – 98.0
Never	38	83.5	45.0, 91.0	0.0 – 97.0
Not applicable	18	39.0	1.0, 74.0	0.0 – 94.0

5.3.6.3.15 Believed that lameness within their flock was a minor problem

The period and point prevalence of lameness were both negatively and significantly correlated with this statement, *i.e.* those that had low levels of lameness believed that lameness was a minor problem in their flock ($p < 0.01$, Rho = -0.38 equally). There was also a trend for flock size to be negatively correlated with the statement ($p = 0.08$, Rho = -0.09) where respondents with larger flock sizes considered lameness more of a problem. Finally, there was significant variation in respondents VAS scores for belief that lameness was a minor problem where farmers treated lame ewes with ID, FR and ID and FR combined with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies (p <0.01 respectively) (Table 96). Interestingly, respondents who stated '*not applicable*' to treatment of cases of ID within 3 days with antibacterials believed lameness to be significantly less of a concern than those who did this '*always*', '*most of the time*', '*sometimes*' or '*never*' (p = 0.04; <0.01; <0.01; and 0.02). In addition, there was a trend for those who did this '*sometimes*' to consider lameness more of a concern than those who did this '*most of the time*' (p = 0.06). Again, respondents who stated '*not applicable*' to treatment of cases of FR within 3 days with antibacterials believed lameness to be significantly less of a concern than those who did this '*always*', '*most of the time*', '*sometimes*' or '*never*' (p <0.01; <0.01; <0.01; and 0.02 respectively). In addition, those who did this '*sometimes*' considered lameness more of a concern than those who did this '*always*', '*most of the time*' and '*never*' (p <0.01; 0.03; and <0.01 respectively). Once more, respondents who stated '*not applicable*' to treatment of cases of ID and FR combined within 3 days with antibacterials believed lameness to be significantly less of a concern than those who did this '*always*', '*most of the time*', '*sometimes*' (but not '*never*') (p = 0.05; <0.01 and <0.01 respectively). In addition, those who did this '*sometimes*' considered lameness more of a concern than those who did this '*most of the time*' and '*never*' (p = 0.03 and 0.02) (Table 96).

Table 96: Number, median, interquartile range and range of respondents visual analogue scores for lameness considered a minor problem in their flock by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis, footrot and both diseases combined with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Interdigital dermatitis				
Always	84	79.5	45.0, 93.0	1.0 – 98.0
Most of the time	88	78.0	59.5, 90.0	1.0 – 98.0
Sometimes	132	70.0	36.5, 85.0	0.0 – 98.0
Never	73	84.0	29.0, 90.0	1.0 – 98.0
Not applicable	34	92.0	80.0, 95.0	0.0 – 98.0
footrot				
Always	110	79.5	48.0, 93.0	1.0 – 98.0
Most of the time	105	75.0	48.0, 87.0	0.0 – 98.0
Sometimes	121	64.0	27.0, 83.0	0.0 – 97.0
Never	46	88.0	30.0, 93.0	0.0 – 98.0
Not applicable	39	92.0	81.0, 96.0	2.0 – 98.0
Interdigital dermatitis and footrot combined				
Always	57	76.0	48.0, 92.0	2.0 – 98.0
Most of the time	55	77.0	60.0, 89.0	1.0 – 98.0
Sometimes	73	64.0	27.0, 83.0	0.0 – 97.0
Never	38	88.0	30.0, 93.0	4.0 – 98.0
Not applicable	19	92.0	83.0, 95.0	2.0, 98.0

5.3.6.3.16 Believed that a ≤2% prevalence of lameness increased flock performance

The period and point prevalence of lameness were significantly negatively correlated with the statement (p <0.01, Rho = -0.15 equally), *i.e.* respondents with lower prevalence’s of lameness had greater agreement that lower prevalence’s were beneficial to flock performance and *vice versa*. Interestingly the statement was positively correlated with flock size ($p = 0.04$, Rho = 0.11), such that farmers with greater numbers of ewes had stronger agreement that lameness levels of ≤2% increased flock performance than those with smaller flocks. There was significant variation in respondents VAS scores for belief that a low prevalence of lameness increased flock performance where farmers treated lame ewes with FR (but not ID alone or ID and FR combined) with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies ($p = 0.04$) (Table 97). Respondents who '*always*' treated cases of FR within 3 days with antibacterials believed a prevalence of lameness of ≤2% to increase flock performance significantly more than those who did this '*most of the time*', '*sometimes*' or '*never*' (p = 0.01; <0.01; and 0.04) (Table 97).

Table 97: Number, median, interquartile range and range of respondents visual analogue scores for flock performance enhanced by levels of lameness ≤2% by respondents frequency of treatment of lame ewes diagnosed with footrot with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Always	107	93.0	81.0, 97.0	1.0 – 98.0
Most of the time	104	87.0	74.5, 95.0	1.0 – 98.0
Sometimes	121	86.0	71.0, 95.0	0.0 – 98.0
Never	44	88.5	74.5, 94.0	1.0 – 98.0
Not applicable	37	90.0	84.0, 97.0	0.0 – 98.0

Finally, there was significant variation in the respondents belief in this statement with differences in the minimum locomotion score that respondents caught for inspection and treatment ($p < 0.01$). Respondents who caught lame ewes at locomotion score 1 and 2 for inspection had significantly greater belief that a prevalence of lameness of ≤2% increased flock performance than those who caught at locomotion score ≥3 ($p < 0.01$ and 0.03) (Table 98).

Table 98: Number, median, interquartile range and range of respondents visual analogue scale scores belief that ≤2% prevalence of lameness increased flock performance by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	117	93.0	80.0, 96.0	1.0 - 98.0
2	176	89.0	75.5, 96.0	0.0 - 98.0
≥3	133	86.0	64.0, 94.0	0.0 - 98.0

5.3.6.3.17 Respondents who never catch individual lame ewes for treatment

Never catching individuals was significantly positively correlated with years farming experience (Rho = 0.13, $p < 0.01$). Similarly, both the period and point prevalence of lameness ($p < 0.01$) and flock size ($p = 0.04$) were significantly and positively correlated with not catching individuals for treatment (Rho = 0.19, 0.24 and 0.11 respectively). Pedigree farmers (n = 84) were more likely to catch individual lame ewes for treatment than commercial farmers (n = 340) and this was significant ($p < 0.01$) (medians of 2.0 (IQR: 0.5, 5.0) *cf.* 3.5 (IQR: 1.0, 10.0).

There was significant variation in respondents VAS scores for never catching individual lame ewes with differences in the minimum locomotion score that respondents caught for inspection and treatment ($p < 0.01$). Respondents who caught lame ewes at locomotion score 1 for inspection were significantly more likely to catch individual lame ewes than those who caught at locomotion scores 2 and ≥3 ($p \leq 0.01$ respectively) (Table 99).

Table 99: Number, median, interquartile range and range of respondents visual analogue scale scores for reluctance to catch and turn a heavily pregnant lame ewe by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	123	2.0	1.0, 5.0	0.0 - 96.0
2	176	3.5	1.0, 10.0	0.0 - 95.0
≥3	134	4.0	1.0, 11.0	0.0 - 98.0[1]

N = number; IQR = interquartile range

Interestingly, there was also a trend (p = 0.06) for respondents that had attended a course in the last 12 months to give higher VAS scores for this question (*i.e.* less likely to always catch individuals for treatment) than those who had not attended a course (medians of 4 (IQR: 1.0, 11.0) *cf.* 3 (IQR: 1.0, 9.0). Finally, there was a trend for variation in respondents VAS scores for never catching individual lame sheep where farmers treated lame ewes with ID, FR and ID and FR combined with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies (p = 0.02; <0.01 and < 0.01 respectively) (Table 100). Respondents who '*always*' treated cases of ID within 3 days with antibacterials were significantly more likely to catch individuals than those who did this '*sometimes*' (p = 0.02). Interestingly, respondents who '*never*' did this were also significantly more likely to catch individuals for treatment than those who did this '*sometimes*' (p <0.01); with a trend in comparison with those who did this '*most of the time*' (p = 0.06). Furthermore, respondents who stated '*not applicable*' to

[1] The apparent contradiction between respondents (n = 2) who 'never' caught individual sheep for treatment (i.e. scored 98) but caught lame sheep with locomotion score ≥3 could be explained by interpreting the question asked in a wider sense. "*What is the lowest score of lameness that you would catch with the intention of treating?*" may have been interpreted as *the lowest score you would treat*.

treating cases of ID were also significantly more likely to catch individuals than those who did this ‘*sometimes*’ (p = 0.02); with a trend in comparison with those who did this ‘*most of the time*’ (p = 0.07). Respondents who ‘*always*’ treated cases of FR within 3 days with antibacterials were significantly more likely to catch individuals than those who did this ‘*most of the time*’ and ‘*sometimes*’ (p = 0.04 and <0.01). Again interestingly, respondents who ‘*never*’ did this were also significantly more likely to catch individuals for treatment than those who did this ‘*sometimes*’ (p = 0.04). Furthermore, respondents who stated ‘*not applicable*’ to treating cases of FR were also significantly more likely to catch individuals than those who did this ‘*most of the time*’ and ‘*sometimes*’ (p <0.01 respectively); with a trend in comparison with those who ‘*never*’ did this (p = 0.09). Respondents who ‘*always*’ treated cases of ID and FR combined within 3 days with antibacterials were significantly more likely to catch individuals than those who did this ‘*sometimes*’ (p <0.01); with a trend in comparison with those who did this ‘*most of the time*’ (p = 0.10). Again interestingly, respondents who ‘*never*’ did this were also significantly more likely to catch individuals for treatment than those who did this ‘*sometimes*’ (p = 0.02). Respondents who stated ‘*not applicable*’ to treating cases of ID and FR combined were also significantly more likely to catch individuals than those who did this ‘*most of the time*’ and ‘*sometimes*’ (p = 0.03 and <0.01) (Table 100).

Table 100: Number, median, interquartile range and range of respondents visual analogue scores to 'I never catch individual lame ewes for treatment by respondents frequency of treatment of lame ewes diagnosed with interdigital dermatitis, footrot and both diseases with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Interdigital dermatitis				
Always	83	2.0	1.0, 6.0	0.0 – 91.0
Most of the time	89	4.0	1.0, 12.0	0.0 – 98.0
Sometimes	131	4.0	2.0, 12.0	0.0 – 98.0
Never	74	2.0	0.0, 7.0	0.0 – 96.0
Not applicable	33	2.0	1.0, 4.0	0.0 – 95.0
footrot				
Always	108	10.0	0.5, 6.0	0.0 – 97.0
Most of the time	106	23.0	1.0, 11.0	0.0 – 98.0
Sometimes	121	47.5	2.0, 12.0	0.0 – 98.0
Never	46	9.0	1.0, 7.0	0.0 – 96.0
Not applicable	38	3.5	0.0, 3.0	0.0 – 28.0
Interdigital dermatitis and footrot combined				
Always	55	2.0	1.0, 6.0	0.0 – 91.0
Most of the time	56	5.0	1.0, 14.0	0.0 – 98.0
Sometimes	72	5.0	2.0, 28.0	1.0 – 98.0
Never	38	2.5	1.0, 8.0	0.0 – 96.0
Not applicable	18	2.0	1.0, 4.0	0.0, 28.0

5.3.6.4 Summary of section 5.3.6

Respondents recognised a lower locomotion score than that which they reported in postal surveys or caught with the intention of treating, although they were positively correlated (Rho = 0.57 and 0.55). Similar proportions of respondents reported above and below locomotion score 2 (mildly lame) (27.5 *cf.* 30.0%). The period and point prevalence of lameness were lower for respondents that caught the first lame sheep in the group; and for those that caught lower locomotion scores.

The majority believed: catching lame individuals rather than waiting until the flock was next gathered to be an effective treatment (80.6%); that the FAWC target of 2% prevalence by 2021 was reasonable (73.3%); and that the FAWC target could be or had already been achieved (70.6%). Respondents that believed the FAWC target: reasonable; achievable; or had already met it had a lower period and point prevalence of lameness.

Respondents VAS scores suggested that they were more motivated to promptly treat mildly lame sheep by empathy towards their sheep than by financial gain and that overall they were reluctant to give treatments to heavily pregnant ewes.

Increased profit was more motivating for younger farmers and farmers that were male, commercial, had more frequent contact with their vet and with increased flock size. It was also more motivating for those that '*always*' or '*most of the time*' treated ID with parenteral and topical antibacterials (*cf.* '*never*' and '*not applicable*'; and '*not applicable*' respectively).

Reduction of pain was more motivating for female farmers, farmers aged <65 years, and those that caught ewes for treatment at locomotion scores ≤2. Increased motivation by pain was correlated with reduced experience and a reduced point prevalence of lameness. Reducing pain was more motivating for those that stated '*always*' or '*not applicable'* to treatment of FR and FR and ID combined with parenteral and topical antibacterials (*cf.* '*most of the time*' and '*sometimes*' respectively).

Improvement of welfare was more motivating for farmers aged <65 years, caught at locomotion score 1, and for those who stated '*always*' or '*not applicable*' to the treatment of FR and FR and ID combined with antibacterials. Increased motivation by welfare was correlated with reduced experience and a reduced point prevalence of lameness.

Reducing transmission of lameness was more motivating for pedigree farmers, those that caught at locomotion score 1, and for those who '*always*' treated FR and FR and ID combined with parenteral and topical antibacterials. Increased motivation to reduce transmission was correlated with a reduced period and point prevalence of lameness and increased flock size.

Proximity to a public place was more motivating for commercial farmers, those aged <65 years, those who had attended an educational event on lameness in the last 12 months and correlated with increased flock size. Those who '*never*' treated FR with parenteral and topical antibacterials were less motivated by proximity to a public location.

Difficulty identifying lame sheep was more of an obstacle for commercial farmers, lowland and upland farmers, those that caught at locomotion scores ≥2, and those that had attended an educational event on lameness in the previous 12 months. Increased difficulty identifying a lame ewe was correlated with an increased point prevalence of lameness and an increased flock size. Those who stated '*always*' or '*not applicable*' to treatment of FR and FR and ID combined with parenteral and topical antibacterials had less difficulty identifying a lame ewe, as did those who visited their vet bi-annually *cf.* less than annually.

Difficulty catching mildly lame sheep was more of an obstacle for commercial farmers and those that caught at locomotion scores ≥2. Increased difficulty catching a mildly lame ewe was correlated with an increased period and point prevalence of lameness and an increased flock size. Those who stated '*always*' or '*most of the time*' to treatment of ID, FR and FR and ID combined with parenteral and topical antibacterials had less difficulty catching a lame ewe.

Distance to handling facilities presented more of an obstacle to prompt treatment for male and commercial farmers and for those that caught at locomotion scores ≥2. It was correlated with an increased period and point prevalence of lameness and an increased flock size. Those who stated '*always*' to treatment of ID, FR and FR and ID combined with parenteral and topical antibacterials reported distance to handling facilities less of an obstacle.

Lack of an assistant was more of an obstacle for commercial and upland farmers and for those that caught at locomotion scores ≥2 and was correlated with increased period and point prevalence of lameness. Those who stated '*always*' or '*not applicable*' to treatment of FR and FR and ID combined with parenteral and topical antibacterials reported lack of an assistant less of an obstacle.

Lack of a trained dog was more of a obstacle to those that caught at locomotion score ≥2 and that had attended an educational event. It was also correlated with increased period and point prevalence of lameness.

Lack of time was more of an obstacle for commercial, male farmers and younger farmers and those that caught at locomotion score ≥2. It was correlated with increased period and point prevalence of lameness and flock size. Those who stated '*always*' or '*not applicable*' to treatment of ID, FR and FR and ID combined with parenteral and topical antibacterials reported lack of an assistant less of an obstacle.

Waiting for more than one ewe to be lame was correlated with increased experience, flock size and the period and point prevalence of lameness. It was more of an obstacle to prompt treatment for male, commercial and upland farmers, those who had attended an educational event and caught at locomotion score ≥2. Those who stated '*always*' or '*not applicable*' to treatment of ID, FR and FR and ID combined with parenteral and topical antibacterials were less likely to wait for more than one ewe to be lame before treatment.

Reluctance to treat lameness during tupping was more of an obstacle for lowland and upland farmers, those that caught at locomotion score ≥2 and was correlated with an increased point prevalence of lameness. Those who '*always*' treated FR with parenteral and topical antibacterials were less likely to avoid treatment during tupping.

Reluctance to treat when heavily pregnant was more of an obstacle for female farmers and those that caught at locomotion score ≥2. It was correlated with increased period and point prevalence of lameness but reduced flock size. Those who stated '*not applicable*' to treatment of FR, and FR and ID combined, with parenteral and topical antibacterials were less likely to avoid treatment when ewes were heavily pregnant.

Belief that lameness was a minor problem within their flock was correlated with a reduced period and point prevalence of lameness and flock size. Those who stated '*not applicable*' to treatment of ID, FR, and FR and ID combined, with parenteral and topical antibacterials believed lameness less of a concern in their flock.

Belief that a ≤2% prevalence of lameness resulted in improved flock performance was correlated with reduced period and point prevalence of lameness and increased flock size. Those who caught at locomotion score ≤2 and those who '*always*' treated FR with parenteral and topical antibacterials were also more likely to believe that it increased flock performance.

Never catching individuals for treatment was correlated with increased experience, flock size and the period and point prevalence of lameness. Individual treatment was less likely to be given by commercial famers, those who had attended an educational event on lameness, and those that treated at locomotion score ≥2. Those who stated '*always*' or '*not applicable*' to treatment of ID, FR, and FR and ID combined, with parenteral and topical antibacterials were more likely to catch individuals.

5.3.7 Routine foot trimming

As a method to control lameness, routine foot trimming was rated as '*excellent'* by 60 (13.4%) respondents, '*good*' by 142 (31.6%), '*average*' by 125 (27.8%), '*poor*' by 91 (20.3%), '*don't know*' by 12 (2.7%) and was not stated by 19 (4.2%) respondents. The rating of routine foot trimming did not vary by frequency of treatment categories for the management of ID, FR or both with antibacterials ($p \geq 0.39$), by years of farming experience or by farm type ($p = 0.53$ and 0.64). Pedigree farmers rated routine foot trimming significantly more highly than commercial farmers ($p < 0.01$) (Table 101). There was also significant variability in respondents rating of routine foot trimming by flock size ($p < 0.01$) (Table 102). Respondents who considered routine foot trimming '*excellent*' had a significantly ($p < 0.01$) smaller flock size than those who rated it '*average*' and '*poor*', with a trend (p=0.08) in comparison with '*good*'. Those who rated it '*good*' had a significantly smaller flock size than those who rated it '*poor*' (p <0.01); with a trend in comparison with '*average*' (p = 0.07). In addition, respondents who rated foot trimming as '*poor*' had a significantly smaller flock size than those who rated it '*average*'(p <0.01). Finally, the 12 respondents who were uncertain how to rate routine foot trimming, had a significantly smaller flock size than those who rated it '*poor*' or '*average*' (p <0.01 respectively).

Table 101: Respondent rating of routine foot trimming as a method to control lameness by flock type.

Respondent	N	Median	IQR	Range
Commercial	336	Average	Good, Poor	Excellent – don't know
Pedigree	83	Good	Good, Average	Excellent – don't know

N = number of respondents; IQR = interquartile range

Table 102: Respondent rating of routine foot trimming as a method to control lameness by flock size.

Respondent	N	Median	IQR	Range
Excellent	56	65.5	37.5, 159	10 – 1400
Good	129	116	47, 284	11 – 1950
Average	119	150	70, 346	10 – 3500
Poor	85	250	103, 480	19 – 2850
Don't know	12	77.5	33.5, 97	20 - 350

N = number of respondents; IQR = interquartile range

The period and point prevalence of lameness varied between respondents ratings of routine foot trimming and this was significant (p <0.01 respectively). Interestingly, farmers that rated routine foot trimming as an '*excellent*' method to control lameness had a significantly lower period prevalence of lameness than those who rated it as '*good*', '*average*' or '*poor*' (p <0.01, 0.02 and <0.01). In addition, conversely, there was a trend for those who rated routine foot trimming as '*good*' to have a higher period prevalence of lameness than those who rated it as '*average*' (p = 0.08). Similarly, the point prevalence of lameness was significantly lower for those respondents that rated routine foot trimming as '*excellent*' compared with all other rating categories (p <0.01; <0.01; <0.01 and 0.03) (Table 103).

Table 103: The number of respondents, median, interquartile range and range of the period and point prevalence of lameness by respondents rating of routine foot trimming as a method to control lameness.

