Hotspot sheep scab management: a community-based regional approach in England

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Abstract

Background: Ovine psoroptic mange (sheep scab), caused by infestation by the mite, *Psoroptes ovis*, leads to clinical disease, economic loss and severely compromised animal welfare. Here, a community-based approach to the management of scab in three high-risk areas of England is described.

Methods: For each of 254 farms, an initial survey of their clinical sheep scab history was followed up by a blood test (ELISA) to detect the presence of scab. This facilitated the co-ordination of treatment across groups of farms in each region. Flocks were retested using the blood test at the end of the programme.

Results: On the first blood test in 2021/22, 25.6% (±5.5%) were positive for scab. On the second test in 2022/23, 9% (±3.94%) of the flocks tested were positive, showing a highly statistically significant reduction in prevalence overall, but with strong regional variation.

Limitations: generating an understanding of the flock-level nature of the blood test and confidence in its detection of scab where clinical signs were not apparent provided ongoing challenges.

Conclusions: The programme demonstrates that a focussed community-based approach can be used to significantly reduce the prevalence of scab in high-risk areas of England. The use of the blood test on all farms allowed the identification of sub-clinical scab. The programme provides an effective model for scab management on a national scale.

KEYWORDS

Community, Disease, ELISA, Psoroptic mange, Prevalence, Risk

INTRODUCTION

Ovine psoroptic mange (sheep scab) is an infectious condition caused by a hypersensitivity response to infestation by the mite, *Psoroptes ovis*.[1,2] Infestation results in clinical disease, economic loss and severely compromises animal welfare. Sheep scab was reintroduced to the UK in 1972 [3,4] and control was regulated until 1992. Deregulation was followed by a 100-fold increase in the number of outbreaks[3] despite many attempts to limit the rising incidence of scab. Estimates suggest that there are about 8,000 outbreaks/year in the UK[5], resulting in an estimated cost of £78-£202 million annually to the sheep industry in Great Britain.[6] The future management of scab has been further complicated by the confirmation of resistance to all the macrocyclic lactones that are currently available for therapeutic treatment.[7,8] As a result, there is an urgent need to develop precision management strategies, based on a better understanding of the causes of scab transmission.

The prevalence of sheep scab varies widely across the UK. [5] Areas of highest prevalence [9] occur where the density of sheep farms is highest and where common grazing is widely practiced. [10] Both of these factors increase the degree of connectedness between flocks and facilitate contact and/or mixing between flocks, encouraging the rapid farm-to-farm transmission of infection. Historically, compulsory national management strategies resulted in control measures being applied to very large numbers of animals that were at low or negligible risk of scab. In contrast, the ability to identify high risk areas allows control measures to be applied in a more focused manner and this is likely to result in lower chemical inputs, lower environmental contamination and minimize the rate of selection for resistance because unexposed mites remain in *refugia* in untreated areas. More focused treatment could be particularly effective if used in association with the recently developed enzyme-linked immunosorbent assay (ELISA) blood test for sheep scab[2] which detects host-circulating antibodies with specificity for the *P. ovis* mite antigen, Pso o 2. This has been shown to be a more effective approach to diagnosis (sensitivity 98.2% and specificity of 96.5% [11,12]) than the traditional skin scrape, which has been reported to have sensitivity as low as 18% [13]. The blood test also allows the identification of sub-clinical infestations, from as early as two weeks post-infestation.

The aim of the work reported here was to use a community-based approach to controlling scab in targeted high-risk areas of England. The approach adopted aimed to test the flocks on groups of contiguous farms (clusters) in the three regions using the scab blood test, to then co-ordinate treatment on farms with flocks that were positive for scab (including in-contact farms as appropriate) and finally to retest all farms the following year to identify any reduction in scab prevalence.

MATERIALS AND METHODS

Three high-risk regions in England were selected. These were: the North (Cumbria, Lancashire, North Yorkshire, and Northumberland), the Midlands (Shropshire and Herefordshire) and the Southwest (Cornwall and Devon). These are known to be areas of high prevalence of sheep scab as identified in previous surveys[5, 9]. Within each broader region, the intention was to select farms that were in clusters; clusters were defined as groups of farms that were contiguous with each other, or with a maximum of 0.5 km between boundaries, and/or that shared common grazing. Physical discontinuity between clusters of farms was considered ideal, with boundaries consisting, for example of roads, rivers or woodland, although this proved difficult to achieve in practice. The objective was to recruit between 70 and 100 farms in each region (up to 300 in total), either as multiple small clusters or as part of fewer large clusters. A key principle of the programme was that farmers who participated had to agree to share information on their scab status with other farmers in their cluster and coordinate any treatments for scab.

Management and farm recruitment

The overall programme was managed by a steering group, composed of the authors (Fig. 1). Within each region, farm recruitment and day-to-day management was undertaken by regional co-ordinators. These were the NSA (National Sheep Association) in SW England, ADAS in the Midlands and the Farmer Network in the North. Regional co-ordinators had the pivotal role of communicating with farmers, their local veterinarians and, as appropriate, with mobile dipping contractors brought in for scab treatment.

Regional co-ordinators initially arranged a series of local farm meetings in their region in the spring/early summer of 2021, presenting the aims of the programme (early meetings were online because of ongoing COVID restrictions, but from July onwards were largely in person). Farmers were recruited at, or shortly after these meetings, and signed approved consent and data protection forms. Each farm was assigned a 3-part unique identifier detailing their region, cluster, and farm number.

The involvement of the farm's own veterinary surgeon was also pivotal in the project; they took blood samples and provided advice and support to the farmers. CPD training talks on the epidemiology and control of scab were given for participating veterinarians in June/July 2021 by members of the steering group, one of which was recorded for wider dissemination.

Participating farmers had an initial farm visit by their relevant coordinator (or by telephone/on-line where a face-to-face meeting was not possible) during mid-late 2021. Farmers initially completed an extensive retrospective questionnaire detailing their experience of scab outbreaks in the previous 10 years in addition to information on their location, farm, flock, management practices, and opinions on sheep scab. During the meeting, the flock/group to be tested for scab with the blood test was decided. These details were uploaded onto a centralised database.

The first blood testing began in June/July 2021. However, the timing of blood testing varied widely within and between regions, so that it could fit with farm-based activities within each cluster. For example, in the North where the use of common grazing was widespread, blood-testing coincided with gathering and in one Midlands cluster, testing coincided with winter scanning. Blood samples were taken from a single management group of 12 animals from each farm. The recommended sample size of 12 animals had been designed to achieve a flock-based sensitivity and specificity of approximately 95%, assuming that the within-flock prevalence of sheep scab was 20% at the time of testing. During blood testing, details were gathered about whether an Organophosphate (OP)/endectocide had been applied in the previous three months, whether scab was evident/suspected in the flock, and whether diagnosis had been confirmed by analysis of skin scrapes. The blood samples were processed with the scab ELISA by Biobest Laboratories Ltd. (Fig 1) following a previously published protocol[11.]

Blood sample plates were read at 450nm on a microplate reader to obtain optical density (OD) values. To avoid subjective interpretation of the OD results from the ELISA, with different veterinarians or farmers making individual decisions about the action required, a Bayesian hierarchical model (Giles Innocent, personal communication) was used to assess the OD outputs and decide whether a flock was positive or negative for scab. The posterior probability was assessed on a scale of 0 to 1, and values > 0.5 were considered to be positive for sheep scab in the analysis.

The scab prevalence data reported here are based strictly on the absolute algorithm interpretation of the OD results. However, for practical farm management advice, where OD values were very close to the cut-off threshold or the overall positive value was generated by a single positive animal, the algorithm output was considered in context of the farm by members of the steering group (see discussion). Factors taken into account were the scab history at that farm, the on-farm risk factors and the date of the last treatment for scab. Farmers were then advised on the most suitable management approach for that flock using four options: treat, no need to treat, monitor, or re-test.