Rating	N	Median	IQR	Range
Period prevalence				
Excellent	56	3.0	1.0, 5.0	0.0 – 25.0
Good	121	5.0	3.0, 10.0	0.0 – 25.0
Average	109	5.0	2.0, 7.0	0.0 – 16.0
Poor	79	5.0	3.0, 7.0	0.0 – 25.0
Unsure	10	4.5	2.0, 10.0	0.0 – 12.0
Point prevalence				
Excellent	56	1.0	0.0, 2.5	0.0 – 8.4
Good	125	2.5	1.0, 4.6	0.0 – 19.5
Average	119	2.2	0.8, 4.2	0.0 – 13.0
Poor	84	2.3	0.7, 4.0	0.0 – 25.0
Unsure	12	3.5	0.5, 10.0	0.0 – 13.3

N = number of respondents; IQR = interquartile range

One hundred and one (22.5%) respondents did not routinely trim the feet of their ewes, 143 (31.9%) trimmed the feet of some of their ewes, 186 (41.4%) trimmed the feet of all of their ewes and 19 (4.2%) respondents did not respond to this question. Of the 329 (73.7%) respondents that routinely trimmed some or all feet of their ewes, 150 (45.6%) farmers trimmed once, 101 (30.7%) twice and 38 (11.6%) more than twice with 40 (12.1%) not stated. Respondents who routinely trimmed all, some or none of their ewes did not vary significantly by farm or flock type (p = 0.52 and 0.47 respectively). Flock size varied significantly (p <0.01) and unsurprisingly was significantly smaller for respondents who trimmed all of their ewes compared with those who trimmed some or none of their ewes (p <0.01) (Table 104). Years of farming experience also differed significantly between those who routinely trimmed all, some and none of their ewes (p <0.01). Respondents who trimmed some of their ewes' feet had significantly more years farming experience than those who trimmed all or none of their ewes feet (p <0.01 and 0.02 respectively) (Table 104). There was also significant variability within frequency of treatment of ewes with antibacterials for ID, and a trend for ID and FR combined (but not FR alone) (p <0.01; 0.08; and 0.66). Respondents who did not routinely foot trim, treated ewes with antibacterials for ID significantly more frequently than respondents who routinely trimmed some or all of their ewes (p <0.01 respectively) (Table 104). Similarly, respondents who did not routinely foot trim, treated ewes with antibacterials for ID and FR combined significantly more frequently than respondents who routinely trimmed some of their ewes (p = 0.02); with a trend for all of their ewes (p = 0.06) (Table 104).

Table 104: Respondents who routinely trimmed all, some and none of their ewes by flock size, farmer experience and frequency of treatment with antibacterials for interdigital dermatitis and interdigital dermatitis and footrot combined.

Respondent	N	Median	IQR	Range
Flock size				
None	96	200	95.5, 437.5	10 - 1450
All	171	70	34, 150	10 - 1400
Some	133	245	92, 460	12 – 3500
Farmer experience (years)				
None	98	30	20, 40	1 - 60
All	180	30	17.5, 36	2 - 70
Some	136	34	25, 43	1 – 70
Frequency of management of ID				
None	96	S/times	M/times - never	Always – n/a
All	178	S/times	Always - never	Always – n/a
Some	132	S/times	M/times – S/times	Always – n/a
Frequency of management of ID/FR combined				
None	56	S/times	M/times - never	Always – n/a
All	106	S/times	Always - never	Always – n/a
Some	76	S/times	M/times – S/times	Always – n/a

N = number of respondents; IQR = interquartile range; m/time = most of the time; s/times = sometimes; n/a = not applicable.

Of respondents that routinely foot trimmed, their frequency of trimming (once, twice and >twice) did not differ significantly by farm type or number of years of farming experience ($p = 0.82$ and 0.30). However, there was a trend for pedigree respondents to routinely trim more frequently than commercial farmers ($p = 0.08$) (Table 105). There was significant variability in flock size between farmers who trimmed once, twice and >twice ($p <0.01$). Unsurprisingly, farmers who trimmed twice or >twice had significantly smaller flock sizes than those that trimmed once ($p <0.01$ respectively) (Table 105). Finally, respondents frequency of routine foot trimming varied significantly within categories for frequency of treatment of sheep lame with antibacterials for FR (p = 0.02) (but not ID or ID and FR combined (p >0.70)). Respondents who trimmed >twice, treated ewes with FR significantly more frequently with antibacterials than those who trimmed twice (p <0.01); with a trend in comparison with those who trimmed once (p =0.06) (Table 105).

Table 105: Respondents frequency of routine foot trimming per annum by flock type, flock size and frequency of treatment of FR with antibacterials.

Respondent	N	Median	IQR	Range
Flock type				
Commercial	220	Once	Once, Twice	Once - >Twice
Pedigree	68	Twice	Once, Twice	Once - >Twice
Flock size				
Once	143	150	65, 367	12 – 3500
Twice	92	73.5	33, 150	11 – 1500
>Twice	36	63.5	43.5, 198	10 - 400
Frequency of management of FR				
Once	150	M/times	Always – S/times	Always – n/a
Twice	97	S/times	M/times - never	Always – n/a
>Twice	38	M/times	Always – S/times	Always – n/a

N = number of respondents; IQR = interquartile range; m/time = most of the time; s/times = sometimes; n/a = not applicable.

The period and point prevalence of lameness was not significantly different between farmers that routinely trimmed the feet of their ewes once, twice or more than twice in the previous 12 months (p = 0.60 and 0.80); nor when respondents that routinely trimmed once were compared with those that trimmed more than once (p = 0.33 and 0.77). Similarly, there was no significant difference in the period or point prevalence of lameness of farmers that did not routinely foot trim their ewes in the previous 12 months compared with those that trimmed all or some of their ewes ($p = 0.53$ and 0.16); nor when respondents that did not routinely trim were compared with those that routinely trimmed all or some of their ewes combined ($p = 0.80$ and 0.25).

Two hundred and seventy five farmers (83.6%) of the 329 that routinely foot trimmed some or all ewes gave one or more reasons for practicing routine foot trimming in the preceding 12 months. Reasons were categorised and are presented in Table 106. Prevention of disease, lameness and/or associated problems; to inspect feet, identify and correct potential foot problems and to reshape and/or reduce overgrowth were the most common reasons listed by 147 (53.4%), 124 (45.1%) and 107 (38.9%) farmers respectively. Two (0.7%) respondents felt the question '*silly*' or '*stupid*', presumably because they felt it should be obvious (Table 106).

Table 106: Farmer’s reason(s) for routine foot trimming given by 275 of 329 respondents who practised routine foot trimming in preceding 12 months

Reason for practicing routine foot trimming	Number (%) respondents
Prevention of disease, lameness and or associated problems	147 (53.4)
Inspect, identify and correct potential foot problems	124 (45.1)
Re-shape and or reduce overgrowth	107 (38.9)
Good standards of flock health, welfare and or performance	28 (10.2)
Convenience when already restrained for another purpose	11 (4.0)
As part of a flock health plan	9 (3.3)
Good practice	8 (2.9)
Habit	8 (2.9)
For shows and or sales	3 (1.1)
Breed of sheep	3 (1.1)
To plan a foot health programme	2 (0.7)
‘silly’ question - obvious	2 (0.7)
For selection of sheep with poor feet to cull	2 (0.7)
On advice provided in literature	1 (0.4)

Sixteen farmers who had recently stopped trimming gave a reason as to why they had stopped, these included: no benefits gained (4); lack of time (3); followed advice received at a seminar (2); reduction in flock lameness (2); now carried out therapeutic foot trimming only (2); switched to vaccination which was more effective than routine trimming (2); reduction in toe granulomas (1); sold old ewes and considered trimming unnecessary in a young flock (1).

Farmers that currently routinely foot trimmed, believed the following would occur if they stopped: increased prevalence of lameness and footrot (154); unchecked overgrowth of hoof horn (98); increased formation of pockets of mud leading to split hooves or shelly hoof (22); reduced welfare (18); misshapen or poor foot shape (16); would miss the opportunity to inspect feet/treat infection/select poor feet for cull (7); reduced productivity (5); were unsure (3); increased foot problem for older ewes (2);

Respondents were asked to consider how likely on a scale of 0 to 100 they were to stop routine foot trimming on the evidence given. The evidence provided is given in Figure 37.

Figure 37: Inset of Q61 of the questionnaire. The evidence provided to respondents.

61. In a recent study, on one farm in the UK, a flock of 170 ewes were divided into two equally sized groups. One group received a routine foot trim and the other no routine foot trim. Changes in body condition, foot shape and damage, the level of lameness and foot lesions were recorded over a period of 3 months. Results showed no difference in:
    - the body condition of ewes
    - foot shape or damage
    - the level of lameness or severity of lameness
    - the level of interdigital dermatitis (scald / strip) or footrot

i.e. the routine trim was not detrimental but not beneficial either

Based on these findings, how likely are you to stop *routine* foot trimming?

Farmers were generally reluctant to stop routine foot trimming. The median response was 13.0 (IQR: 3.0, 47.0, range: 0.0 - 98.0) (Table 60, page 237). Commercial farmers (n = 244) were less opposed to stopping routine foot trimming than pedigree farmers (n = 71) and this was significant ($p < 0.01$) with median scores of 15.0 (IQR: 4.0, 53.0) *cf.* 6.0 (IQR: 2.0, 25.0). The period and point prevalence of lameness and flock size were significantly and positively correlated with increased VAS score (*i.e.*, those with higher prevalence's of lameness and larger flocks were less opposed to stopping routine foot trimming) (Rho = 0.13, 0.19 and 0.21, $p < 0.01$ respectively).

There was significant variation in respondents VAS scores for likelihood of stopping routine foot trimming with differences in the minimum locomotion score that respondents caught for inspection and treatment ($p < 0.01$). Respondents who caught lame ewes at locomotion score 1 for inspection were significantly less likely to stop routine foot trimming than those who caught at locomotion scores 2 and ≥3 ($p < 0.01$ and 0.02 respectively) (Table 107).

Table 107: Number, median, interquartile range and range of respondents visual analogue scale scores for likelihood of stopping routine foot trimming by the minimum locomotion score caught for treatment by the respondent.

Locomotion score caught	N	Median	IQR	Range
1	89	6.0	2.0, 29.0	0.0 - 98.0
2	131	20.0	5.0, 54.0	0.0 - 98.0
≥3	100	13.5	4.0, 48.5	0.0 - 98.0

Finally, there was a trend for variation in respondents VAS scores for likelihood of stopping routine foot trimming where farmers treated lame ewes with FR (but not ID alone or ID and FR combined) with topical and parenteral antibacterials within 3 days of becoming lame at different frequencies ($p = 0.09$) (Table 108). Respondents who stated '*not applicable*' to the treatment of ewes lame with FR within 3 days with topical and parenteral antibacterials were significantly less likely to stop routine foot trimming than those who did this '*most of the time*' or '*sometime*s' ($p = 0.04$ and 0.01). There was also a trend for those who '*always*' treated lame ewes with FR within 3 days with antibacterials to be less likely to stop routine foot trimming than those who '*sometimes*' did this (p = 0.08) (Table 108).

Table 108: Number, median, interquartile range and range of respondents visual analogue scores for likelihood of stopping routine foot trimming by respondents frequency of treatment of lame ewes diagnosed with footrot with topical and parenteral antibacterials within 3 days of becoming lame.

Frequency of treatment	N	Median	IQR	Range
Always	86	8.0	2.0, 47.0	0.0 – 98.0
Most of the time	76	16.5	4.5, 46.0	0.0 – 98.0
Sometimes	86	19.5	6.0, 65.0	0.0 – 98.0
Never	31	7.0	4.0, 45.0	0.0 – 97.0
Not applicable	31	6.0	1.0, 27.0	0.0 – 77.0

Two hundred and thirty five (54.6%) farmers who carried out routine foot trimming to some or all ewes in the previous 12 months responded to the question '*what evidence would you require to stop routine foot trimming?*' Their responses were categorised, counted and ordered by grouping similar categories (Table 109). A total of 22 (9.4%) farmers required a longer study with 11 (4.7%) requests for studies ≥ 1 year and up to 2 years in duration with 4 (1.7%) requests for studies of 3 or more years. Larger trial(s) were requested by 29 (12.3%) of the respondents. This included: more sheep, more farms, '*more*' evidence and '*proof*' beyond doubt by 6 (2.6%), 3 (1.3%), 16 (6.8%), and 4 (1.7%) farmers respectively. Evidence was also sought in relation to the farm type (extensive or intensive) or geography (lowland, upland or hill) by 9 (3.8%) respondents along with the ground and soil type by 10 (4.3%) respondents. The season and weather (particularly when wet) were listed by 3 (1.3%) respondents equally with sheep breed considered important by 5 (2.1%) and other management factors for lameness by 2 (0.9%) respondents. A precise and comparable assessment of lameness, and nutrition were also requested, listed each by 1 (0.4%) respondent. The outcome measure sought by farmers included detriment, benefit, and no difference by 33 (14.0%), 3 (1.3%) and 3 (1.3%) respondents respectively. It included an assessment of welfare (12, 5.1%), profitability or flock performance (4, 1.7%), lameness (28, 11.9%) and foot disease (13, 5.5%). Concern was expressed about the effect of overgrowth and or misshapen feet on disease, lameness, mobility and welfare (23, 9.8%) with additional concern raised about the effect of not trimming '*problem feet*' (4, 1.7%) and those sheep with severely overgrown '*slipper*' feet (3, 1.3%). A further respondent (0.4%) suggested that if at his pre-tup checks nothing needed treatment he would stop routinely trimming, though in his view, this was unlikely. Respondents also considered the source of the evidence important. Eleven (4.6%) required evidence gained from personal experience, 2 (0.9%) would evaluate literature, 7 (3.0%) required further detailed explanation, with 6 (2.6%) equally split between evidence provided from another farmer or their vet with 6 (2.6%) stating that they would be happy with any evidence; and a further respondent (0.4%) stating that they would use '*common sense*'. Twenty-nine (12.3%) farmers responded with '*none*' or '*nothing*' to the question of evidence required; 15 (6.4%) stated that they would not stop trimming; 4 (1.7%) felt that it was impractical to stop; 1 (0.4%) felt that the evidence required was unlikely to be found; 1 (0.4%) required '*compelling*' evidence and 8 (3.4%) were unsure what evidence they required. Finally a group of responses fell into an '*other evidence*' category that included amongst others the provision of a good alternative (3, 1.3%), that routine foot trimming was part and parcel of a necessary routine check (4, 1.7%) and that this was a '*silly*' question (2, 0.9%) (Table 109).

Table 109: Number and percentage of 235 farmers who provided the evidence they required to stop routine foot trimming and who also carried out routine trimming in the previous 12 months, by the criteria required to stop routine foot trimming

Evidence required by respondent	No. (%) of respondents
Longer studies	*22 (9.4)*
≥1 to 2 years	11(4.7)
≥3 years	4 (1.7)
'Longer'	7 (3.0)
Larger studies	*29 (12.3)*
More sheep	6 (2.6)
More farms	3 (1.3)
More evidence	16 (6.8)
Proof (beyond doubt)	4 (1.7)
Geography, farm and flock details	*35 (14.9)*
Farm type and or geography	9 (3.8)
Ground and or soil type	10 (4.3)
Seasons	3 (1.3)
Weather	3(1.3)
Breed	5 (2.1)
Age	1 (0.4)
Nutrition	1 (0.4)
Reliable assessment of lameness	1 (0.4)
Other lameness management factors considered	2 (0.9)
Outcome	*131 (55.7)*
Detrimental	33 (14.0)
Not detrimental	4 (1.7)
Beneficial	3 (1.3)
Not beneficial	4 (1.7)
No difference	3 (1.3)
Welfare not compromised	12 (5.1)
Profitability / performance not compromised	4 (1.7)
No lame sheep	16 (6.8)
Reduced lameness	12 (5.1)
No overgrown and or misshapen feet	23 (9.8)
Footrot	6 (2.6)
Shelly hoof	2 (0.9)
Foot problems / problem feet	4 (1.7)
All diseases of the foot	1 (0.4)
Overgrown curled up 'Slipper' feet	3 (1.3)
No treatment necessary at pre-tup check	1 (0.4)

Evidence required by respondent (continued …)	No. (%) of respondents
Source of evidence	*33 (14.0)*
Personal experience	11 (4.6)
Own evaluation of literature	2 (0.9)
Another farmer	3 (1.3)
Vet	3 (1.3)
Further explanation	7 (3.0)
Any evidence and or that provided	6 (2.6)
Common sense	1 (0.4)
Level of evidence required	*59 (25.1)*
None or nothing	29 (12.3)
Would not stop trimming	15 (6.4)
Not possible or practical to stop	4 (1.7)
Unlikely to change	1 (0.4)
Unlikely to find evidence	1 (0.4)
Compelling	1 (0.4)
Don't know	8 (3.4)
Other	*10 (4.3)*
A good alternative	3 (1.3)
But it is part of a routine health check	1 (0.4)
Silly question	2 (0.9)
Routinely check all feet and trim if required only	3 (1.3)
But decades of evidence that sheep, cows and horses all require routine foot trimming	1 (0.4)

No. = number; % = percentage

5.3.7.1 Summary of section 5.3.7

Over 70% of respondents used routine foot trimming as a method to control lameness with 42.3% trimming more than once a year. There was no difference in the period or point prevalence of lameness between those that did or did not use routine foot trimming or in the frequency of its use. However, respondents who rated routine foot trimming as '*excellent*' had a lower period and point prevalence of lameness.

As a method to control lameness, routine foot trimming was given a higher rating by pedigree farmers and respondents with smaller flocks; these farmers also trimmed more frequently. Flock size was smaller for those who routinely trimmed all ewes and farming experience greater for those who trimmed some ewes.

Respondents who did not routinely foot trim, treated ID, and ID and FR combined more frequently with antibacterials. Those that trimmed >twice a year treated FR more frequently with antibacterials.

Reasons for practising routine foot trimming were primarily to prevent disease, lameness and/or associated problems, to inspect feet, identify and correct potential foot problems and to reshape and or reduce overgrowth. In general, they believed that the prevalence of lameness and disease would increase, that horn would grow unchecked and misshapen or damaged hooves would occur if they stopped routine trimming. Conversely, those that had stopped routine trimming believed no benefit was gained, thought foot trimming increased lameness and/or alternative lameness management practices were more effective.

Farmers that had: commercial flocks; larger flocks; caught sheep for inspection at locomotion score ≥2; a higher prevalence of lameness and that '*sometimes*' treated FR with antibacterials were more likely to consider stopping routine trimming.

Evidence required by farmers to change foot trimming behaviour covered a variety of factors and included: large, lengthy studies on more than one farm that included details of soil type, geography, climate, intensive and extensive farms and sheep breed.

5.3.8 Multivariate analysis

Multivariate analysis was used to explore the data on farmer attitudes using dimension reduction techniques. The techniques used are described in detail on pages 194-197 and a recapitulation of the methods provided here. Principle component analysis (PCA) was used to investigate the underlying structure within the VAS data and the number of components to retain was assessed using a combination of four methods: Cattell's scree test; the Kaiser criterion along with assessment of the loadings; the percentage of variance criterion (Hair *et al*., 2009); and parallel analysis (O'Connor, 2000). Procrustes rotation analysis was used to determine the best of three alternative substitutes for missing VAS values based on the dataset (Marshall Brown *et al*., 2012); the mean, the median and 49 (the mid-point of the VAS scale). PCA was re-run and the reduced components compared with the period prevalence of lameness. Canonical variates analysis (CVA) was used to examine the ratio of between-group to within-group variation of the VAS attitude data by low (≤2.0%), medium (>2.0 and <7.0%) and high (≥7.0%) period prevalence's of lameness. CVA was then repeated for VAS attitude data by the five frequency categories for prompt treatment of lame sheep with antibacterials for: ID; FR; and ID and FR combined.

Kaiser's criterion (Table 110), the scree test (Figure 38), percentage of variance criterion (Table 76) and parallel analysis for PCA (Figure 39) suggested retention of 6, 3, 6 and 4 components respectively.

Table 110: Principal component analysis: component eigenvalues and the % of variance explained by each component. The cut off points for Kaiser's and the percentage of variance for social science criterion are highlighted.

Component	Eigenvalue	% of Variance	Cumulative %
1	4.34	24.13	24.13
2	2.25	12.51	36.64
3	1.35	7.51	44.15
4	1.19	6.60	50.75
5	1.18	6.55	57.30
6	**<u>1.03</u>**	5.73	**<u>63.03</u>**
7	0.88	4.89	67.92
8	0.84	4.65	72.58
9	0.77	4.28	76.85
10	0.69	3.83	80.68
11	0.68	3.80	84.48
12	0.57	3.17	87.65
13	0.53	2.92	90.58
14	0.45	2.49	93.07
15	0.42	2.32	95.39
16	0.35	1.94	97.33
17	0.28	1.57	98.90
18	0.20	1.10	100.00

Figure 38: Scree test screeplot for the correlation matrix of respondents' attitudes from the 18 visual analogue scales

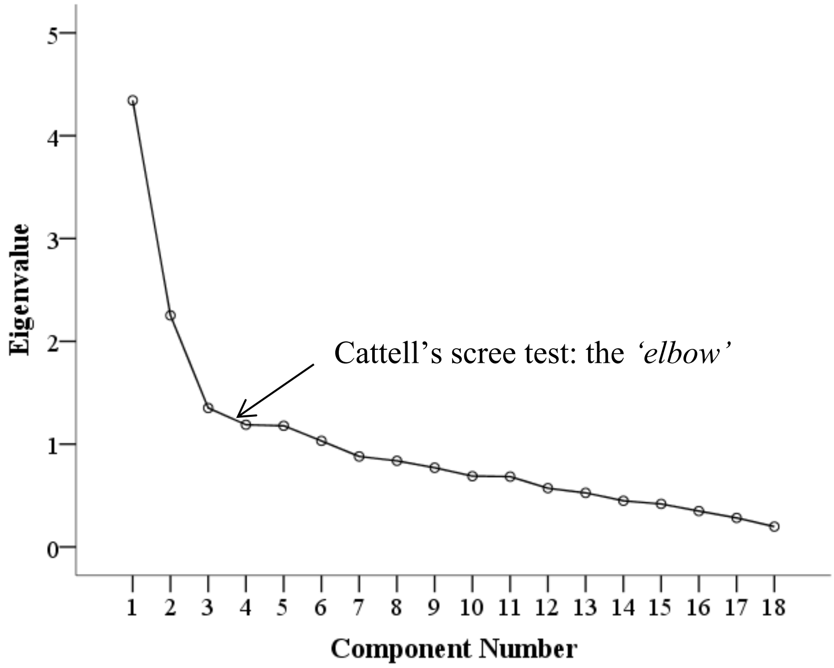
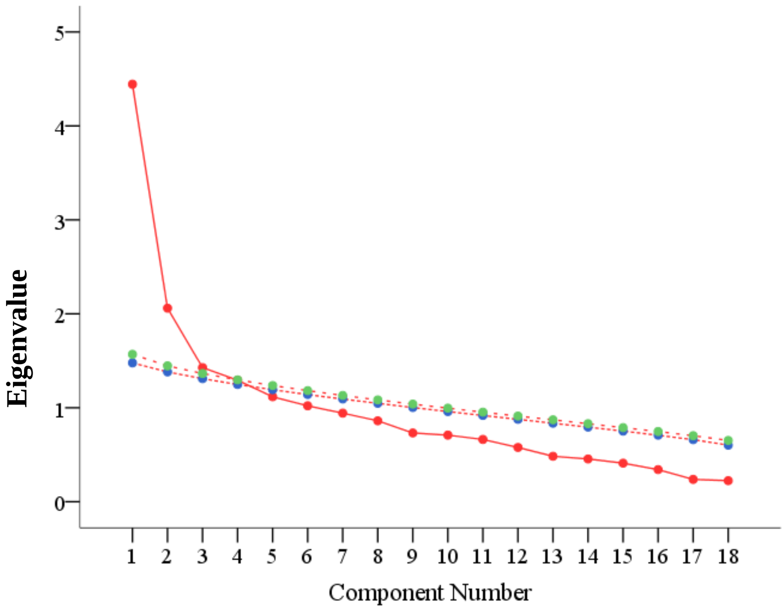


Figure 39: Parallel analysis screeplot for a Principal Component Analysis: The eigenvalues of the original data (red) with the mean (blue) and 95th percentile (green) of eigenvalues for 5000 datasets of data generated from simulations of the original data are plotted for each component.



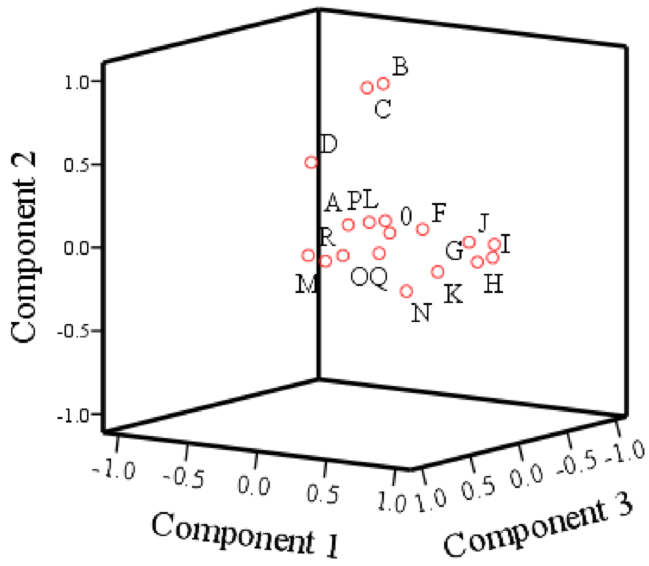
To retain maximal useful variation for an accurate estimation of the effect of different values for missing observations, 6 components were retained which explained 63.03% of the variance (Table 110). The component loadings and PCA plot using a correlation matrix and varimax rotation is shown in Table 111, Figure 40. Loadings greater than 0.5 for each component are highlighted and help to define a meaning for each of the components: Component 1 = "*practical obstacles*", component 2 = "*farmer sensitivity*", component 3 = "*pride*", component 4 = "*sheep productivity*", component 5 = "*balancing perceived risk*" and component 6 = "*attitude to routine foot trimming*" and explain 24.1, 12.5, 7.5, 6.6, 6.6 and 5.7% of the variance respectively (Table 110, above).

Table 111: Component loadings for Principal Component Analysis: raw data

Variable	Component					
	1	**2**	**3**	**4**	**5**	**6**
Lack of an assistant	**0.89**	-0.02	0.03	0.03	0.02	-0.05
Lack of a trained dog	**0.84**	0.01	0.00	0.01	0.11	-0.18
Distance to handling facilities	**0.79**	-0.07	0.06	-0.05	-0.06	0.03
Difficulty catching in field	**0.65**	0.06	-0.08	0.04	-0.22	-0.01
Lack of time	**0.61**	-0.10	-0.02	-0.17	0.11	0.33
Require >1 lame ewe / group	**0.44**	-0.15	0.08	-0.06	-0.34	0.20
Difficulty identifying in field	**0.44**	0.15	-0.06	0.01	-0.21	0.22
Relieve pain	0.08	**0.92**	-0.03	0.03	0.03	-0.11
Improve welfare	-0.02	**0.91**	-0.01	-0.03	0.01	0.02
Reduce disease transmission	-0.15	**0.44**	0.36	-0.05	0.08	0.28
Importance of public location	0.08	-0.09	**0.86**	0.02	-0.05	-0.21
Improve profit	-0.05	0.10	**0.73**	0.03	-0.04	0.09
Belief in scale of productivity loss	0.06	-0.09	0.13	**0.83**	0.19	0.35
Believes lameness a minor problem	-0.09	0.08	-0.07	**0.75**	-0.17	-0.24
Reluctance to treat at tupping	-0.09	-0.06	0.06	-0.07	**-0.74**	0.16
Reluctance to treat when pregnant	0.05	-0.03	-0.12	0.13	**-0.66**	-0.11
Provision of individual treatment	0.10	0.01	0.11	-0.05	**-0.55**	0.01
Likely to stop routine trimming	0.01	-0.03	-0.07	0.04	-0.12	**0.82**

The Kaiser-Meyer-Olkin measure of sampling adequacy for the raw data was 0.80, considered 'good' (Kaiser, 1970). As expected, Pearson's correlation tests showed no significant correlations between the 6 components ($p > 0.1$).

Figure 40: Principal component analysis with 6 components retained: raw data.



Symbol	Attitude description
A	Improve profit
B	Relieve pain
C	Improve welfare
D	Reduce disease transmission
E	Importance of public location
F	Difficulty with identification in the field
G	Difficulty catching in the field
H	Distance from handling facilities
I	Lack of an assistant
J	Lack of a trained dog
K	Lack of time
L	Belief that lameness is a minor problem
M	Belief in scale of productivity loss
N	Requires >1 ewe to be lame in a group
O	Reluctance to treat during tupping
P	Reluctance to treat when heavily pregnant
Q	Provision of individual treatment to lame sheep
R	Likelihood of stopping routine foot trimming

Procrustes sums of squares residuals for configurations that used the mean, median and middle values as estimates compared with the original raw data were 0.2515, 0.0452 and 0.0356 respectively. The smallest sums of squares residual (error) was produced when 49, the middle VAS value was used for all missing VAS observations. Missing observations from VAS data were therefore coded as 49 for subsequent analysis. The PCA was re-run using all 449 observations. Loadings greater than 0.45 for each component are highlighted (Table 112) and were again used to re-define a meaning for each component: Component 1 = "*obstacles*", component 2 = "*farmer sensitivity*", component 3 = "*profit*", component 4 = "*productivity*", component 5 = "*balancing perceived risk*" and component 6 = "*attitude to routine foot trimming*" and explained 62.9% of the total variance (24.3, 12.3, 7.3, 6.9, 6.4 and 5.8% respectively).

Table 112: Component loadings for Principal Component Analysis: For 449 observations, with missing observations coded as VAS mid-value (49).

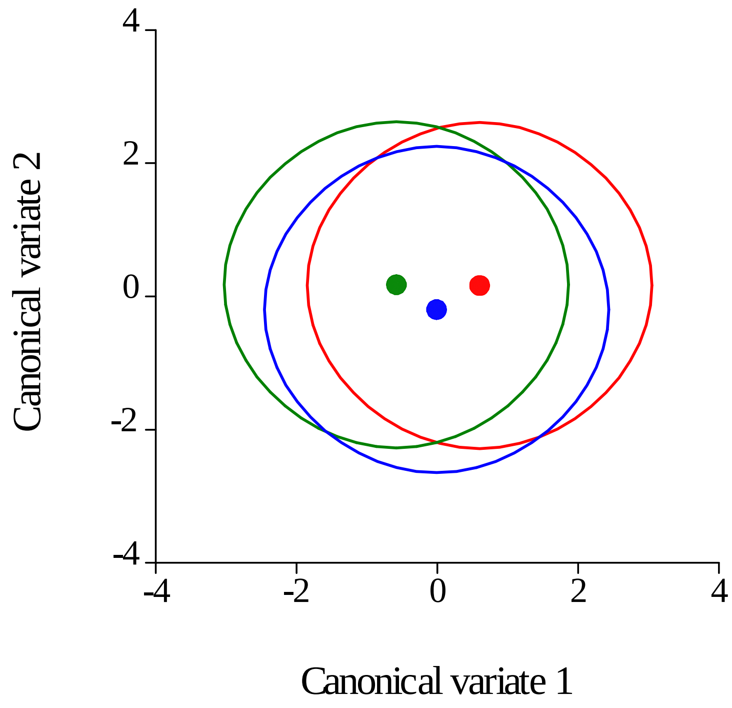
Variable	Component					
	1	**2**	**3**	**4**	**5**	**6**
Lack of an assistant	**0.79**	0.11	-0.16	0.01	-0.10	0.24
Distance from handling facilities	**0.78**	0.19	-0.08	-0.01	-0.19	0.07
Difficulty catching in field	**0.69**	0.16	-0.22	0.09	-0.20	-0.04
Lack of time	**0.69**	0.17	0.05	-0.15	-0.21	-0.10
Requires >1 ewe lame / group	**0.68**	0.09	0.20	0.04	0.07	-0.08
Lack of a trained dog	**0.64**	0.07	-0.24	-0.07	-0.06	0.35
Difficulty identifying in field	**0.54**	0.25	-0.11	-0.04	-0.09	-0.21
Provision of individual treatment	**0.47**	0.05	0.24	0.00	0.36	0.12
Relieve pain	-0.35	**0.73**	-0.42	0.07	0.04	-0.02
Improve welfare	-0.36	**0.73**	-0.40	0.05	0.05	-0.08
Reduce disease transmission	-0.38	**0.61**	0.09	-0.18	0.11	-0.09
Improve profit	-0.11	**0.55**	**0.51**	-0.11	-0.05	0.17
Believes lameness a minor problem	-0.19	0.06	0.03	**0.73**	-0.22	0.34
Belief in scale of productivity loss	-0.10	0.23	0.39	**0.55**	-0.41	-0.13
Reluctant to treat when pregnant	0.30	0.05	-0.18	0.41	**0.57**	-0.07
Reluctant to treat at tupping	0.41	0.07	0.17	0.33	**0.53**	-0.15
Likely to stop foot trimming	0.32	0.23	0.31	-0.04	-0.09	**-0.58**
Importance of public location	0.01	0.42	0.40	-0.22	0.16	**0.49**

The period prevalence of lameness was significantly ($p < 0.01$) positively correlated with the components "*obstacles*" and "*balancing perceived risk"* and significantly negatively correlated with the component "*productivity*". It was also significantly ($p = 0.05$) negatively correlated with the component "*attitude to routine foot trimming"* (Rho = 0.19, 0.15, -0.18, -0.10 respectively).

Biplots were used to gain a better insight into the structure of the data. Results are not included within the thesis because to be informative, each biplot required dismantling into separate plots for each response category. Consequently, biplots were used to inform the decision for subsequent analysis: canonical variates analysis.

Canonical variates analysis of the 18 VAS attitude data showed that there was very little separation in farmer attitudes by categories of low (≤2.0%), medium (>2 and ≤6.0%) and high (>6.0%) period prevalence of lameness (Figure 41). Eigenvalues for canonical variate 1 and 2 were significantly less than one (0.190 and 0.034 respectively) and showed that there was substantially more within-group variation than between-group variation. Canonical variate 1 and 2 explained 84.9% and 15.1% of the variance respectively. The loadings of latent vectors for canonical variate 1 were highest for respondent attitudes to: whether lameness was considered a minor problem, reducing pain and individual treatment (-0.027, -0.017 and 0.015). For canonical variate 2 loadings were highest for attitudes to: reducing pain, distance to handling facilities and improving welfare (-0.032,-0.024 and 0.020).

Figure 41: Canonical variate plot: Farmer attitudes towards management of lameness in their flock by low (green), medium (blue) and high (red) period prevalence of lameness



Inner circle = means; outer circle = 95% CI for populations

Further exploration showed that the small amount of variation between farmers with low, medium and high categories of period prevalence of lameness groups was predominantly due to farmer attitudes to barriers rather than motivators for treatment of lameness (Figure 42 and Figure 43).

Eigenvalues for motivators for canonical variate 1 and 2 were 0.015 and 0.007 and accounted for 68.5% and 31.5% of the variance respectively. Loadings for canonical variate 1 were highest for respondents attitudes to productivity (0.031), followed by welfare (-0.025), transmission (0.021) and pain (0.018). Loadings for canonical variate 2 were highest for respondents attitudes to pain (0.067), followed by welfare (-0.027), profit (0.016) and transmission (-0.013) (Figure 42).

Eigenvalues for barriers for canonical variate 1 and 2 were 0.081 and 0.022 and accounted for 78.3% and 21.7% of the variance respectively. Loadings for canonical variate 1 were highest for respondents attitudes to individual treatments (0.019), followed by lack of time (0.017), lack of an assistant (-0.014), waiting for more than one individual to be lame in a group (0.013) and reluctance to treat heavily pregnant ewes (0.013). Loadings for canonical variate 2 were highest for respondents attitudes to distance to handling facilities (-0.029), followed by lack of time (0.023), difficulty identifying individual animals (-0.015), lack of a dog (0.013) and reluctance to treat heavily pregnant ewes (0.012) (Figure 43).

Figure 42: Canonical variate plot: farmer attitudes to motivators for management of lameness in their flock by low (green), medium (blue) and high (red) period prevalence of lameness

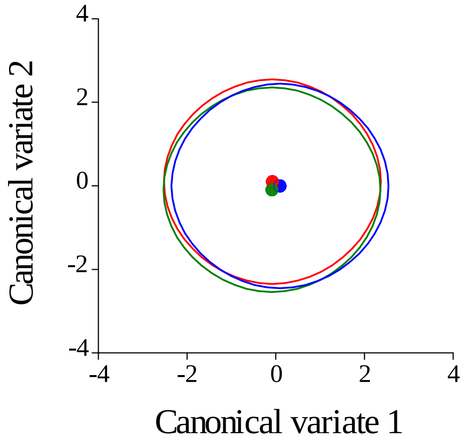


Figure 43: Canonical variate plot: farmer attitudes to obstacles for management of lameness in their flock by low (green), medium (blue) and high (red) period prevalence of lameness

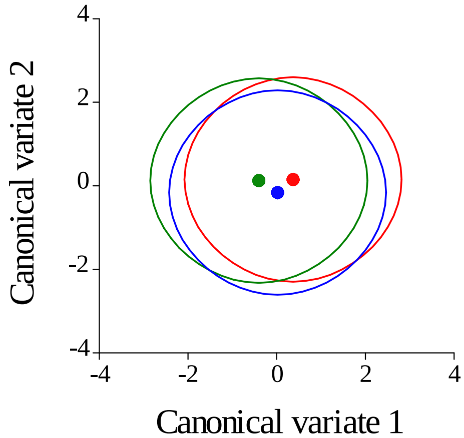
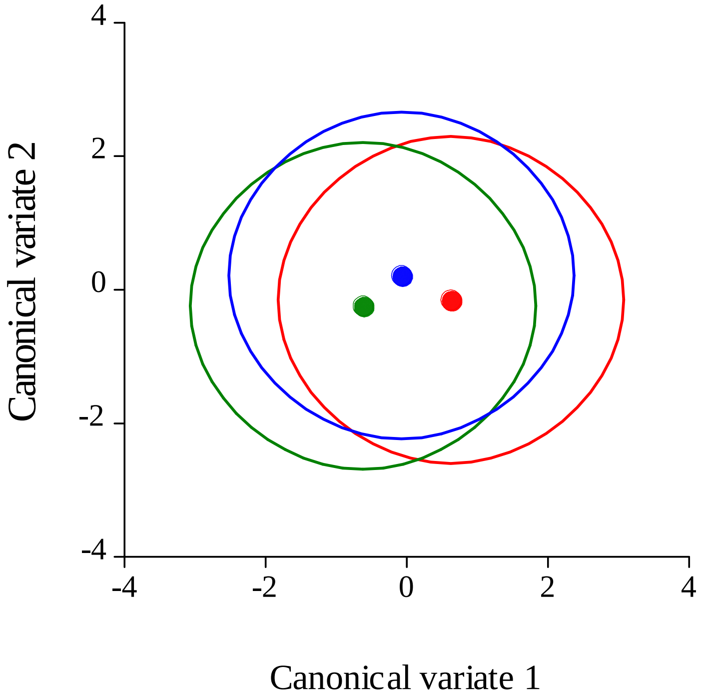


Figure 42and Figure 43: Inner circle = means; outer circle = 95% CI for populations

The analysis was re-run for respondents that had commercial lowland flocks. Eigenvalues for canonical variate 1 and 2 were again significantly less than one (0.240 and 0.073 respectively) (Figure 44) and 2 explained 76.7% and 23.3% of the variance respectively. The loadings of latent vectors for variate 1 were highest for respondent attitudes to: pain, individual treatment, whether lameness was considered a minor problem and welfare (-0.050, -0.024, 0.022 and 0.017). The loadings of latent vectors for variate 2 were highest for respondent attitudes to: pain, time, individual treatment and waiting for more than one individual to be lame (0.029, -0.025, -0.019 and 0.017).

Figure 44: Canonical variate plot: Commercial lowland farmer attitudes to management of lameness in their flock by low (green), medium (blue) and high (red) period prevalence of lameness



Inner circle = means; outer circle = 95% CI for populations

Examination of attitudes towards motivators gave latent roots of 0.055 and 0.014 with 79.5% and 20.5% of the variance explained by canonical variate 1 and 2 respectively. Loadings on variate 1 were highest for respondents attitudes to pain (-0.081) and welfare (0.029) and for variate 2: belief in the scale of productivity loss (0.033) and transmission (0.014) (Figure 45).

The eigenvalues for the barriers for commercial lowland farmers were 0.090 and 0.05 with 65.4% and 34.6% of the variance explained by canonical variate 1 and 2 respectively (Figure 46). Loadings for variate 1 were highest for respondent attitudes to: individual treatments (0.031), lack of time (0.021) and reluctance to treat heavily pregnant lame ewes (0.011). For variate 2 loadings were highest for respondent attitudes to: lack of time (0.023), waiting for more than one animal to be lame (-0.022), reluctance to treat heavily pregnant ewes (-0.014) and provision of individual treatments (0.014).