The OD results and interpretation were copied to the regional co-ordinators; the farm's own veterinarian then communicated the results to the farmer and the cluster to allow coordinated treatments to take place. Veterinarians undertook a follow-up visit to each farm to discuss the results, treatment options and, if required, further biosecurity measures. Where treatment was required, co-ordination with neighbours was encouraged to ensure recently treated farms were not quickly reinfested by the sheep of contiguous farms. The use of contract dippers and OP dip was recommended but, where not considered appropriate, farmers and their veterinarians were allowed to use their treatment of choice.

All prevalence estimates are reported here as percentages with ±95% confidence intervals. The differences between the regional prevalence estimates were assessed with chi-square analysis, using the *chisq.test* function in R (R version 4.1.1), with sequential Bonferroni corrections, made to the acceptance thresholds (P-value) when multiple comparisons were made.[14]

RESULTS

Farmer participation

Farmer recruitment began in early 2021; the speed of recruitment varied widely between regions. In the North and Southwest, recruitment was rapid, whereas in the Midlands bringing farmers together initially proved to be more problematic. In effect, all interested farmers within a designated geographic boundary were accepted into the programme. However, the ability to describe discrete 'clusters' proved variable; in the North clusters represented flocks sharing commons, geographic groupings were more easily defined in the Southwest, but in the Midlands, clusters were difficult to define and farms were grouped simply into two broad areas, one of which was very large. Blood testing of 12 sheep per farm began in June 2021. The cut-off date for completion of the first blood test was 31/03/2022. In total, 254 farms (North = 83, Midlands = 80, Southwest = 91) had performed at least one blood test by the first cut-off date and had completed the background questionnaire sufficiently comprehensively, to allow inclusion in the data analysis. The second blood test took place between mid to late 2022 and early 2023, and the cut-off date for second blood test used in the analysis was 28th February 2023, by which time 66 (North), 76 (Midlands) and 56 farms (Southwest) had tested.

Prevalence

As part of the initial questionnaire farmers were asked whether they had experienced clinical sheep scab in the previous year (2020). Overall, 17.4% (±4.6%, n=48) farmers self-reported clinical scab in 2020 in the three regions: 19.3%, ±9%, n=16 in the North, 26.9% ±10.5%, n=25 in the Midlands and 7.0% ±5.6%, n=7 in the Southwest. However, the blood test identified 25.6% (±5.5%, n=65) farms that were positive for scab in 2021/22: 33.7% ±10.5%, n=28 in the North, 21.2% ±9.4%, n=17 in the Midlands and 22.0% ±8.9%, n=20 in the Southwest (Fig. 2). Overall, there were significantly more scab outbreaks detected using the blood test in 2021/22 compared to the self-reported clinical cases in 2020 (χ^2= 4.8, df = 1, P = 0.03). The number of farms positive based on the blood test was significantly greater than reported clinical cases in the North (χ^2 = 3.7, df = 1, P = 0.05) and the Southwest (χ^2 = 7.6, df = 1, P = 0.005), but not in the Midlands (χ^2= 0.47, df = 1, P = 0.5). These data are discussed in more detail elsewhere.[14]

Subsequently, 9% (±3.94%) of the flocks that completed the second test by 28/02/2023 were positive. Overall, there was a significant reduction in the number of farms that tested positive between the first and second tests (χ^2 = 17.7, df = 5, P < 0.001), however, the overall result was strongly driven by the significant decline in positive flocks in the North, whereas the falls in the percentage of positive cases in the Midlands and Southwest were not statistically significant. In the North 6% (n=4) of 66 farms were positive as indicated by the blood test (Fig. 2). In the Midlands, 10.5% (n=8) of the 76 who completed a second test were positive, although two of these were subsequently negative on a further test one month later. In the Southwest, 10.7% (n=6) of 56 farms were positive (Fig. 2). In terms of farms that were positive on both the first and second blood test, there were none in the North, two in the Midlands and one in the Southwest.