Figure 45: Canonical variate plot: Commercial lowland farmer attitudes to motivators for management of lameness in their flock by low (green), medium (blue) and high (red) period prevalence of lameness

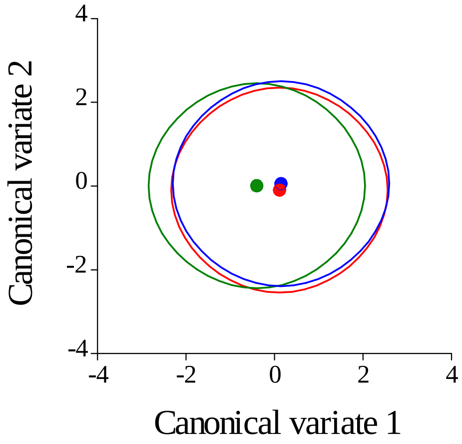


Figure 46: Canonical variate plot: Commercial lowland farmer attitudes to barriers for management of lameness in their flock by low (green), medium (blue) and high (red) period prevalence of lameness

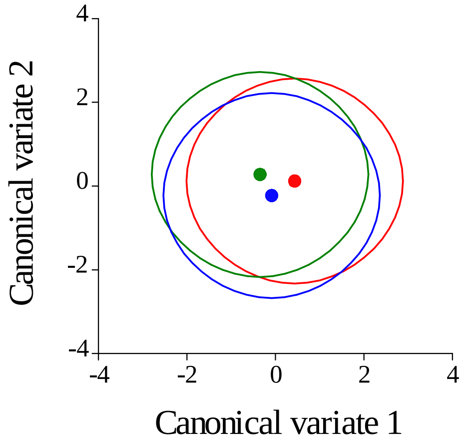
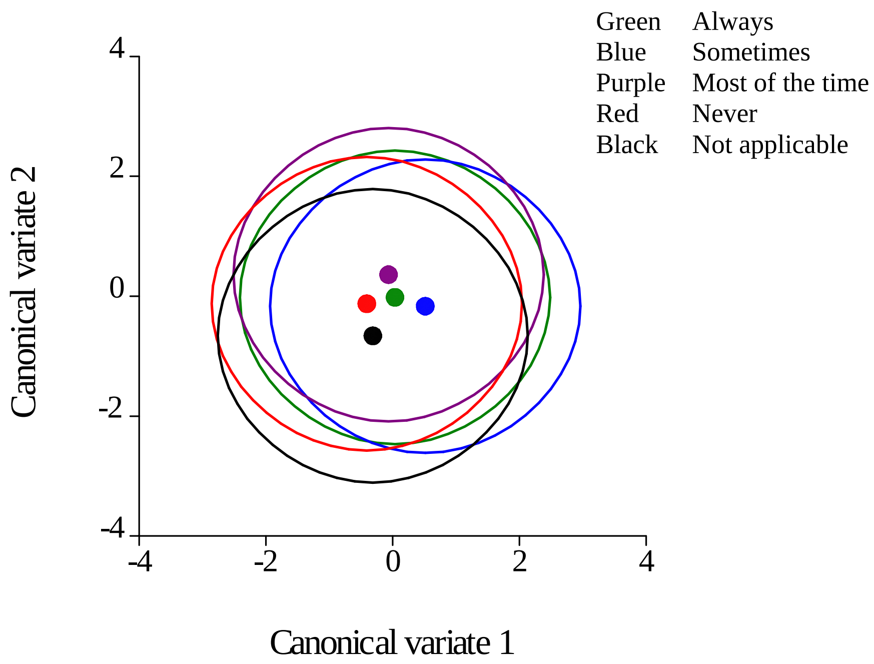


Figure 45 and Figure 46: Inner circle = means; outer circle = 95% CI for populations

Canonical variate plots of the VAS attitude variables by frequency categories for the management of ID, FR and both diseases combined are given for all respondents (Figure 47 - Figure 49). Eigenvalues for all three analyses were substantially <1 and again showed that there was greater variation within-groups than between-groups (Table 113).

Figure 47: Canonical variate plot: Farmer attitudes towards management of lameness in their flock by categories of frequency of treatment of ewes lame with interdigital dermatitis within 3 days with topical and parenteral antibacterials



Inner circle = means; outer circle = 95% CI for populations

Figure 48: Canonical variate plot: Farmer attitudes towards management of lameness in their flock by categories of frequency of treatment of ewes lame with footrot within 3 days with topical and parenteral antibacterials

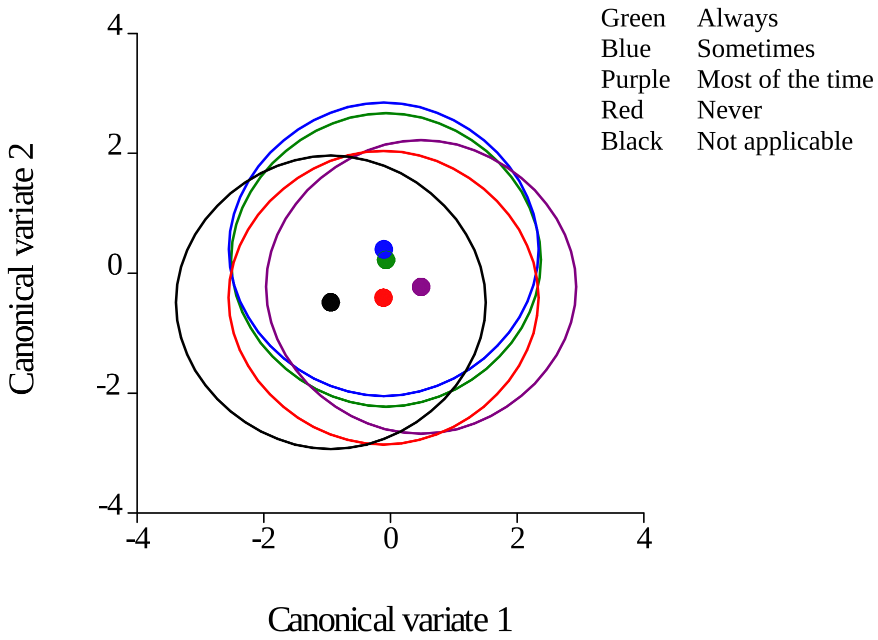


Figure 49: Canonical variate plot: Farmer attitudes towards management of lameness in their flock by categories of frequency of treatment of ewes lame with interdigital dermatitis and footrot combined within 3 days with topical and parenteral antibacterials

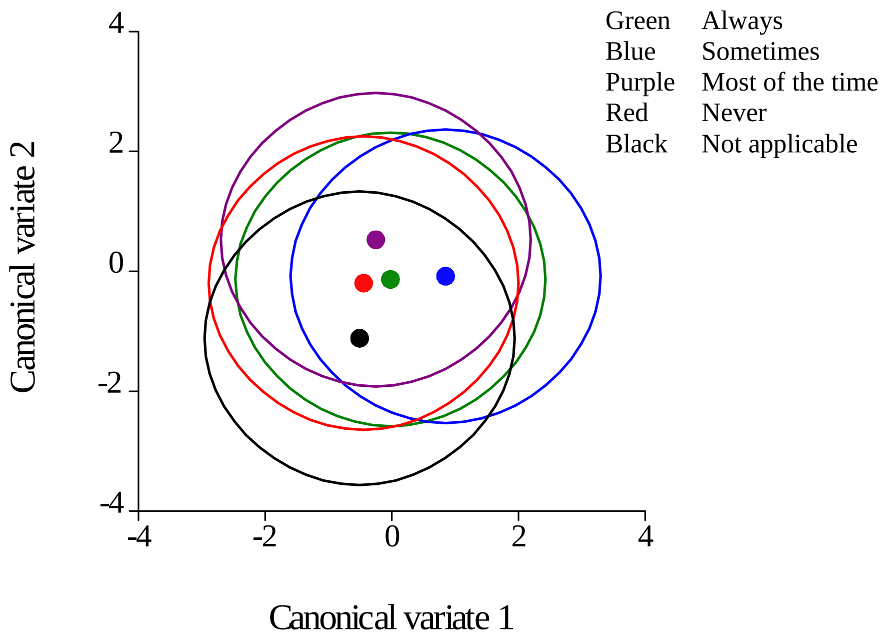


Figure 48 and Figure 49: Inner circle = means; outer circle = 95% CI for populations

Table 113: Canonical Variate Analysis output of 449 respondents' attitudes toward management of lameness in their flock by the frequency of prompt treatment of lame sheep with antibacterials for ID, FR and both diseases combined.

Management of:	**Canonical variate**			
	Eigenvalue (% variation)			
	1	**2**	**3**	**4**
ID	0.097 (36.6%)	0.088 (33.1%)	0.047 (17.6%)	0.034 (12.7%)
FR	0.159 (44.6%)	0.108 (30.4%)	0.048 (13.5%)	0.041 (11.5%)
Both	0.237 (41.6%)	0.198 (34.7%)	0.079 (13.9%)	0.056 (9.9%)

The attitudes that contributed most to the variation in management of ID (*i.e.* the loadings) for variate 1 were: reducing pain (-0.033), difficulty catching (-0.023), improving welfare (-0.020) and distance to handling facilities (0.019). For variate 2 loadings were highest for attitudes to: improving welfare (-0.032), reducing transmission (0.019), provision of individual treatment (0.019) and distance to handling facilities (-0.015) (Figure 47).

The attitudes that contributed most to the variation in management of FR (*i.e.* the loadings) for variate 1 were: improving welfare (-0.036), reducing pain (0.024), considering lameness a minor problem (-0.019), provision of individual treatment (0.015) and waiting for more than one animal to be lame (0.012). For variate 2 loadings were highest for attitudes to: reducing pain (-0.035), reducing transmission (0.030), improving welfare (0.021), distance to handling facilities (0.018) and difficulty catching (-0.017) (Figure 48).

The attitudes that contributed most to the variation in management of both ID and FR combined (*i.e.* the loadings) for variate 1were: reducing pain (-0.045), improving welfare (0.036), reducing transmission (0.022) and distance to handling facilities (0.020). For variate 2 loadings were highest for attitudes to: improving welfare (-0.044) and provision of individual treatment (0.021) (Figure 49).

5.3.8.1 Summary of section 5.3.8

There was very little separation of farmer attitudes by categories of low, medium and high period prevalence's of lameness. Barriers gave slightly greater separation than motivators but no dominate attitudes emerged.

5.4 Discussion

5.4.1 Implications of research

This study highlights the large variation within sheep farmers' attitudes towards the management of lameness in sheep and the difficulties in attempts to distinguish key motivators and barriers to the prompt treatment of lame individual animals. Farmers' decisions are influenced by a variety of factors (Edwards-Jones, 2006) and motivation to change may be influenced by a broad variety of advantages (McKenzie-Mohr and Smith, 1999). This may help to explain the lack of variation in the motivators and barriers to treatment of lame sheep between high, medium and low prevalences of lameness.

In this study, perceptions of pain and welfare emerged as motivators that were more important than profit or productivity to sheep farmers. This is similar to findings of the qualitative study (chapter 4) but also of those of Leach *et al.* (2010b) in dairy cattle in which monetary motivators were not as important as pride in a healthy herd or empathy for pain and suffering of lame individuals.

From the qualitative interviews (Chapter 4) it was clear that although the majority of sheep farmers believed that lameness resulted in lost performance, and therefore financial loss, they were not able to quantify this loss due to ineffective flock record keeping and fluctuating market prices. Farmers were more motivated to act when dramatic and visual financial losses were seen *i.e.* mastitis and fly strike. Indeed, in the control of mastitis for dairy cows farmers financial and welfare advantages are equally motivating (Valeeva *et al*., 2007) probably because the financial impact of high somatic cell count is immediately obvious.

One explanation for empathy motivators yielding higher VAS scores than financial motivators in the current study may be that sheep farmers are not aware of (or perhaps do not believe) the scale of productivity lost through lameness because they do not have the records to assess it. Footrot is estimated to cost the sheep industry >£24 million each year and a study by Wassink *et al*. (2010b) estimated an increased profit of £6.30 per ewe for a reduction in prevalence of 6 to 2%; despite the increased costs of treating lame ewes (labour and treatment). This research has been publicised to the industry through EBLEX and UK Vet: Livestock relatively recently (EBLEX, 2008a; Green *et al*., 2008; 2009) but knowledge transfer may not yet have filtered down to those vets that are predominantly small animal and a proportion of sheep farmers. Alternatively, financial reward *cf.* non-financial rewards may simply not be as motivating for some farmers; possibly because of the shielding effect of the SPS subsidy and/or varying market prices. Certainly, in this study farmers with larger flock sizes were more motivated by productivity and profit, an observation also seen by Leach *et al*. (2010b) with lameness in dairy cattle. A further study by Austin *et al*. (2005) reported that Scottish sheep and pig farmers attitudes to animal welfare were divided between those motivated by welfare and those motivated by business. Sheep farmers were less business orientated than their pig counterparts (Austin *et al*., 2005) and this offers support to the hypothesis that subsidised industries may be less motivated by financial gain.

In the current study, motivation to reduce transmission of disease also received a higher VAS score than financial motivators a trend not seen in the interviews. In contrast, in interviews, farmers with farms under the gaze of the public eye reported public observation an important motivating factor. However, with a median VAS score of 50 (*i.e.* not important) the importance of this motivator was less apparent in the quantitative study. The wide range in VAS scores for motivation to treat lame sheep when in proximity to a public location (IQR: 8.0–92.0) may be attributed to the farm setting *i.e.*, farmers without close interaction with the public being less motivated by this theme. The fact that non-financial incentives generally received higher scores than financial ones needs to be recognised when designing strategies to encourage farmers to reduce lameness in sheep flocks. To be effective to the majority of farmers a strategy will need to embrace a mix of incentives.

Barriers to the treatment of lame sheep explained most of the separation observed within high, medium and low prevalences of lameness in CVA. This is an important concept and should be understood in any strategy to encourage the reduction of lameness. Never treating individuals, lack of time, reluctance to treat heavily pregnant ewes, waiting for more than one individual to be lame and lack of an assistant gave the highest loadings. Lack of time and labour shortages are concepts in interviews that were perceived to be out of the control of the farmer and are unsurprising considering the trend for reduction of agricultural labour on farms (DEFRA, 2010). In the univariate analysis all the obstacles were correlated with an increased prevalence of lameness as well as catching at higher locomotion scores and this requires further investigation to establish cause and effect. It may be that farmers with low prevalences of lameness do not have these barriers or have overcome them; further research is therefore required. If these barriers do in fact lead to a higher prevalence of lameness, this may be important when communicating new technologies on lameness control to farmers. The increased IQR of VAS scores for barriers generally, compared with the motivators (except public location), indicate that barriers may be more problematic for some farmers than others. Reluctance to treat lame ewes when heavily pregnant (a theme that emerged from the interviews) scored highly and the author recommends that this be addressed in any strategy because legislation (Welfare of Farmed Animals (England) Regulations 2007) requires that these animals receive appropriate care without delay. The evidence suggests this reluctance may be unwarranted with careful gathering (Wassink *et al*., 2010a).

Barriers to the prompt treatment of individuals with topical and parenteral antibacterials (*i.e.* current industry recommended treatment for ID and FR) from CVA analysis were highest for difficulty catching mildly lame individuals in the field, and distance from handling facilities; the former perhaps explains why they were also associated with never catching individuals. The difference in relative loadings of barriers (*i.e.* the differences in their importance) between CVA for prevalence of lameness and frequency of treatment with antibacterials highlights that a breadth of barriers needs to be addressed within lameness control strategies.

5.4.2 The value of a qualitative study to support a quantitative study

The interviews from Chapter 4 were used to inform and guide construction of the questionnaire to enable quantitative exploration of sheep farmers' attitudes and beliefs towards management of lameness in sheep from the farmers' perspective. Whilst it was acknowledged in Chapter 4 that there may be further opinion not expressed by farmers interviewed, although the interview process was stopped when saturation was reached (Rubin and Rubin, 2005), using this strategy ensured the study concentrated on material relevant to the farmers' point of view. This combination of qualitative then quantitative methodologies was used by Kauppinen *et al*. (2010) to study Finnish pig and dairy farmers' attitudes towards animal welfare. The authors considered this coupling a successful pairing because the qualitative interviews revealed themes not previously identified in the literature, and additionally provided validity and explanation for the quantitative findings. In the current study, reluctance to treat heavily pregnant lame ewes was a theme identified in the qualitative study that would not have been incorporated in the quantitative study otherwise and which subsequently materialised as one of the more dominant barriers. It adds weight to the usefulness of coupling a qualitative approach prior to and in conjunction with a quantitative study.

5.4.2.1 Associations with previous research on lameness in sheep

The median period prevalence of lameness in this study was 5.0, substantially lower than the 8-10% reported by earlier studies (Grogono-Thomas and Johnston, 1997; Kaler and Green, 2008a). Farmers' assessments of the prevalence of lameness are reasonably accurate and reliable (King and Green, 2011) and therefore it is unlikely that the difference in prevalence estimates reported between studies is caused by reporting error. There could be three possible explanations for the lower figure. Firstly, respondents may find it difficult to accurately provide period prevalence, particularly one over a long period of time. The questionnaire was targeted at farmers during autumn/winter, a period when the prevalence of lameness in sheep flock is reported to be at its lowest (Wassink *et al*., 2004). Consequently, respondent's estimates may have been affected by recall bias that may have resulted in a lower estimate than the actual situation. The current study survey was posted in November, similar to the 1994 Grogono-Thomas and Johnston (1997) survey posted in October. In comparison, the 2004 Kaler and Green (2008a) survey was posted in March, a period when the prevalence of lameness in sheep flocks is increasing (Wassink *et al*., 2004). It is therefore possible that the lower prevalences of lameness reported in the current and 1994 study (5.0 and 8.0 *cf.* 10.4%) may in part be attributed to recall bias. Secondly, in recent years there has been a considerable effort by the English sheep industry to give impact to research outcomes that have reduced lameness in sheep. The lower prevalence of lameness could be the result of successful knowledge transfer. Studies carried out by Wassink *et al*. (2010b) and King and Green (2011) of 161 and 35 sheep farmers respectively, both reported a 2006 and 2008 period prevalence of lameness in ewes of 5.0% (IQR: 3-10 and 4-10% respectively). Both these authors attributed their lower mean prevalence (*cf.* the previous reported national average) to their method of participant selection, amenable farmers interested in reducing lameness. These studies coupled with results of this stratified random postal survey suggest that the national prevalence of lameness is in fact decreasing. Finally, the annual weather summary for England in 2011 to April 2012 showed above average temperatures with several counties experiencing their driest on record (Met Office, 2012). Consequently the weather during periods of data collection may have contributed to the reduced prevalence of lameness. Support is lent to the latter two explanations by the low point prevalence of lameness and good correlation between respondent's period and point prevalence of lameness. The point prevalence was significantly lower than the period prevalence of lameness (5.0 *cf.* 2.2%) and this is almost certainly due to the season (winter). Furthermore, notwithstanding a short period and the effect of regional weather and husbandry practices differences, there was no evidence that the point prevalence varied between November 2011 and April 2012. This supports the theory that the reduction could be due to effective knowledge transfer; or alternatively that farmers may now be more reluctant to admit higher prevalences of lameness.

Eighty-nine percent of farmers recognised sheep with locomotion score 2 as lame; with similar proportions of farmers reporting lame sheep at locomotion score < and >2 (30.0% *cf.* 27.5%). These findings are congruent with King and Green (2011) and Kaler and Green (2008b) in which 100% and 90% of farmer's recognised locomotion score 2 as lame respectively. The larger sample size used in the Kaler and Green (2008b) compared with the King and Green (2011) study (192 *cf.* 35 respondents) probably accounts for the greater agreement with the current study. In addition, also similar to the findings of King and Green (2011) and Kaler and Green (2008b), the locomotion score that farmers recognised as lame was significantly lower than that which they reported in postal surveys or caught for treatment. This quantitative study with explanation provided by the qualitative interviews (Chapter 4) now explains the reasons why farmers do not treat the mildly lame sheep that they recognise as lame. The predominant reasons are lack of time; difficulty identifying individual animals; difficulty catching mildly lame animals; lack of available assistance but also that farmers believe that mild cases of lameness may be transient and correct themselves without the need for intervention.

Both the period and point prevalence of lameness were significantly lower in pedigree flocks. One possible explanation for this may be that pedigree animals have more economic value than their commercial counterparts; with smaller flock sizes and greater flock inspections. Pedigree farmers were significantly more motivated by increased profit and reduced disease transmission. In general they also considered obstacles significantly less of a hindrance to the prompt treatment of lame individuals. It may be important to consider that the 'worth' of commercial individuals, and perhaps therefore farmer attitudes, may fluctuate with live weight price markets and this should be borne in mind when framing a take home message for farmers.

Respondents who always treated lame sheep with topical and parenteral antibacterials for ID, FR and both diseases combined had significantly lower prevalence of lameness compared with those treating sheep 'most of the time' or 'sometimes'. Similarly those who caught at lower locomotion scores and caught the first lame sheep in a group also had lower prevalences of lameness. These results all support the findings of previous work (Wassink *et al*., 2010a; 2010b; Green *et al*., 2007a; Kaler and Green, 2008b; Kaler *et al*., 2010a; 2010b; Kaler *et al*., 2011). However, farmers who stated 'never' or 'not applicable' to the treatment of cases of ID, FR and both diseases combined with parenteral and topical antibacterials also had significantly lower prevalences of lameness compared with ‘most of the time’ and ‘sometimes’. In addition those that stated ‘not applicable’ frequently had lower prevalences of lameness than those who stated ‘always’. There may be three reasons for this observation. Within the analysis, farmers who stated ‘not applicable’ were also farmers that were positively associated with the provision of individual treatments to lame sheep and the provision of prompt treatment to the first lame sheep seen in a group. Therefore, one obvious explanation is that prompt, individual treatment (even if not the industry recommended treatment) of lame sheep reduces the prevalence of lameness because ID and FR are transmissible (Beveridge, 1941; Roberts and Egerton, 1969; Parsonson *et al*., 1967). Secondly, not all farmers will have FR on their farm. This question was not asked in the questionnaire and perhaps some of this difference relates to farmers that do not have FR in their flock. Thirdly, there may be alternative treatments for ID and FR that are as effective as the current industry recommended treated *i.e.* prompt treatment with topical and parenteral antibacterials. There are few clinical trials on management practices used by farmers to control lameness in sheep (though risk factors have been identified from observational studies). It is plausible that alternative highly effective practices exist. This interesting finding requires further analysis omitting farmers with zero levels of lameness (*i.e.* no lameness therefore no treatment) and a follow-up study.

Over 35% of respondents treated lame sheep with ID and FR differently, with significantly more respondents never treating ID with topical and parenteral antibacterials compared with FR. In addition, for those that used antibacterials, they treated ID significantly less frequently. There are two possible reasons for this. Firstly perhaps some of this difference could relate to farmers that do not have FR in their flock. Secondly, it could be an indication of an education gap in part of the sheep farming community. Farmers may not be aware of the link in aetiology between ID and FR or may not perceive ID to be painful (or even as painful as FR). In this study, farmers were less motivated to treat ID to relieve pain than FR. It perhaps suggests that better education is needed about the link in aetiology between ID and FR and also that ID is painful (Ley *et al*., 1989; 1994).

Educational events on lameness were attended by respondents who had higher levels of lameness, a finding consistent with that of Wassink *et al*. (2010b). In addition, respondents that made changes after attending these events had a significantly higher prevalence of lameness and this suggests that farmers are using educational events for advice. Most events were organised by vets (72.2%) and EBLEX (42.6%) and this perhaps indicates that these two sources are farmers' preferred social referents. This theory is supported by the findings of the qualitative interviews and also by Wassink *et al.* (2010b) who reported that sheep farmers' ideal source of information, in decreasing order, was veterinary consultation, DEFRA and EBLEX.

However, in the current study, the scope and frequency of veterinary involvement in flocks was generally very limited with vets primarily used to access medicinal products and/or advice. Furthermore, 8% of farmers did not use or did not have a vet and these farmers did not have a significantly higher prevalence of lameness than those with a vet. There was however a distinct trend for respondents with a higher prevalence of lameness to contact their vet more frequently; this trend was also seen with increasing flock size. These results suggest that farmers use vets when the need arises and additionally implies that there is an economic element to lack of veterinary involvement in flocks.

The VAS was used because it has greater sensitivity (Scott and Huskisson, 1976) and captures greater variation than a Likert scale (Hasson and Arnetz, 2005). Indeed in the current study, there were several small variations in the median responses between categories of respondents which were statistically significant and that have biological credibility. These differences may not have been captured by categorical scales such as the Likert scales.

Gender difference in human-animal interactions are well reported (Herzog, 2007) with women having greater concern for individual animals than men, who are less humanistic and less sympathetic (Kellert and Berry, 1987; Driscoll, 1992; Eldridge and Gluck, 1996; Knight *et al*., 2004). Age has also been reported to have a determining effect on decision making in business ethics (Ruegger and King, 1992) and with farmer attitudes to animal welfare (Austin *et al*., 2005). The differences in attitudes reported by gender and age in this study may have biological significance in addition to statistical significance. In the Austin *et al*. (2005) study male and younger Scottish sheep and pig farmers were significantly more business orientated; a finding congruent with the current study. It is plausible that biological significance could also be attributed to other variables that *define* respondents, such as experience. Increased farming experience was negatively correlated with motivation to reduce pain and improve welfare; and positively correlated with never catching individuals and waiting for more than one ewe to be lame before providing treatment. It is therefore suggested that experience may reduce a farmer’s sensitivity and empathy towards his sheep or it may be an example of cognitive dissonance where belief (that lameness is painful and reduces welfare) is changed by behaviour (Festinger & Carlsmith, 1959). Interestingly, the prevalence of lameness was not correlated with years of farming experience, whereas a positive correlation might have suggested some acclimatisation and desensitisation to higher prevalences of lameness (Whay *et al*., 2002).

However the period and point prevalence of lameness were significantly lower for those farmers that checked their flocks '*today*' compared with '*yesterday*' or '*3 or more days ago*'. There are two potential explanations for this. Firstly, those that check their flock every day, may have better husbandry practices and are perhaps more likely to treat more frequently. However, in this study, there was no evidence of this, with no significant variation within the frequency of prompt treatment of lame ewes with ID, FR or combined with antibacterials by increased frequency of the last check. Secondly, perhaps recall bias led to an overestimation of the prevalence of lameness.

In this study, lowland farmers checked their flocks more frequently than upland and hill farmers and this is likely to be a consequence of legislative requirement for daily checks on lowland flocks (Welfare of Farmed Animals (England) Regulations, 2000, Schedule1, paragraph 2) and also possibly ease of access. In the qualitative study, the majority of farmers indicated that routine daily inspections of the flock were carried out first thing in the morning. However, in this study, >50% of farmers had not checked their flocks 'today'. This might indicate, converse to the qualitative study (Chapter 4), that the majority of flocks are not checked first thing. Both studies collected data in the winter/early spring.

However, farmers' early starts coupled with changes in the number of daylight hours throughout the seasons may affect when farmers can check their flocks practically. Alternatively, it may suggest that 50% of farmers consider themselves to have husbandry systems in which sheep welfare does not require frequent human attention (Welfare of Farmed Animals (England) Regulations 2007) and therefore check their flock less than daily.

5.4.2.2 Limitations of the research

5.4.2.2.1 Data

To increase efficiency and minimise error incorporated during data entry, data entry was outsourced to a local UK company who used a key and verify technique that they reported to be 99.98% accurate. The database was then additionally checked for error before analysis began. Although the questionnaires were returned to the company for re-entry following this check, the revised database was consistent with a data entry accuracy of 99.98%.

This study did not include questions addressing farmer motivation to treat lame sheep to increase farmer well-being which was identified in the qualitative questionnaire and was an oversight. Farmer well-being was identified by Kauppinen *et al*. (2010) as an important motivator to improve on farm animal welfare; though these authors added that farmers also considered this motivation the most difficult to put into practice. Although farmer well-being was not identified by Leach *et al*. (2010b) as a motivator to reduce lameness in dairy cattle these authors did identify a possible proxy for it: extra work. Of the 10 motivators they examined however, extra work was the least motivating factor. It is possible that well-being and extra work are not suitable substitutions for one another or alternatively that motivations to reduce lameness and improve welfare differ. If the latter explanation is correct sheep farmers in general may not consider farmer well-being as an important motivator. Whatever the reason, the author suggests that further studies that examine farmer motivations to reduce lameness in sheep include questions on farmer health/well-being. In addition, the design of take home messages to sheep farmers aimed at reducing lameness in flocks perhaps include an element of improved farmer well-being.

5.4.2.2.2 Visual analogue scales

The VAS is a sensitive, easily administered, quick and convenient tool that has been used to measure an extensive range of subjective phenomena. Subjective phenomena may be difficult to validate absolutely (Aitken, 1969) nonetheless the VAS is considered a valid and reliable tool for the measurement of pain, sensation and mood (Dixon and Bird, 1981; Revill *et al.*, 1976; Seymour, 1982; Scott and Huskinsson, 1979a; Scott and Huskinsson, 1979b; Luria, 1979). However, to the author's knowledge there have been no evaluations of its reliability and validity for the measurement of attitude. A key assumption from this study was that the VAS is a valid tool for collection and analysis of attitude, and this requires further research.

A further limitation of the VAS is that it may be difficult for users to understand (Huskisson, 1983; Williams *et al.*, 1988); and it has been suggested that the concept of bipolar VAS may be more difficult to appreciate than unipolar VAS (Wewers and Lowe, 1990). To facilitate respondents' comprehension of VAS within the questionnaire, VAS questions were grouped and formatted identically. This also ensured precise parallel comparison could be made between VAS questions (Wewers and Lowe, 1990). In addition, an example question and clear concise instructions were given as recommended by Price *et al*. (1983). Furthermore, a horizontal orientation was used because it has been shown to result in higher respondent completion rates and scores that are more consistent compared with vertical orientations (Scott and Huskisson, 1976). Research by Sriwatanakul *et al*. (1983) has also shown individuals to prefer horizontal over other orientations. The position of VAS descriptors has also been shown to influence the distribution of scores (Huskisson, 1983; Scott and Huskisson, 1976). Therefore to minimise bias, numeric and verbal bipolar descriptions were positioned beyond the end of VAS; additional calibration was also omitted. Completion rates for VAS questions within this study were good, comparable to that of other questions within the questionnaire, and indicate that respondents were able to comprehend VAS questions.

Lastly, a small source of error may have been introduced by the reduction in length of VAS from 100 to 98mm during production, though any error will have been moderated since all questions and questionnaires were affected equally. In a study to test the reliability and reproducibility of the VAS, Revill *et al*., (1976) reported no significant increase in the mean errors of horizontal VAS lines of 50 compared with 100mm. Consequently, although the outcome evaluated was pain and not attitude, it is suggested that any error introduced in the current study due to a 2mm reduction is perhaps negligible.

5.4.2.2.3 Generalisability of the results

Postal questionnaires are an inexpensive and popular tool for large scale data collection in veterinary epidemiology (Vaillancourt *et al*., 1991). Nonetheless a major limitation is the potential for a low response rate (O'Toole *et al*., 1986). This was a long questionnaire with 12 pages and 67 questions, many of which were open, without financial incentive or recompense and took approximately 20 minutes to complete. The address list was known to contain redundancy and a number of postcode inaccuracies were found during the analysis. A useable response rate of 46.2% was therefore good. Previous similar stratified random postal surveys on lameness in English sheep flocks have reported lower useable response rates of 32% (Kaler and Green, 2008a) and 20% (Grogono-Thomas and Johnston, 1997). The former study used an 8 paged questionnaire and included a cover letter, two reminders and a second copy of the questionnaire, whereas the latter study did not use reminders which may account for the lower response rate. Indeed, in the current study, the initial response was boosted by 35.8% after delivery of a second copy of the questionnaire to non-responders. The inclusion of reminders should be and is recommended in other studies (Edwards *et al*., 2002; Nakash *et al*., 2006). The questionnaire in the current study was purposefully targeted at farmers in the winter months when farmers are generally least busy (Pennings *et al*., 1999). This is likely to have increased the response proportion compared with Kaler and Green (2008a). The combination of a freepost self-addressed envelope (Fox *et al*., 1988), coloured ink (Edwards *et al*., 2002), University of Warwick and EBLEX logos (Fox *et al*., 1988; Edwards *et al*., 2002) and a cover letter explaining the aims of the research may also have helped facilitate an increased response rate. The response rate in the current study was however modest in comparison with the 64%, 60% and 61% response rates of postal surveys that used non-random sampling of compliant sheep farmers interested in participating in further research on lameness (Wassink *et al*., 2003a;

2004; 2005; 2010b). However, a major limitation of this sampling method is selection bias.

Selection bias in the current study was minimised using stratified random sampling of sheep farmers in England. To increase precision and representativeness, sampling was stratified by county and flock size. There was no significant difference between the distribution of respondents and non-respondents, although the average flock size of respondents with commercial flocks with >20 sheep was higher than that of the DEFRA agricultural survey for 2011 (311 *cf.* 238) (DEFRA, 2012). The author does not know why there was this difference; it may be due to differences in the phrasing of questions. Response bias for other reasons cannot be excluded *e.g.* non-respondents may have had smaller flocks than respondents.

To maximise the sample size and statistical power of the analysis, missing observations within VAS questions were estimated. In order to introduce the least amount of measured error, the effect of three potential estimates for missing values were evaluated and compared to the original dataset using Procrustes rotation analysis (Marshall Brown *et al*., 2012). The alternative would have meant substantial loss of data (39.2%) and on benefit an error of 3.6% was incorporated into multivariate analysis of attitudes. The sample size of the study was sufficient to include a 95% confidence limit and a 5% precision.

The majority of farmers in this study were male (80.6%), over 45 years old (78.0%) had commercial flocks (78.2%) and had lowland farms (71.5%). These characteristics are similar to those of the general population of sheep farmers with commercial holdings of >20 sheep from the DEFRA Census of Agriculture and

Horticulture (June 2010) and increase the external validity of the findings from this study. DEFRA figures for comparison with equivalent data in the current study are: 82.8% *cf.* 86.0% male; 84.0% ≥45 years old *cf.* 77.6% >45 years old; and 71.3% of farms not in a Less Favoured Area *cf.* 71.3% classified by farmers as lowland in the current study (DEFRA farming statistics, personal communication). It should be noted that successful message framing will require consideration of the trend for an ageing population of sheep farmers (DEFRA, 2010) because the senior age of farmers presents obstacles to the prompt treatment of mildly lame sheep, *i.e.* decreased physical capability to catch sheep and perhaps also a greater predisposition for health/welfare issues for the farmer.

Farmer responses may have been affected by differences in regulation, legislation or common practices between countries and could not be controlled for within the analysis. Therefore addresses outside England were excluded from the analysis. Caution and further research should be recommended if the findings from the current study are to be applied to sheep farming communities outside England.

5.4.3 Routine foot trimming

In this study, there was no significant difference in the prevalence of lameness for farmers that did or did not routinely foot trim; or in the annual frequency of use or proportion of its use within the flock. This finding is consistent with the clinical trial in this thesis (Chapter 2) but in contrast to previous research findings (Grogono-Thomas and Johnston, 1997; Wassink *et al.*, 2003a; 2003b; 2004; Green *et al.*, 2007a; and Kaler and Green, 2009) that suggest an associated increased prevalence of lameness with increased frequencies of routine trimming (see introduction to Chapter 2). Farmers who rated routine foot trimming as an ‘*excellent*’ method to control lameness had a lower prevalence of lameness. The findings of Chapter 2 support the evidence that poor trimming technique causes lameness (Morgan, 1987; Hosie, 2004; Winter 2004a; 2004b) and current industry recommendations are to avoid trimming, in particular over trimming which leads to hoof damage. The only evidence of farmers’ trimming technique comes from a study carried out in 1994 (Grogono-Thomas and Johnston, 1997; see introduction Chapter 2) which suggested that 50% of farmers had poor technique. It is plausible that trimming technique has improved in the last 18 years, particularly if there has been successful knowledge transfer. Certainly, although the majority of farmers in this study practiced routine foot trimming, it appears that this practice is on the decline: 70% *cf.* 87% in 1994 (Grogono-Thomas ad Johnston, 1997) and 76% in 2004 (Kaler and Green, 2009). It is possible that farmers who rated rate routine foot trimming as ‘*excellent*’ had a better trimming technique and/or combined routine foot trimming with other more effective lameness management practices compared with farmers who rated it less than excellent. This is plausible because farmers who rated routine foot trimming had significantly smaller flocks, with smaller flocks associated with less barriers, prompt treatment to the first lame sheep in a group, and greater individual treatment. This theory requires further analysis; and further research to establish cause and effect because this could not be established from the study design. The subgroup of farmers who rated routine foot trimming as ‘*excellent*’ may perhaps provide further weight that technique is important in avoiding increased susceptibility of the sheep from over trimming and/or limiting environmental contamination when gathering (Wassink *et al.*, 2003a; Chapter 2). The study by Green *et al.* (2007a) suggests that foot trimming increases susceptibility to *D. nodosus* rather than gathering *per se*.

Further research investigating the technique of routine foot trimming would be helpful to confirm this hypothesis.

In the current study, farmers that did not routinely foot trim treated cases of ID and ID and FR combined promptly more frequently with parenteral and topical antibacterials than those that routinely trimmed; conversely those that routinely trimmed >twice treated FR more frequently. This may suggest that farmers who routinely trim may perhaps use whole flock control measures rather than individual treatments, a hypothesis proposed by Kaler and Green (2009) and Kaler *et al*. (2010a) to treat ID but not FR.

From the evidence given to farmers that routine foot trimming was not beneficial, the majority of farmers were resistant to the idea of stopping the practice. This despite the suggestion by Wassink *et al.* (2010b) that because farmers were dissatisfied with the practice of routine foot trimming as a method to control lameness they might be easily dissuaded from it. Those less reluctant to the idea of stopping the practice were farmers that '*sometimes*' promptly treated FR with parenteral and topical antibacterials; caught at locomotion score ≥2; had higher prevalences of lameness; commercial; and larger flocks. The latter is not surprising considering the senior age of sheep farmers and the decline of work force on farms (DEFRA, 2010). Routine foot trimming is a laborious task estimated to take 1 hour per 15 sheep (Wassink *et al*., 2005). One explanation for less opposition to stopping the practice from farmers that have higher prevalences of lameness may be that they do not see a benefit from it.

This study suggests that for maximum research impact, the evidence required to prompt a mainstream change would need to be well-designed, robust and tailored to include a variety of individual farm managements. The author suggests that the evidence needed would require a cost-benefits analysis of a stratified randomised, clinical, controlled, multi-farm trial spanning at least 2 years. The trial would need to include measures of flock productivity, sheep age and breed, assessment of horn growth, shape and colour, the prevalence of lameness and foot disease, soil type and farm topography and include details of general farm management practices as well as trimming style. A trial of this scale would require a large research grant. If its findings are congruent with the findings of Chapter 2, *i.e.* routine foot trimming is not beneficial, and detrimental only where overzealous trimming is carried out, the evidence may still fail to persuade the 25% who required a detrimental outcome to stop this practice. The author therefore suggests that a piece of research of this magnitude may be more efficient and have greater impact if the trial included a holistic assessment of several lameness management practices, including routine foot trimming; perhaps something similar to the methodology used for the successful DairyCo Mastitis Control Plan (Green *et al*., 2007b). This could provide farmers with a '*must*, *should, could*' guide on how to best control lameness in a given system of flock management. Additionally, it would address the lack of clinical trials on management practices used by farmers to prevent lameness in their flock (*i.e.* new stock quarantine; isolation and culling of lame sheep; footbathing and vaccination) (see Chapter 1: General Introduction); and the need for treatments that are farmer focused, *i.e.* those that take into consideration labour shortages; other enterprises and changing seasonal priorities of the farming calendar.

5.5 Conclusions

It is likely that a breadth of strategies will be necessary to achieve a reduction in lameness within sheep flocks; but essentially one that is not focused on financial incentives alone. There is a need for farmers to keep better records about their flock which enable assessment of where profits are gained and losses are made and a need for further research into the control of lameness to be farmer focused. This will enable farmers to practically and successfully adopt new practices and to assess their impact. Education about the linked aetiology of ID and FR and that ID is a painful condition would be recommended. Strategies should address the difficulties farmers' face identifying and catching individual mildly lame sheep both in the field and once gathered and their reluctance to treat mildly lame ewes when heavily pregnant. Vets are indicated as sheep farmers preferred source of advice and further research is needed to identify their social referents to maximise research impact and successful knowledge transfer; but also how their input into flock management can be increased within an economically acceptable framework to farmers.

Chapter 6 General discussion

The implications of the research outcomes are discussed within the context of existing knowledge and in relation to the objectives of this thesis. Finally, some limitations of the research findings, recommendations for industry and areas of further research are given.