Costs

This project was funded by the EU-funded Rural Development Programme for England (RDPE) awarded by the Department for Environment, Food & Rural Affairs (Defra) of the UK Government and as such the costs were very tightly constrained. A payment of £150 was made available to the co-ordinators for each farm visit. The coordinators also received a payment for each farmer that attended the subsequent cluster group meetings and £100 was paid to the farm's own veterinary surgeon to visit and take blood samples for sheep scab blood testing with an additional £100 available for the second blood collection visit. Funding was also made available at £72 for each flock-level blood test with two (flock-level) tests provided for each property at a total cost of £144. Finally, £250 was available for the farmer's own vet to visit each property and undertake a biosecurity audit, focusing on best practice control and risk factors for sheep scab control. The overall cost averaged out at about £700 per farm over the two-year programme. The farmers paid for any treatment costs themselves.

DISCUSSION

This programme was designed to act as a pilot to test a novel community-based approach to scab control. This involved the use of a Sheep Scab ELISA blood test to allow the early identification of the presence of scab in a flock (before clinical signs). Three regions in England with highest prevalence of persistent scab were selected. The programme resulted in a significant reduction in the number of flocks testing positive for scab overall, with a reduction from 26% to 9% positive among those tested. However, this overall significant reduction was driven principally by the size of the reduction in the Northern region; the magnitude of effects in the Midlands and Southwest were less pronounced although notably many farmers used their blood retest outside of the appropriate end-of-programme time-frame and so were not included in the data analysis.

The programme provided invaluable insight into future approaches that are likely to be both effective and sustainable in the UK. The first, and possibly most important observation, was that in many cases sub-clinical scab, as detected by the blood test, can persist in flocks without being obvious to the farmer or veterinarian. This appeared to be the case particularly in the North and may have been associated with the more widespread use of common grazing, less frequent inspections and more hardy hill breeds in these areas (discussed in more detail elsewhere[14]). The important implication is that management programmes that rely on farmer self-diagnosis are unlikely to be effective, since sub-clinical cases will be missed. Hence, the blood test needs to be used on all farms in a management area; its use only on farms where scab is suspected would have the same consequence as self-diagnosis, namely sub-clinical scab will be missed, allowing scab to persist and spread, unnoticed and unchecked.

A further lesson relating to the blood test is that both veterinarians and farmers need to have confidence in the test outputs. Lack of confidence undermines the willingness to accept that a flock might be infested and to take the expensive step of treating and doing so in collaboration with neighbours. Generating confidence in the blood test must be achieved by clear explanations of its benefits, but also its limitations. It is a flock-level test and should not be used, nor the OD results interpreted, for individual animals. Furthermore, it has a defined sensitivity and specificity, which means that the outputs need to be considered and explained to farmers with some care. Awareness that antibodies persist for up to about three months after an infestation has been treated, and that antibody responses may vary with age, breed and previous infestation history also need to be considered.

Arguably, the most important limitation to what could be achieved in this programme was the amount of funding available. In the initial costings, two blood tests were allowed for each farm, one at the start and one at the end of the programme. However, where flocks tested positive, those farmers who treated wanted follow-up testing more quickly to confirm that the treatment had been successful, which used up their second funded test. Alternatively, some farmers and veterinarians were reluctant to accept the indication that sub-clinical scab was present based on a positive blood test result because it was not associated with clinical signs of scab. This had two consequences. Firstly, confirmatory testing was often requested, again using up the second allocated test for each farm. Secondly, the initial aim had been simply to use the statistical algorithm to determine the scab status based on the ELISA OD and give a positive/negative result. However, to explain outcomes to sometimes sceptical farmers and veterinarians, a process of interpretation and explanation of the OD results assumed greater importance. This is why in addition to 'positive' or 'negative' results, additional categories of 'monitor' or 'retest' were included in the advice given to farmers. This interpretation of the algorithm outputs in the light of scab history for each individual farm was relatively labour-intensive, requiring expertise. This would not be possible on a larger scale. Multiple testing added expense and used up the funds available, which contributed to the lower number of tests being available for the concluding blood test at the end of the trial.