6.1 Context of the study

One way to increase agricultural production is to minimise loss caused by disease. However, to reduce disease, an understanding of disease aetiology, pathogenesis and successful control strategies, alongside farmers’ perceptions and their capabilities to adapt to potential recommended disease control strategies are needed. Although there are a number of studies examining lameness in sheep that span several decades (Beveridge, 1941; Parsonson *et al*., 1967; Egerton and Roberts, 1971; Skerman *et al*., 1983; Whittington, 1995; Kaler *et al*., 2009; Russell *et al*., 2013) they rarely address famers’ perceptions of, or attitudes towards lameness. According to well-established social theory (Fishbien and Ajzen, 1975; Ajzen 1991), attitudes, subjective norms, perceived behavioural control, and their extensions: role merger, moral norms, personality, perceived self-efficacy and anticipated regret (Piliavin and Callero, 1991; Lemmens *et al*., 2005; Austin *et al*., 2005; Armitage and Connor, 1999, Sandberg and Conner, 2009) form an integral part of the decision making process that empower change.

6.2 Key findings and achievements

An interdisciplinary approach to veterinary epidemiological studies into lameness in sheep was achieved using the objectives laid out in the aims of this thesis.

The five objectives were as follows and were achieved with some limitations:

1. To assess whether routine foot trimming is an effective management practice in the control of lameness.
2. To assess whether farmer estimates of the prevalence of lameness on their farm are accurate, reliable and a valid tool for epidemiological studies.
3. To qualitatively explore and understand farmers beliefs and attitudes towards management of lameness in sheep and the motivators and barriers to treatment of lame sheep as perceived by farmers.
4. To quantify the motivators and barriers to treatment of lame sheep as perceived by farmers.
5. To assess the evidence required by farmers to stop routine foot trimming should the practice be detrimental or non-beneficial.

The first outcome of the study is that sheep farmer estimates for the prevalence of lameness in their flocks were consistent, accurate and reliable for studies of risk. Although there was a tendency for farmers to underestimate the true prevalence of lameness when their estimates were >9%, farmers' initial estimates of the prevalence of lameness were significantly and highly linearly correlated with the researcher's estimate (Spearman's rho = 0.73) (Chapter 3). This correlation increased to 0.86 when farmers subsequently inspected the group with the researcher, with farmer initial and re-estimates of lameness prevalence also highly correlated (rho = 0.89). Lower initial estimates *cf.* re-estimates by farmers may have been due to: estimates based on previous inspection time periods, exclusions of particular categories of sheep (*e.g.* treated or prolonged lameness), unwillingness to breach cross compliance (Rural Payments Agency, 2010), cognitive dissonance (Festinger and Carlsmith, 1959), desensitisation (Whay *et al*., 2002), or pressure to give a socially or morally correct response in a face-to-face setting (Krysan *et al*., 1994). In order to reduce the risk of the latter, farmers were asked to identify lame sheep rather than decide whether a sheep identified by the researcher was lame. Farmer estimates of lameness were most highly correlated with researcher estimates of sheep with locomotion score ≥2, suggesting that farmers both recognise mildly lame sheep (Kaler and Green, 2008b) and include these in their estimates. It additionally suggests that unlike lameness in dairy cattle, where the researcher and farmer estimates for prevalence of lameness were moderately correlated (r = 0.59 *cf.* 0.73 in the current study) (Whay *et al*., 2002) farmers have some consistent mechanism to classify lame sheep. The study findings add validity to previous epidemiological studies that have used farmer estimates for the prevalence of lameness to identify risk factors associated with lameness in sheep (Grogono-Thomas and Johnston, 1997; Wassink *et al*., 2003a; 2003b; 2004; 2005; 2010b; Kaler and Green, 2008a; 2009). It additionally suggests that farmer recognition of lame sheep from video clips is similar to recognition within their own flocks (Kaler and Green, 2008b).

The use of video clips of lame sheep during interviews (chapter 4) was very effective at engaging farmer response. It was the part of the interview in which farmers provided greatest insight into their attitudes towards management of lameness and how this impacted on their decision making process. The qualitative and quantitative analysis demonstrated that farmers use lameness management events for advice (a theory originally proposed by Wassink *et al*., 2010b). Accordingly, the use of video clips of lame sheep at lameness management events may be useful to promote discussion with and dissemination of appropriate management advice to farmers.

A second outcome of the study is the first stratified random postal questionnaire in England to suggest that the average annual prevalence of lameness in sheep flocks may be decreasing (Chapter 5). The 5.0% prevalence of lameness in 2011 was substantially lower than the 8% in 1994 (Grogono-Thomas and Johnston, 1997) and 10.4% in 2004 (Kaler and Green, 2008a). Farmers' assessments of the current point prevalence of lameness are reasonably accurate and reliable (Chapter 3; King and Green, 2011). Consequently, it may not be unreasonable to assume that farmers' estimates for a 12 month period prevalence of lameness are also reasonably accurate and reliable. This may be difficult to assess (Chapter 3; King and Green, 2011). However, recall bias and the seasonal variation in ID/FR prevalence (Wassink *et al*., 2003a; 2004), may make it hard for respondents to provide an accurate appraisal of a 12 month period prevalence (Chapter 3; King and Green, 2011). The median current point prevalence of lameness in the current study was also 5.0% but cannot be compared with figures for 2004 (Kaler and Green, 2008a) and 1994 (Grogono-Thomas and Johnston, 1997) because these data were not collected. Two subsequent studies from 2006 (Wassink *et al*., 2010b) and 2008 (Chapter 3; King and Green, 2011) also reported a similar period prevalence (5.0% equally) and provide further support that the annual period prevalence of lameness has decreased since 2004; although these were not from random samples but were from compliant farmers interested in research on lameness in sheep and this limits their supportive value. The exceptionally dry and higher than average temperatures for England between 2011 to April 2012 (Met Office, 2012) are likely to have reduced the transmission rate of *D. nodosus* and therefore probably contributed to the reduced prevalence of lameness compared with the 1994 and 2004 studies. The lower prevalence of lameness may also suggest that knowledge transfer processes are perhaps achieving some success in reducing flock lameness. Alternatively, sheep farmers may now be more reluctant to admit high lameness prevalences. The FAWC recommendations (a target of 2% by 2021) (FAWC, 2011) were given in the questionnaire, although the effect of its inclusion will have been limited by its inclusion much later in the questionnaire *cf.* lameness prevalence requests.

A third outcome of the research is the generation of evidence and explanation to support the hypothesis, originally proposed by Kaler and Green (2008b), that farmers recognise even mildly lame sheep but that they make a separate decision whether to catch and treat them. All the farmers in Chapter 3, and 89% of farmers in Chapter 5 recognised sheep with locomotion score ≥2 as lame; a finding similar to the 90% reported by Kaler and Green (2008b). The minimum locomotion score that farmers caught a lame sheep for inspection was not significantly correlated with the minimum locomotion score recognised or reported as lame (Chapters 3 and 5); or with increasing thresholds of lameness prevalence by locomotion score severity recorded by the researcher (Chapter 3). This supports the findings and hypothesis proposed by Kaler and Green (2008b) that famers recognise mildly lame sheep but make a separate decision to catch for treatment. Lack of time, difficulty identifying individual animals, difficulty catching mildly lame individuals and lack of labour were predominant reasons for not treating all animals regarded as lame (Chapters 4 and 5). However, farmers also believed mild cases of lameness were transient and self-correcting. Lack of time and labour are reported as barriers in studies examining farmers' attitudes to lameness in dairy cattle (Leach *et al*., 2010a) and treatment of ectoparasites in sheep (Morgan-Davies *et al*., 2006). The current study additionally highlighted farmers' lack of understanding about the linked aetiology of ID and FR and also that they are less sympathetic towards lameness caused by ID compared with FR (Chapter 4 and 5). They may believe ID and mild cases of lameness to be less painful (Kaler and Green, 2008b) or have a smaller production loss compared with FR and severe lameness. This knowledge gap needs to be addressed in future knowledge transfer programmes.

The size of the flock was also a factor in the influences that motivated treatment for lameness, though it was not correlated with the prevalence of lameness. Increased flock size was positively correlated with motivation to increase profit, to reduce public criticism of lameness and to reduce transmission of ID/FR. It was also positively correlated with several barriers (difficulty identifying and catching mildly lame ewes and lack of time), with the need to wait for more than one ewe to be lame in a group, and with less frequent individual treatments (Chapter 5). The qualitative study (Chapter 4) helped to provide context to some of these associations with large group sizes considered more difficult and time consuming to manage. Frequent gathering was considered impractical with labour availability and additionally was thought to lead to increased transmission. Moreover, the reasons for keeping sheep on farms also provided useful explanation as to why mildly lame sheep were not treated promptly. Sheep flocks were used to maintain grass land where this was unsuitable for other agricultural enterprises. Where sheep formed part of a mixed farming system they added fertility to the ground and provided income and employment for employees all year round. Commercial flocks in particular, were frequently considered a subsidiary enterprise to other farm enterprises in terms of farm income; although not in terms of the proportion of labour necessary to maintain them. This conflict when combined with the general decline in farm labour, meant that when farm priorities clashed, unless an immediate, dramatic and visual loss was evident, non-routine flock interventions (such as treatment of lameness) received lower prioritisation, and therefore treatment was delayed. This new understanding helps to explain the paradoxical findings reported by Wassink *et al* (2010b). Individual treatments may be effective resulting in farmer satisfaction but they are not always practical for all farms or at all times of the year, resulting in the puzzling preference for whole flock control programmes; with a desire for these to be more effective. Further research on whole flock control measures is needed.

A fourth outcome of the research is that it generated novel results on the motivators and barriers to treatment of lame sheep. The study (Chapter 5) showed great variation in sheep farmers' attitudes as is seen in other studies of farmer attitudes (Willock *et al*., 1999a; Austin *et al*., 2005; Stott *et al*., 2005; Morgan-Davies *et al*., 2006; Leach *et al*., 2010a; 2010b). There was very little separation in farmer attitudes by low, medium and high flock prevalence of lameness. Non-financial motivators generally received higher scores than financial ones and this is a finding congruent with other studies examining behaviour motivation in farmers (Willock *et al*, 1999a; Austin *et al*., 2005; Morgan Davies *et al*., 2006; Garforth *et al*., 2006; Leach *et al*., 2010b). In addition, the barriers for treatment of lame sheep provided greatest explanation for the small separation seen between categories of low, medium and high flock prevalence of lameness. Cause and effect could not be established from the quantitative study design and so further research into the barriers for treatment of lameness are also required to establish whether they in fact lead to a higher prevalence of lameness. If they do then this may be important when communicating new technologies on lameness control to farmers.

The combination of qualitative then quantitative methodologies revealed a dominant barrier (reluctance to treat heavily pregnant ewes) that may not have been investigated without this study design. The qualitative data additionally provided explanation for quantitative associations and the coupling increased validity of the results from each; benefits also observed by Kauppinen *et al*., (2010). Further research providing a cost benefit analysis of treatment of lame sheep when heavily pregnant would be useful.

A fifth outcome of the research is that it provided the first clinical trial on the effectiveness of routine foot trimming, as a practice to control lameness in sheep. The finding of the study showed that the practice was not beneficial in the study flock. Furthermore, where hoof horn was accidentally over trimmed by the shepherd resulting in blood loss or sensitive tissue exposure, sheep later became lame. This study supports the hypothesis that the trimming of healthy hooves increases the transmission of disease by increasing the susceptibility of over trimmed hooves to *D. nodosus* (Wassink *et al*., 2003a) rather than through environmental contamination at gathering events (Wassink, *et al* 2003a). Green *et al*, (2007a) also found that foot trimming increased susceptibility rather than gathering *per se*. The current study coupled with earlier studies (Grogono-Thomas and Johnston, 1997; Wassink *et al*., 2003a; 2003b; 2005; 2010b; Green *et al*., 2007a; Kaler and Green, 2009) suggests that the time spent routine foot trimming by the 73.3% of farmers currently practising it (Chapter 5) might be better spent on other efficacious treatment and prevention practices. It also suggests that those most strongly opposed to stopping routine foot trimming are those not consistently providing mildly lame sheep with prompt treatment with parenteral and topical antibacterials. This perhaps supports the hypothesis by Kaler *et al*, (2010b) that where routine foot trimming is being used as a control measure, treatments to individual lame sheep are being neglected.

The findings from the postal survey (Chapter 5) suggest that the practice of routine foot trimming has not declined significantly since 2004 (76% *cf*. 73% in the current study) (Kaler and Green, 2008a); although it is less than the 87% of 1994 (Grogono-Thomas and Johnston, 1997). Routine foot trimming is a laborious task estimated to take 1 hour per 15 sheep (Wassink *et al*., 2005). A reduction in the availability of farm labour (DEFRA, 2010) is one possible explanation for this decline and evidence from the quantitative data in Chapter 5 also suggests that farmers have also stopped foot trimming because they do not see a benefit from the practice. Data from the qualitative study indicated that farmers were generally aware of current advice not to trim, particularly not to over trim; and had partially followed this recommendation. This may provide explanation for the non-significant association between the prevalence of lameness and the practice, and frequency, of routine foot trimming seen in this study which is contrary to findings seen in earlier studies (Grogono-Thomas and Johnston, 1997; Wassink *et al*., 2003a; 2003b; 2005; 2010b; Green *et al*., 2007a;

Kaler and Green, 2009) but consistent with the clinical trial in this thesis (Chapter 2).

Farmers in this study were generally reluctant to stop foot trimming despite evidence provided that it was not beneficial (although they were not told that over trimming was detrimental). Data on the evidence required by farmers to form an intention to change this behaviour was provided in Chapter 5. It indicated that farmers required much stronger evidence (longer, larger, multi-farm trials) that includes a large number of factors to make the results generalizable to their farm circumstances. A further clinical trial designed to incorporate the evidence required by farmers is therefore recommended. It may be reasonable to assume that the evidence farmers require to change foot trimming behaviour will be similar for other lameness management practices. Consequently this evidence may be useful for other future study designs.

The sixth outcome was that this study provides evidence that vets, EBLEX and respected farmers are the preferred social referents of sheep farmers with the role of the vet limited both in scope and frequency. These findings support earlier findings by Wassink *et al*. (2010b) and ADAS (2007) respectively. Generally farmers did not consider veterinary involvement financially viable (Chapter 4) although results of Chapter 5 suggest that farmers use vets when the need arises with farms with larger flocks and those with higher prevalences of lameness having significantly greater contact with their vet (Chapter 5). This perhaps indicates there is an economic element to this trend. Farmers perceived themselves to be the expert on their farm and of their flock, with greater practical experience than most vets, and they also have access to free advice from many sources (Chapter 4). Consequently veterinary use was limited to emergencies, problems outside the farmer's experience and to access medicines. Further research on the current future role of the vet is recommended and is the subject of a current study (Kaler and Green, personal communication). The advice provided by vets to sheep farmers may be dependent on their specialism (predominantly large or small animal) and there is a need to ensure that the recommended advice from research reaches the vets who advise these farmers. This requires research to examine the social referents for vets. Whoever the social referent responsible for bringing about a change in behaviour most farmers assessed improvements in the prevalence of lameness from memory when adopting new management practices. Farm records of lameness were for the majority lacking (Chapter 4). This makes it difficult for anyone to precisely quantify the benefits of any new management tool/approach. This may provide an insight into why farmers use a variety of management tools, are uncertain of their effectiveness and are reluctant to change.

6.3 Implications for industry and policy

The research contained in this thesis, suggests that farmers need to be better informed about the link between the aetiology of ID and FR; and that ID is painful for sheep. The benefits of routine foot trimming continue to remain unclear but the detriment of even a small accidental over trim needs to be understood by those using routine foot trimming as a management practice to control lameness. Routine foot trimming perhaps ought not to be promoted as a beneficial management practice without further clinical trials and research investigating trimming technique.

Sheep farmers appear more motivated by non-financial than financial rewards and this need to be understood by those seeking to change farmer behaviour. Tackling the barriers perceived by farmers to delay treatment (assuming these barriers are causative) may provide an increased uptake of currently recommended lameness management practices; compared with messages that address only the motivators for change. It is clear that farmers perceive considerable uniqueness about farm and flock circumstances. Consequently, industry needs to formulate a range of effective practical solutions to assist farmers find a route around present barriers to best practice. Alternatively, industry perhaps needs more than one clearly defined strategy that farmers can use to suit individual farm circumstances.

This thesis provides some evidence that knowledge transfer in the sheep industry is working, with vets, EBLEX and respected farmers being the preferred social referents of knowledge transfer. Advice provided by vets to sheep farmers may be dependent on their specialism (predominantly large or small animal) and there is a need to ensure that the latest recommended advice from research reaches the vets who advise these farmers. Nevertheless, farmers need to keep better flock records to enable themselves and their advisors to precisely assess the benefit of any change in management practice. Sheep farming has been supported by subsidy since 1940. Whilst the extent and range of these have been reduced by the CAP reform and subsequent changes in public policy, it is still currently subsidised by voluntary sign-up to environmental schemes *via* the SPS. (For a historical review of farm animal subsidy see Woods (2011)). Subsidisation of the sheep industry provides a key explanation as to why sheep farmers do not keep flock records that enable assessment of profit and loss; and consequently perhaps why they are less motivated by financial gain. The inclusion of a requirement within SPS Cross

Compliance legislation to keep better flock records could perhaps be recommended. This would provide a tool to enable the industry to effectively assess reductions in disease, improvements in flock health and productivity. The recommendation for better record keeping is shared and supported by recent unpublished work by Kaler and Green (personal communication) that examines sheep farmer opinion to the role of the vet in flock health management.

Chapters 4 and 5 highlight that the role of the vet is limited in England’s sheep flocks both in scope and frequency, a finding in agreement with a study by ADAS (2007). Sheep farmers are however using vets when the need arises. Greater veterinary involvement in farm flocks may be beneficial to flock health but generally farmers do not see this as financially viable. Moreover, farmers perceive themselves to be the expert on their farm and flock generally, with greater practical experience than most vets, and additionally have access to free advice elsewhere. Consequently veterinary use is limited to emergencies, problems outside the farmers experience and to gain medicines. Further research on the future role of the vet is recommended and is being addressed in a current study (Kaler and Green, personal communication).

6.4 Recommendations for future research

A further study with a random population of producers to confirm the results of chapter 3 (farmer recognition of lameness in their flocks) and to assess the accuracy of farmer estimates for a 12 month period prevalence of lameness would be beneficial. It may be difficult in practice to achieve and it is unlikely that sufficient reason or resources would be obtained to make the results strictly generalisable. An alternative recommendation is for future studies to request farmer estimates of the current prevalence of lameness and either shorter period prevalences of lameness or the maximum and minimum prevalence of lameness over a given time period.

A key assumption in this research was that the VAS is a reliable and valid tool for collecting attitude data; this requires testing. In practice this may be difficult to achieve. Attitudes may evolve over time with new experiences and respondents may remember scores; a test-retest method is not suitable for evaluation of a dynamic phenomenon (Wewers and Lowe, 1990). An assessment of criterion-related validity *i.e.* against alternative instruments may however present a practical option. Similarly, although the use of a single trained observer will have minimised observer bias, the ID and FR scoring scales used in Chapter 2 also require testing for reliability and repeatability. This has been achieved for the Egerton and Roberts (1971) footrot classification system (Foddai *et al*., 2012) and a similar approach could be used.

The study design in Chapter 5 was observational and retrospective and could not distinguish between cause and effect. Further studies could be recommended to examine whether farmers with a low prevalence of lameness actually have fewer barriers (*i.e.* they have a greater labour force; a trained dog; less difficulty identifying and catching individuals; more time; and less distance to central handling facilities), have overcome these barriers or simply perceive less barriers; and whether barriers to the prompt treatment of lame sheep are causative or explanatory.

A cost-benefits analysis of the effect of treating mildly lame ewes during very early pregnancy and in particular when heavily pregnant would be useful because not treating these sheep reduces their welfare, increases transmission of disease and because lambs of lame ewes are significantly at risk of becoming lame (Kaler *et al*., 2010b) therefore increasing the work-load of the farmer. A reminder to farmers that current legislation requires appropriate treatment of these sheep is perhaps warranted.

Further analysis and a follow-up study to examine the group of farmers not using current recommended practice that have lower level of lameness *i.e.* those that stated ‘*never*’ and in particular ‘*not applicable*’ to the prompt treatment of mildly lame sheep with parenteral and topical antibacterials would be useful and is planned. The results would require testing in a clinical trial, but may provide a practical, alternative recommended practice that would also result in a low prevalence of lameness for sheep farmers’ flocks.

There is a lack of clinical trials on management practices used by farmers to prevent lameness in their flock (*i.e.* new stock quarantine; isolation and culling of lame sheep; footbathing, routine foot trimming and vaccination) (see Chapter 1). There is also a need for effective treatments that are farmer focused, *i.e.* those that take into consideration labour shortages; other enterprises and changing seasonal priorities of the farming calendar. Further clinical trials of lameness in sheep are recommended and could include a holistic assessment of several lameness management practices. This could be similar to the methodology used for the successful DairyCo Mastitis Control Plan (Green *et al*., 2007b). This would provide farmers with a ‘*must, should, could*’ guide on how to best control lameness in a given system of flock management.

6.5 Conclusions

The research contained in this thesis has made an original contribution to knowledge and improved our understanding of the epidemiology of lameness in sheep from the farmers' perspectives, using multi- and inter-disciplinary approaches. The work suggests that farmer estimates of the prevalence of lameness are a valid tool for epidemiological studies. Farmers can recognise even mildly lame sheep but make a separate decision to catch and treat them and this separate decision is caused by practical obstacles that prevent prompt treatment; and additionally relates to the reason for having a flock. The motivators for treatment of lame sheep are primarily non-financial with barriers accounting for the majority of the small amount of variation in farmer attitude towards management of lameness by lameness prevalence. There is a need for farmers to keep better flock records to enable a precise assessment of the benefit of any new management practice and to assess where profit and loss is made. Evidence was given for the hypothesis that routine foot trimming is not beneficial as a practice to control lameness, and is detrimental when over trimming occurs. Further research on routine foot trimming is warranted and required by farmers. Finally, further research that enables a 'must, should, could' guide on how best to control lameness in a given system of flock management is recommended.

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Appendix 1: Data collection form for T1 and T2

Ewe Record Sheet

	Yes		Yes
Young?	☐	Old?	☐
Thin?	☐	Fat?	☐
Poor feet?	☐	Good feet?	☐
Lesions?	☐	No lesions?	☐

Date: ☐ **Ear-tag ID:** ☐

Teeth (circle): 2 4 6 FM BM **Ewe breed:** ☐ **BC score:** ☐

Foot scores

Left fore			FR/ID active lesion score	Comments
Interdigital			☐	
Inner digit	Integrity score	Overgrowth? (circle)		
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Outer digit				
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Treatment (tick)	FT ☐	FS ☐	AB ☐	

Right fore			FR/ID active lesion score	Comments
Interdigital			☐	
Inner digit	Integrity score	Overgrowth? (circle)		
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Outer digit				
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Treatment (tick)	FT ☐	FS ☐	AB ☐	

Left rear			FR/ID active lesion score	Comments
Interdigital			☐	
Inner digit	Integrity score	Overgrowth? (circle)		
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Outer digit				
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Treatment (tick)	FT ☐	FS ☐	AB ☐	

Right rear			FR/ID active lesion score	Comments
Interdigital			☐	
Inner digit	Integrity score	Overgrowth? (circle)		
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Outer digit				
Heel & Sole	☐		☐	
Wall	☐	part / full	☐	
Treatment (tick)	FT ☐	FS ☐	AB ☐	

FT = Foot trim FS = Foot spray AB = Antibiotic injection

Appendix 2: Foot trimming and locomotion scoring forms

Foot Trimming Form

Date: ☐ **Ear Tag:** ☐ **Branding ID:** ☐

LEFT FORE	**Inner digit**	**Outer digit**	**RIGHT FORE**	**Inner digit**	**Outer digit**
Trim sole?	☐	☐	**Trim sole?**	☐	☐
Tissue exposed?	☐	☐	Tissue exposed?	☐	☐
Bled?	☐	☐	Bled?	☐	☐
Cut off toe?	☐	☐	**Cut off toe?**	☐	☐
Tissue exposed?	☐	☐	Tissue exposed?	☐	☐
Bled?	☐	☐	Bled?	☐	☐
Trim wall?	☐	☐	**Trim wall?**	☐	☐
Below level of sole?	☐	☐	Below level of sole?	☐	☐
At level of sole?	☐	☐	At level of sole?	☐	☐
Above level of sole?	☐	☐	Above level of sole?	☐	☐
Tissue exposed?	☐	☐	Tissue exposed?	☐	☐
Bled?	☐	☐	Bled?	☐	☐
Foot spray? ☐			**Foot spray?** ☐		

LEFT REAR	**Inner digit**	**Outer digit**	**RIGHT REAR**	**Inner digit**	**Outer digit**
Trim sole?	☐	☐	**Trim sole?**	☐	☐
Tissue exposed?	☐	☐	Tissue exposed?	☐	☐
Bled?	☐	☐	Bled?	☐	☐
Cut off toe?	☐	☐	**Cut off toe?**	☐	☐
Tissue exposed?	☐	☐	Tissue exposed?	☐	☐
Bled?	☐	☐	Bled?	☐	☐
Trim wall?	☐	☐	**Trim wall?**	☐	☐
Below level of sole?	☐	☐	Below level of sole?	☐	☐
At level of sole?	☐	☐	At level of sole?	☐	☐
Above level of sole?	☐	☐	Above level of sole?	☐	☐
Tissue exposed?	☐	☐	Tissue exposed?	☐	☐
Bled?	☐	☐	Bled?	☐	☐
Foot spray? ☐			**Foot spray?** ☐		

Antibiotic injection (tick) **Yes** ☐ **No** ☐ **If yes, amount in ml:** ☐

Lameness Recording Sheet

Date:________________ **Recorder:**________________ **Field ID:** ________________

Sheep ID	**Group**	**Loco score**	**Feet (tick)**			
			LF	**RF**	**LR**	**RR**

LF = left fore RF = right fore LR = left rear RR = right rear

Appendix 3: Researcher and shepherd treatment forms

Treatment Recording Sheet (Researcher)

Date:		**Field ID:**		**Ear Tag:**		**Branding ID:**		**Recorder:**	

Foot scores

LEFT FORE	FR/ID active lesion score	Healing? (tick)	Other reasons for lameness	**RIGHT FORE**	FR/ID active lesion score	Healing? (tick)	Other reasons for lameness
Interdigital				**Interdigital**			
Inner digit				**Inner digit**			
Outer digit				**Outer digit**			
Treatment (tick)	Foot Trim	Foot Spray		**Treatment (tick)**	Foot Trim	Foot Spray	

LEFT REAR	FR/ID active lesion score	Healing? (tick)	Other reasons for lameness	**RIGHT REAR**	FR/ID active lesion score	Healing? (tick)	Other reasons for lameness
Interdigital				**Interdigital**			
Inner digit				**Inner digit**			
Outer digit				**Outer digit**			
Treatment (tick)	Foot Trim	Foot Spray		**Treatment (tick)**	Foot Trim	Foot Spray	

Antibiotic injection (tick)	**Yes**	**No**	**If yes, amount in ml:**	

Treatment Recording Sheet (shepherd)

Date:		**Ear Tag: Branding ID:**		**Field ID:**		**Recorder Initials:**	

LEFT FORE	(tick)		Other reasons for lameness (please note)	**RIGHT FORE**	(tick)		Other reasons for lameness (please note)
Scald				**Scald**			
Footrot				**Footrot**			
Treatment	Foot Trim	Foot Spray		**Treatment**	Foot Trim	Foot Spray	

LEFT REAR	(tick)		Other reasons for lameness (please note)	**RIGHT REAR**	(tick)		Other reasons for lameness (please note)
Scald				**Scald**			
Footrot				**Footrot**			
Treatment	Foot Trim	Foot Spray		**Treatment**	Foot Trim	Foot Spray	

Antibiotic injection (tick)	**Yes**	**No**	**If yes, amount in ml:**	

Appendix 4: Frequency distribution of sheep level features for 106 lame ewes

Variable	Categories	No. Lame	denominator	%	No. C	No. T	% C	% T
Breed	Suffolk-x	60	99	60.6	30	30	30.3	30.3
	Mule	41	67	61.2	22	19	32.8	28.4
	-99	5	7	71.4	2	3	28.6	42.9
Age	2	0	2	0.0	0	0	0.0	0.0
	4	8	15	53.3	3	5	20.0	33.3
	6	25	38	65.8	15	10	39.5	26.3
	FM	72	114	63.2	36	36	31.6	31.6
	BM	1	4	25.0	0	1	0.0	25.0
T1 Allocation	Treatment	52	85	61.2	0	54	0.0	63.5
	Control	54	88	61.4	56	0	63.6	0.0
T1 Body Condition	0	0	0	0.0	0	0	0.0	0.0
	0.5	0	0	0.0	0	0	0.0	0.0
	1	0	0	0.0	0	0	0.0	0.0
	1.5	3	3	100.0	1	2	33.3	66.7
	2	13	19	68.4	8	5	42.1	26.3
	2.5	24	43	55.8	10	14	23.3	32.6
	3	33	60	55.0	17	16	28.3	26.7
	3.5	25	34	73.5	13	12	38.2	35.3
	4	7	13	53.8	5	2	38.5	15.4
	4.5	0	0	0.0	0	0	0.0	0.0
	5	0	0	0.0	0	0	0.0	0.0
	-99	1	1	100.0	0	1	0.0	100.0
T2 Body Condition	0	0	0	0.0	0	0	0.0	0.0
	0.5	0	1	0.0	0	0	0.0	0.0
	1	2	2	100.0	1	1	50.0	50.0
	1.5	1	1	100.0	1	0	100.0	0.0
	2	20	37	54.1	11	9	29.7	24.3
	2.5	45	69	65.2	20	25	29.0	36.2
	3	32	52	61.5	17	15	32.7	28.8
	3.5	2	6	33.3	2	0	33.3	0.0
	4	3	3	100.0	2	1	66.7	33.3
	4.5	0	1	0.0	0	0	0.0	0.0
	5	0	0	0.0	0	0	0.0	0.0
	-99	1	1	100.0	0	1	0.0	100.0
T1 Max Integrity	0	40	75	53.3	24	16	32.0	21.3
	1	28	47	59.6	13	15	27.7	31.9
	2	24	36	66.7	11	13	30.6	36.1
	3	14	15	93.3	6	8	40.0	53.3
T2 Max Integrity	0	30	53	56.6	13	17	24.5	32.1
	1	52	89	58.4	30	22	33.7	24.7
	2	18	24	75.0	7	11	29.2	45.8
	3	5	6	83.3	4	1	66.7	16.7
	-99	1	1	100.0	0	1	0.0	100.0

Variable	Categories	No. Lame	denominator	%	No. C	No. T	% C	% T
T1 ID	0	74	133	55.6	38	36	28.6	27.1
	1	1	1	100.0	1	0	100.0	0.0
	2	20	25	80.0	11	9	44.0	36.0
	3	9	12	75.0	3	6	25.0	50.0
	4	2	2	100.0	1	1	50.0	50.0
T2 ID	0	75	135	55.6	35	40	25.9	29.6
	1	4	6	66.7	3	1	50.0	16.7
	2	8	11	72.7	4	4	36.4	36.4
	3	12	13	92.3	10	2	76.9	15.4
	4	6	7	85.7	2	4	28.6	57.1
	-99	1	1	100.0	0	1	0.0	100.0
T1 FR	0	101	167	60.5	50	51	29.9	30.5
	1	4	5	80.0	3	1	60.0	20.0
	2	1	1	100.0	1	0	100.0	0.0
	3	0	0	0.0	0	0	0.0	0.0
T2 FR	0	95	161	59.0	47	48	29.2	29.8
	1	8	9	88.9	1	7	11.1	77.8
	2	2	3	66.7	2	0	66.7	0.0
	3	0	0	0.0	0	0	0.0	0.0
	-99	1	1	100.0	0	1	0.0	100.0
Treatments T1-T2	0	82	148	55.4	40	42	27.0	28.4
	1	18	19	94.7	9	9	47.4	47.4
	2	4	4	100.0	3	1	75.0	25.0
	3	2	2	100.0	2	0	100.0	0.0
T1-T2 ID	0	95	162	58.6	48	47	29.6	29.0
	1	11	11	100.0	6	5	54.5	45.5
T1-T2 FR	0	101	168	60.1	49	52	29.2	31.0
	1	5	5	100.0	5	0	100.0	0.0
Foot Trim level	0	54	88	61.4	54	0	61.4	0.0
	1	0	0	0.0	0	0	0.0	0.0
	2	22	40	55.0	0	22	0.0	55.0
	3	20	34	58.8	0	20	0.0	58.8
	4	10	11	90.9	0	10	0.0	90.9

T = treatment; C = control; No. = number

Appendix 5: Participant information leaflet

THE UNIVERSITY OF WARWICK

Participant Information Sheet

The University of Warwick has an experienced sheep lameness research team that works closely with EBLEX Ltd (the Beef and Lamb Sector Company for England). We are dedicated to increasing knowledge and finding methods to reduce lameness in sheep using practical, farmer orientated solutions. To do this we need your help.

Study title:

Lameness, welfare and production in sheep: farmer perceptions and behaviour.

What is the purpose of the study?

To explore the views of farmers with regard to lameness, welfare and production in lowland sheep flocks in Great Britain.

Why have I been chosen?

We are asking 35 farmers and shepherds who have everyday care of a flock of sheep in a lowland area of Great Britain to give us their views on health and production in their flock. You are part of that sample, if you choose to take part.

What will happen to me if I decide to take part?

A researcher will contact you to arrange a convenient date and time to visit your farm. On the day of the research visit, before the researcher arrives, you will be asked to identify a group of sheep on the farm in which there are lame sheep.
On arrival the researcher will introduce herself and answer any further questions you may have. She will then ask to walk around the field of sheep to make observations. She will not handle the sheep. This will take up to 1 hour depending on the size of the field / group. The researcher will do this part of the study by herself and quietly walk among the sheep, minimising disturbance.

After the observation period, the researcher will ask you to walk around this field of sheep with her and ask you to point out any sheep that you would consider to be lame and those you would treat for lameness. This may take up to 1 hour depending on the size of the field/ group.

After this period the researcher will conduct a detailed interview and chat further about your views on health and production in your sheep flock. The interview will take about one hour.

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Do I have to take part?

Participation in the project is voluntary. You do not have to take part and ar free to withdraw from the project at any stage if you wish.

What are the possible disadvantages and risks of taking part?

There are no disadvantages associated with this study.

What are the possible benefits of taking part?

This survey is one of the first surveys of its kind. The results will help to ai understanding of aspects of health and production in the sheep meat industr from the producer's perspective. Previous studies by this group have led t substantial cost saving benefits to farmers and significantly reduced th prevalence of lameness in these farmers' flocks.

Will my taking part in this study be kept confidential?

All information you provide is completely confidential and will be used solel for statistical purposes. The interview will be recorded and typed up shortl after the interview. The audio file will be stored securely as a passwor protected file and the written transcript will treated as confidential and code so that only the researcher knows your identity. Any information you provid that is used in either written or oral publication will be anonymous. Dat collected will be used solely for research purposes in accordance with th 1998 Data Protection Act.

What will happen to the results of the research study?

The results of the research will be analysed and written up as part of a thesi for a doctoral degree in Biological Sciences at the University of Warwick. Th research findings may also be published in academic journals, the farmin press, on websites and presented at conferences and seminar events.

Who is organising and funding the research?

The research project has been designed by Elisabeth Hawker (th researcher) who has a practical based Master of Science by Research degre (MSCR) in minimising lameness in sheep. She has two publications o lameness in sheep and has given presentations to farmers and academics a national and international conferences. The project is supervised by tw academics at the University of Warwick: Professor Laura Green who is veterinary expert in sheep lameness; and Professor John McEldowney who i an expert on decision making frameworks in the management of livestoc diseases. The research is funded by a Doctoral training grant CASI studentship from the Biotechnology and Biological Sciences Researc Council in collaboration with Pfizer.

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Who has reviewed the study?

The study has been reviewed and approved by the University of Warwick's Bio Ethics Research Committee, a Postgraduate Advisory Committee and members of the University of Warwick Biological Sciences Department.

Contact for Further Information:

Researcher:	**Project supervisor:**
Elisabeth Hawker Dept. Biological Sciences University of Warwick Gibbet Hill Road Coventry CV4 7AL	Professor Laura Green Dept. Biological Sciences University of Warwick Gibbet Hill Road Coventry CV4 7AL
Tel: 024 765 75874 Fax: 024 765 24619 Email: Elisabeth.Hawker@Warwick.ac.uk	Tel: 024 765 23797 Fax: 024 765 24619 Email: Laura.Green@Warwick.ac.uk

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Appendix 6: Consent form

THE UNIVERSITY OF WARWICK

Consent Form

☐ I confirm that I have read and understood the information sheet dated 07/11/2008 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without being penalised or disadvantaged in any way.

☐ I understand that any data collected will be stored confidentially and used anonymously. My name and contact details will be stored securely and separately and will not be disclosed or used for any purpose other than the research purposes given in the information sheet.

☐ I understand that relevant sections of any data collected during the study, may be looked at by responsible individuals from the University of Warwick, where it is relevant to my taking part in this research. I give permission for these individuals to have access to this data.

I agree to take part in the above study and am willing to:

☐ Allow the researcher to observe my sheep in the field

☐ Be interviewed

☐ Have my interview audio taped

Name of participant	Date	Signature
Name of person taking consent if different from researcher	Date	Signature
Researcher	Date	Signature

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Appendix 7: Participant instructions

THE UNIVERSITY OF WARWICK

Participant instructions

On the day of my visit, before I arrive:

1. Please identify a group of sheep on your farm that has the greatest number of lame sheep.

2. Please think about an answer to the following question:

   In the whole of your flock, approximately what percent of your ewes were lame in 2008?

On arrival:

I will introduce myself and ask if there are any questions you have about the visit or research. I will then ask you to sign a form giving your consent to take part in the study. I will then spend a bit of time walking around the group of sheep you have identified in advance minimising any disturbance to the group. I will **not** handle the sheep. You are not required to be present during this period which may take between 30 minutes to 1 hour depending on the size of the group.

After the observation period I will ask you to walk around the field of sheep with me and ask you to point out any sheep that you would consider to be lame and those you would treat for lameness. This may take up to 30 minutes depending on the size of the field / group. We do **not** need to catch or handle any sheep.

Finally, I will conduct a more detailed interview with you which will be tape recorded to allow for statistical analysis later on. For the interview it would be helpful if you could provide a quiet room with a couple of chairs and a table that can be used for the tape recorder. It is anticipated that the interview will last approximately 1 hour.

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Appendix 8: Covering letters

THE UNIVERSITY OF WARWICK

Elisabeth Hawker
Dept. Biological Sciences
University of Warwick
Gibbet Hill Road
Coventry
CV4 7AL

Tel. 024 765 75874
Fax. 024 765 24619
Email: Elisabeth.Hawker@warwick.ac.uk

[Farmer Name]
[Address 1]
[Address 2]
[Address 3]
[Address 4]
[Postcode]

[Date]

Dear [Farmer],

Thank you for agreeing to help with our research into lameness in sheep. Our ultimate aim is to provide results that will assist you, the farmer, to lower levels of lameness in your flock using practical, farmer oriented solutions. Your help is very much appreciated.

Further to my telephone call please find enclosed a participant information leaflet and a consent form which contains further information about the proposed study.

There are no correct or incorrect answers to any questions we ask during the visit. We just ask you to be as honest and accurate as you can. The data we gather will be confidential and any information you provide that is used in either oral or written publication will be anonymous.

I will contact you in about a week's time to answer any questions you may have and to arrange a convenient date and time for the interview. Participation in the project is entirely voluntary. You do not have to take part and are free to withdraw at any stage if you wish.

Should you have any questions about the research please do not hesitate to contact me. We are very grateful for your help in our research.

I look forward to meeting you.
Kindest regards and best wishes
Yours sincerely,

Elisabeth Hawker (BSc, LLB, MSc)

THE UNIVERSITY OF WARWICK

Elisabeth Hawker
Biological Sciences Department
University of Warwick
Gibbet Hill Road
Coventry
CV4 7AL

Tel: 02476575874
Email: Elisabeth.Hawker@warwick.ac.uk

[DATE]

[ADRESS]

Dear [FARMER],

Thank you very much for agreeing to help with this study. I look forward to meeting you at [TIME] on [DATE] at [FARM].

I have enclosed a short document that contains a few extra details about the visit and interview.

If you have any questions or there are any problems please do not hesitate to contact me on:

Tel: 024 765 75874
Mob: 0781 44 777 14

I look forward to meeting you at [TIME] on [DATE].

Kindest regards and best wishes
Yours sincerely,

Elisabeth Hawker

Appendix 9: Interview schedule

Interview Schedule: Producers

Section 1: Interview details:

Interview No.