Another constraint of the programme design, again linked to cost, was that many larger farms run sheep in several flocks or management groups and therefore wanted to test each group. This was not feasible given the funding available and may have limited the impact in some cases. For some farms, there was difficulty in deciding which management group to test; the recommendation from the steering group was to test the one most likely to have or have been in contact with other sheep with scab. In any future iteration of this programme, the number of tests clearly needs to be related to the number of management groups run by each farm.

In two of the three regions farmers were readily engaged, collaborated with neighbours and the regional co-ordinators and recruitment and retention was good. In one region, recruitment and collaborative activity was more difficult at the start, although did improve rapidly over the course of the programme and, ultimately, the engagement was similar across all three regions. In practice, the aim of identifying geographically discrete clusters was difficult to achieve uniformly and the reduction in scab incidence was considered to be strongest in regions and clusters where farmers had a pre-existing network or history of collaboration between neighbours. One additional issue was the need to get flocks tested within specific time windows to allow co-ordination because testing needed to fit with farm management. Too great an asynchrony in testing would allow infection in an area to persist and reinfect. In the present programme, co-ordination was particularly likely in the North because a large proportion of animals were grazed on commons and co-ordinated gathering and treatment was an existing practice. The variations in the timing of blood-testing may have had an impact on the scab prevalence that was recorded in each region.

The importance of co-ordination highlights the need for the involvement of enthusiastic, effective and engaged regional co-ordinators and veterinarians, with on-the-ground experience in each area. The active participation and expertise of the regional co-ordinators engaged in this programme was considered to be an essential element of its success and would be for any future management programmes. Ideally, these co-ordinators should be part of organisations and veterinary practices already embedded and working within their local communities.

CONCLUSIONS

Overall, the programme demonstrated that a community-based approach could be used to achieve significant reductions in the prevalence of scab within high-risk areas of England. The programme engaged farmers and promoted a collective approach to disease management, which is essential given the potential for scab to spread between contiguous farms. For the future, tighter co-ordination of testing and treatment within regions and geographic clusters should be encouraged, and strategies to engage the occasional uncooperative farmers who de-motivated neighbours are important. The subsidisation of treatment costs for positive farms would also be valuable, but the authors believe that some farmer contribution to cost is also important. A substantial increase in discussion amongst farmers about scab was evident, with some setting up WhatsApp groups to share information; these discussions also helped to highlight best practice (for example, not applying OP plunge dip via showers or jetter systems, which are not likely to be effective). Coordination made it easier and more convenient for farmers to contact and synchronise with mobile dippers. The use of the blood test on all farms was considered to be pivotal – allowing the identification of farms with sub-clinical scab. The programme was relatively inexpensive (although was clearly under-resourced) and provides an effective model which, with some modification, could be extended nationally. However, self-evidently, harmonisation and standardisation of the management approach across devolved nations in the UK will be essential.

AUTHOR CONTRIBUTIONS

The initial concept for the application to RDPE was generated by SCOPS (Lesley Stubbings) with subsequent contributions to study design by Stewart Burgess and Richard Wall. All authors contributed to project management. Stewart Burgess undertook interpretation of the ELISA OD outputs and provided advice to veterinarians and farmers. Richard Wall wrote the first draft of the manuscript; all authors contributed subsequent redrafting and all authors have reviewed and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

FUNDING INFORMATION

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DATA AVAILABILITY STATEMENT

The anonymised data that support the findings of this study will be shared on reasonable request.

ETHICS STATEMENT

Ethical approval was granted by the Moredun Research Institute and all participants provided written informed consent prior to enrolment in the study.