Name of interviewer: Elisabeth Hawker

Date of interview:

Position in the business:

Address of the business:

Postcode:

Tel:
Fax:
E-mail:
Web address:

Section 2: Background Information about the farm and flock

1. What is your position on the farm? (job title)

2. Please tell me a little about the history and key motivations behind establishing the farm?
    a. Date of establishment
    b. Range of enterprises and size of each
    c. Lifestyle reasons
    d. Entrepreneurial
    e. Economic necessity

3. How would you describe yourself in terms of your approach towards farming?
    a. Progressive
    b. Entrepreneurial
    c. Traditional

4. How many years have you been farming?

5. How old are you?

☐ <25	☐ 26-35	☐ 36-45
☐ 46-55	☐ 56-65	☐ >65

6. What is your highest educational qualification?

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7. Could you tell me a little bit about your sheep flock and management?
    a. Breed
    b. Size of flock
    c. Number of full-time and part-time employees
    d. Stocking density
    e. Housing
    f. Lambing period

8. Have there been any significant changes to management of the sheep flock in the last 5 years?
    a. Number of employees
    b. Size of flock
    c. Breeding programme

Section 3: Flock management

9. Could you briefly talk me through a typical day with your sheep flock?

10. What are the most important tasks in the flock?
    a. in the year
    b. weekly
    c. daily

11. What would you say is the biggest concern you currently have about your flock?

Section 4: Lameness

12. Approximately what percent of the group of sheep inspected this morning were lame?

13. In your flock, approximately what percent of your ewes were lame in 2008?
    a. Does this vary monthly

14. How did you calculate these figures?
    a. Sheep that you treated
    b. All lame sheep you see

15. Do you record lameness in your flock records?
    a. Why / why not?

16. What treatments have you given for lameness to this group of sheep in the last two weeks?

17. What method do you use to identify lameness in the flock?

18. If you see a lame sheep in your flock, what happens next?
    a. Individual treatments / whole flock

19. How do you treat sheep with FR and ID?

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20. Have you always treated these diseases this way?
    a. When and why did you change?

21. Where did you hear about these methods and why do you use them?

22. Are you satisfied with these methods?

23. Are there alternatives that you could use?

24. Why do you treat lame sheep?
    a. Motivation
    b. Barriers
    c. What does lameness mean to you?
    d. How important is lameness in the context of other health issues:
        i. Worms
        ii. Fly strike

25. Do you currently cull sheep for lameness?
    a. Do they go for immediate cull
    b. Why / why not?

26. Do you think that lameness affects production?

27. Would you say that lameness is a welfare issue?

Section 4: Production and health

28. If you were looking to make improvement in your flock's performance where would you go to get this information?
    a. Nutrition
    b. Disease
    c. Increasing your lambing percentage
    d. If more than one, who is the most influential

29. Where would you ideally like to get this information from?

30. What do you use your vet for?

31. When did you last see your vet and what was this for?

32. Do you have a vet that you usually deal with?

33. How knowledgeable do you feel your vet is about flock management?
    a. managing lameness
    b. managing disease
    c. EBVs
    d. flock performance
    e. grassland management
    f. biosecurity on the farm
    g. managing pregnancy
    h. improving fertility

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34. Are you satisfied with the advice you receive from your Vet?

35. I would like to interview some of the vets of the farmers we have interviewed to get their views on health and production in sheep flocks. Would you be willing to give us permission to contact your vet?

    a. If yes, what is the name and address of vet?

Section 5. Flock management and the buyer

36. Who do you sell your sheep to?

37. Does the person / company that you sell your sheep to have any influence on production or management of your flock?

38. What about any welfare standards or protocols you have to adhere to?

39. Do you think that good standards of animal welfare are something that is profitable for sheep producers?

Section 6: Final section, the future

40. How do you see your flock developing over the next 5 years?

41. What factors are currently influencing your plans for the future?

42. Finally, are there any other issues you would like to raise about your farm business, especially in relation to flock health, welfare or production?

I. Would you like to see a copy of the interview transcript?
   Yes ☐ No ☐

II. Would you like me to send you a summary of the research results once completed?
   Yes ☐ No ☐

III. If I have any further questions, can I contact you?
   Yes ☐ No ☐

IV. Would you be interested in taking part in further research?
   Yes ☐ No ☐

Version 1.0 Dated 24/10/2008

Appendix 10: Postal questionnaire

THE UNIVERSITY OF WARWICK

Better Returns Programme

EBLEX

Questionnaire on your opinions and management of lame sheep in your flock

Even if you do not consider lameness to be a problem in your flock please complete this questionnaire. We need answers from farmers with high, low and zero levels of lameness.

Please answer all questions as accurately and honestly as possible, there are no right or wrong answers to anything we ask.

Your opinions are very valuable and important to us and are all confidential.

PLSS/2011/[IDcode] Version 1.0 Dated: 19/08/2011

SECTION 1: YOU, YOUR FARM AND YOUR FLOCK

1. How many years have you been farming?__________ *(years)*

2. Are you:
   ☐ Male ☐ Female

3. How old are you? *(Please tick only one answer)*
   ☐ Less than 25 ☐ 26-35 ☐ 36-45
   ☐ 46-55 ☐ 56-65 ☐ over 65 ☐ Unwilling to say

Please select *one flock* on your farm and answer *all questions* based on this one flock.

4. Is this flock: *(Please tick only one answer)*
   ☐ Lowland ☐ Upland ☐ Hill

5. Is this flock: *(Please tick only one answer)*
   ☐ Commercial ☐ Pedigree

6. What was the average level of lameness in this flock over the last 12 months? __________%

SECTION 2: LAMENESS IN YOUR FLOCK

7. Please write in today's date: __________ *(day/month/year)*

8. When did you last check this flock for lameness? *(Please tick only one answer)*
   ☐ Today ☐ Yesterday ☐ 3 or more days ago ☐ Over a week ago

9. At this check, how many ewes were in this flock?__________

10. At this check, in this flock, how many ewes *(treated and untreated)* were lame?__________

11. At this check, in this flock, how many ewes that you previously treated were still lame?__________

12. At this check, in this flock, how many ewes were untreated and lame? __________

13. At this check, in this flock, how many lame ewes were too mildly lame to treat?__________

14. At this check, in this flock, how many ewes were lame enough to treat? __________

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15. Did you use an antibiotic injection *and* antibiotic spray within 3 days of becoming lame to treat **adult ewes lame with footrot or interdigital dermatitis (scald/strip)** between lambing and weaning 2011? *(Please tick one answer for each column)*

For footrot:	For interdigital dermatitis (scald/strip):
☐ Always	☐ Always
☐ Most of the time	☐ Most of the time
☐ Sometimes	☐ Sometimes
☐ Never	☐ Never
☐ Not applicable	☐ Not applicable

SECTION 3: YOU AND YOUR VET

16. In the last 12 months, what services have you accessed from your vet? *(Please tick all that apply)*
    ☐ Medicines ☐ Advice ☐ Flock health planning
    ☐ Seminars/meetings/courses ☐ None
    ☐ I do not have a vet *(if you do not have a vet, please go to question 21)*
    ☐ Other *(please state)*: __________

17. How frequently do you contact your vet regarding your sheep? *(Please tick only one answer)*
    ☐ Monthly ☐ Every 3 months ☐ Twice a year ☐ Once a year
    ☐ Less than once a year

18. When did you last contact your vet about your sheep? __________ *(month/year)*

19. What was this contact for? __________

20. Was this contact:
    ☐ A telephone call ☐ A visit to the practice
    ☐ A farm visit for sheep only ☐ A farm visit for cattle and sheep

21. **Between lambing 2010 and lambing 2011**, did you attend any meetings, seminars or courses on lameness in sheep?
    ☐ Yes ☐ No *(If no, please go to section 4, question 27)*

22. Who organised the meeting(s), seminar(s) or course(s)? *(Please tick all that apply)*
    ☐ Vet ☐ EBLEX ☐ ADAS ☐ HCC
    ☐ RDA ☐ Don't know ☐ Other *(please state)*: __________

23. After attending the event, did you make any changes to management of lameness in your flock?
    ☐ Yes ☐ No *(If no, please go to section 4, question 27)*

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24. If yes, what did you change?

____

____

25. Was this successful at reducing levels of lameness?

☐ Yes ☐ No ☐ Don't know

26. If yes, what was your level of lameness: **Before the changes** ______________ %

After the changes ______________ %

Don't know ☐

SECTION 4: YOUR VIEWS ON LAMENESS

The table below provides descriptions of lameness in sheep with increasing severities of lameness

	Score	Description of sheep when lying, standing and walking
	0	Sound (not lame), bears weight on all four legs when walking
Increasing severity of lameness ↓	1	Uneven posture, shortened stride on one leg when walking
	2	Visible nodding of head in time with a shortened stride when walking
	3	Not weight bearing on affected limb when standing but weight bearing when walking
	4	Not weight bearing on affected limb when standing or walking
	5	Difficulty rising, reluctant to move, lame on more than one limb
	6	Will not stand or move

27. From the table, what is the lowest score you would recognise a sheep as lame?

1 2 3 4 5 6 *(Please circle only one answer)*

In the last 12 months:

28. From the table, what is the lowest score of lameness that you would catch with the intention of treating?

1 2 3 4 5 6 *(Please circle only one answer)*

29. How many ewes would need to be lame at this score for you to catch them?

☐ 1 ☐ 11 – 20
☐ 2 – 5 ☐ More than 20
☐ 6 – 10 ☐ I do not catch lame individuals

30. If you gave a different answer for question 27 (what you recognise as lame) and question 28 (what you would treat) why do you not treat all ewes that you recognise as lame?

____

____

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31. From the table, what is the lowest score of lameness that you would report sheep as lame for a postal survey?

1 2 3 4 5 6 *(Please circle only one answer)*

A number of farmers were interviewed about potential motivations and obstacles to immediate treatment of lame ewes.

The statements below are from what farmers have told us in these interviews. We have placed a 10cm line, immediately below each statement, each 10cm line represents a scale from 0 to100.

Please mark with a cross on the line your opinion of the statement where 0 is never why you would treat a lame ewe and 100 is always a reason you would treat a lame ewe.

(For example: I treat lame ewes to keep their fleece white)

0 Never —X————————— *100* Always)

32. I treat lame ewes to improve my profit.

0 Never ______________ **100** Always

33. I treat lame ewes to relieve their pain.

0 Never ______________ **100** Always

34. I treat lame ewes to improve their welfare.

0 Never ______________ **100** Always

35. I treat lame ewes to prevent the spread of lameness.

0 Never ______________ **100** Always

36. I make a special effort to catch and treat a lame ewe if it were near a footpath, bridleway or other public place.

0 Never ______________ **100** Always

37. Are there any any other reasons why you treat lame ewes? *(Please state the reason and fill in the scale to suggest how important this reason is).*

Other reason: ______________________________

0 Never ______________ **100** Always

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For the following statements, please indicate your opinion by marking an 'X' on the line below each statement where 0 never prevents you catching a lame ewe and 100 always prevents you catching a lame ewe for treatment.

38. I have difficulty finding and identifying a mildly lame ewe once the flock is gathered.

0 Never ______________ **100** Always

39. I have difficulty catching a mildly lame ewe in the field for treatment.

0 Never ______________ **100** Always

40. The distance of the flock from suitable handling facilities prevents me from treating a lame ewe immediately.

0 Never ______________ **100** Always

41. Lack of an assistant to help gather ewes prevents me from treating a lame ewe immediately.

0 Never ______________ **100** Always

42. Lack of a suitably trained dog to gather ewes prevents me from treating a lame ewe immediately.

0 Never ______________ **100** Always

43. Lack of time prevents me from treating a lame ewe immediately.

0 Never ______________ **100** Always

44. Are there any any other reasons that prevent you from treating a lame ewe immediately? *(Please state the reason and fill in the scale to suggest how important this reason is).*

Other reason: ______________________________

0 Never ______________ **100** Always

Page 6 of 12

For the following statements, please indicate your opinion by marking an 'X' on the line below each statement to show <u>how much you agree or disagree</u> on a scale of 0 to 100, where 0 is disagree and 100 is agree.

45. Lameness is a minor problem in my sheep flock.

0 Disagree ________________ **100 Agree**

46. Levels of lameness of 2% or less result in fewer barren ewes, fewer ewe deaths, ewes with more milk, greater lamb survival and lambs that finish earlier.

0 Disagree ________________ **100 Agree**

47. It is too time consuming to catch a ewe for treatment every time one is lame. I have to wait until there is more than one in a group.

0 Disagree ________________ **100 Agree**

48. I am reluctant to catch and turn a lame ewe during tupping for inspection and treatment.

0 Disagree ________________ **100 Agree**

49. I am reluctant to catch and turn a lame ewe that is heavily pregnant for inspection and treatment.

0 Disagree ________________ **100 Agree**

50. I never catch individual lame ewes for treatment.

0 Disagree ________________ **100 Agree**

51. *"Some farmers never catch and treat individual lame sheep but wait until the flock is gathered".*

Do you think this is an effective practice for managing lameness?

☐ Yes ☐ No ☐ Don't know

52. Please explain why? *(Please write your answer in the space below).*

53. Recent recommendations given by the Farm Animal Welfare Committee state:

"The prevalence (level) of lameness in flocks farmed in Great Britain should be reduced to 5% or less within five years of the publication of this Opinion (2011) as an interim target and to 2% or less (which is already possible with best practice) within ten years."

Do you think this is a reasonable target for your flock?

☐ Yes ☐ No ☐ Don't know

54. Do you think you could achieve it in your flock?

☐ Yes ☐ No ☐ Don't know ☐ Already achieve it

55. Please explain your answer:

SECTION 4: ROUTINE FOOT TRIMMING

56. Did you trim the feet of ewes in this flock as a <u>*routine*</u> procedure in the last 12 months?

☐ **No ewes** *(If no, please answer question **57A** below)*

☐ **All ewes** ☐ **Some ewes** *(If all or some ewes, please go to question **57B**)*

57. **A)** If you have stopped <u>*routine*</u> foot trimming, why have you stopped? *(Please go to question 63)*

57. **B)** If you currently <u>routinely</u> foot trim, what do you believe would happen if you stopped?

58. How often have the feet of your ewes been <u>routinely</u> trimmed in this flock in the last 12 months? *(Please tick one answer)*

☐ **Once** ☐ **Twice**

☐ **More than twice** *(If more than twice, please state how often)*: ____________

59. Why did you foot trim as a <u>*routine*</u> procedure in the last 12 months?

60. In a recent study, on one farm in the UK, a flock of 170 ewes were divided into two equally sized groups. One group received a routine foot trim and the other no routine foot trim. Changes in body condition, foot shape and damage, the level of lameness and foot lesions were recorded over a period of 3 months. Results showed no difference in:

- the body condition of ewes
- foot shape or damage
- the level of lameness or severity of lameness
- the level of interdigital dermatitis (scald / strip) or footrot

i.e. the routine trim was not harmful but not beneficial either

Based on these findings, on a scale of 0 to 100 how likely are you to stop <u>*routine*</u> foot trimming?

(Please mark your answer on the line below with an 'X')

0 Very unlikely ________________ **100 Very likely**

61. Please explain the reason(s) for your answer:

62. What evidence would you require to stop <u>*routine*</u> foot trimming?

63. How do you rate the use of <u>*routine*</u> foot trimming as a method to control lameness?

☐ Excellent ☐ Good ☐ Average ☐ Poor ☐ Don't know

END OF QUESTIONNAIRE

Thank you for completing this questionnaire,
your help is very much appreciated.

Please return your completed questionnaire in the FREEPOST envelope provided.

If you would like to receive the results of this survey and / or participate in further research into lameness or mastitis in sheep please complete the final page on the reverse of the questionnaire (page 12).

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Page **11** of **12**

Research Results

Would you like to receive a summary of the results of this survey when they are available?

☐ Yes ☐ No

If you are interested in receiving updates on research into lameness and mastitis in sheep being carried out at the University of Warwick please tick as appropriate:

☐ **I would like to receive results of this survey only**

☐ **I would like to receive newsletters on lameness and mastitis when new results arise by email**

☐ **I would like to receive newsletters on lameness and mastitis when new results arise by post**

Are you interested in helping further with research into lameness and mastitis in sheep?

☐ Yes ☐ No

If you have ticked any of the boxes above, please check or update your details below, including your email address and telephone number. All of your details will be kept confidential and will not form any part of this survey. Details provided will not be used for any other purpose.

[Farmer name]
[Farmer address]

Email: ____________________

Phone: ____________________ **Mobile:** ____________________

Thank You!

Please return your completed questionnaire in the FREEPOST envelope provided.

PLSS/2011/[IDcode] Page **12** of **12**

Appendix 11: Initial cover letter

THE UNIVERSITY OF WARWICK

Farmer perceptions of lameness in sheep survey

Dear [Farmer Name],

The University of Warwick has an experienced sheep lameness research team that works closely with EBLEX (the organisation for the English sheep and beef industry). We are dedicated to increasing knowledge and finding methods to reduce lameness in sheep using practical, farmer orientated solutions. To do this we need your help.

Lameness in sheep is rated by sheep farmers as the second largest cause of economic loss, yet the prevalence of lameness in the UK is estimated to be approximately 12%. The enclosed survey aims to aid understanding of lameness management from your point of view and will provide valuable data to direct further research. Previous studies by our group have led to substantial cost saving benefits to farmers and significantly reduced the prevalence of lameness in these farmers' flocks.

You are one of 1000 randomly selected sheep farmers in England who are being asked to complete the enclosed questionnaire. There are no correct answers. We just ask you to answer as honestly and accurately as you can. There are 63 questions and it should take approximately 20 minutes to complete. The success of this survey depends on our obtaining replies from as many farmers as possible. Therefore, even if you do not consider lameness a problem in your flock, please complete the enclosed questionnaire.

All replies will be treated confidentially and used solely for statistical purposes. Data collected will be anonomised and used for research purposes in accordance with the 1998 Data Protection Act. The research is funded by a doctoral training grant CASE studentship from the Biotechnology and Biological Sciences Research Council in collaboration with Pfizer and has been reviewed and approved by the University of Warwick's Biological Ethics Research Committee.

The questionnaire is being sent out in October 2011 and we hope that you will reply promptly. You will receive up to two reminders. We will send you a summary of the results from this survey when they are available.

If you have any difficulties or questions, please contact us below by telephone or email.
We thank you for your help with this survey.

Yours sincerely,

Elisabeth King (BSc. LLB. MScR) and Prof. Laura Green (B.V.Sc. MSc. PhD. MRCVS)

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Better Returns Programme

EBLEX

Appendix 12: Final reminder cover letter

THE UNIVERSITY OF WARWICK

Reminder: Farmer perceptions of lameness in sheep survey 2011

Dear [Farmer name],

If you have already replied please disregard this reminder and many thanks! We understand that you are busy, but we would really appreciate if you could take some time in your hectic schedule to fill in our questionnaire on your perceptions of lameness in sheep.

Lameness in sheep is rated by sheep farmers as the second largest cause of economic loss. Yet, the prevalence of lameness in the UK nationally is estimated to be 12% and has not changed since 1994. This survey aims to understand management of lameness from your point of view and will provide valuable data to direct further research. Our ultimate aim is to provide results that will assist you, the farmer, to lower levels of lameness in your flock using practical, farmer orientated solutions. We need your help to do this.

The success of this survey depends on obtaining replies from as many farmers as possible. Therefore, even if you do not consider lameness a problem in your flock, please complete the enclosed questionnaire and return it in the enclosed freepost envelope.

All replies will be treated confidentially and used solely for statistical purposes. Data will be anonomised and we will only publish aggregated results.

We will send you a report of results from this study when available. If you don't have any sheep on your farm, kindly return the blank questionnaire.

If you have any difficulties or questions, please contact us by telephone or email.
We thank you for your help with this survey. It is very much appreciated.

Yours sincerely,

Elisabeth King (BSc. LLB. MScR) and Prof. Laura Green (B.V.Sc. MSc. PhD. MRCVS)

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Better Returns Programme

EBLEX

Appendix 13: Reminder postcard

THE UNIVERSITY OF WARWICK

Better Returns Programme

EBLEX

Lameness Questionnaire Reminder

Dear Farmer,

We recently sent you a questionnaire about your perceptions of lameness in sheep to help enable us to understand your views of this important problem. Our ultimate aim is to provide results that will assist you, the farmer, to lower levels of lameness in your flock using practical, farmer oriented solutions. We really would be most grateful if you could find the time to complete and return the questionnaire we sent. If you have lost your questionnaire please contact us using the details below and we will send a second questionnaire. If you have returned your questionnaire in the last few days, please ignore this request and many thanks!

Kind regards,
Elisabeth King (BSc. LLB. MScR) and Laura Green (B. V. Sc. MSc. PhD. MRCVS)

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Appendix 14: Thank you postcard

THE UNIVERSITY OF WARWICK

Better Returns Programme

EBLEX

Thank You !

Dear Farmer,

Thank you so much for answering our questionnaire on lameness in sheep your help is very much appreciated. Our ultimate aim is to provide results that will assist you, the farmer, to lower levels of lameness in your flock using practical, efficient, farmer oriented solutions. It is because of your help that we will be able to better understand your views of this important and costly problem and help contribute to advice on how best to control and manage lameness.
We will send you a summary of the results from the questionnaire when complete.

Kind regards,
Elisabeth King (BSc. LLB. MScR) and Laura Green (B. V. Sc. MSc. PhD. MRCVS)

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