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Figure 1: Reporting structure of a scab management programme in three regions of England.
significant

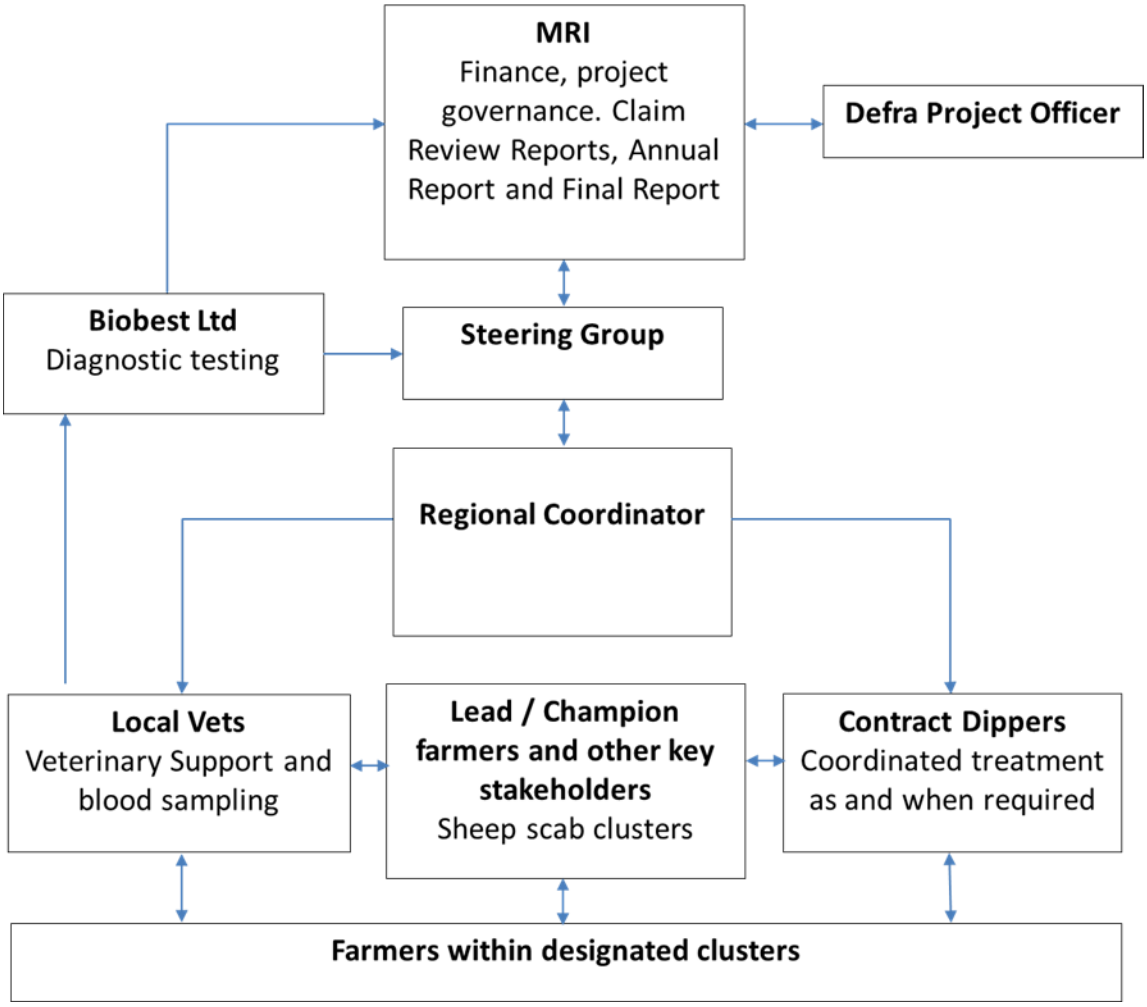

Fig 2. The percentage of farms that reported scab in 2020 based on clinical signs and the percentage that tested positive for scab (± 95% binomial confidence interval), as determined by a blood test ELISA in three regions of England, at the start and end of a two-year scab management programme.