

Working towards the eradication of *Psoroptes ovis* in Wales

A report of a proposed strategy to the Welsh Government by the Welsh Sheep scab Group

Sept 2018

Animal Health and Welfare Wales were commissioned to prepare this strategy on behalf of the Welsh sheep scab industry group.

Contents

1	EXECUTIVE SUMMARY	6
2	INTRODUCTION	7
3	CURRENT SITUATION	7
3.1	BACKGROUND	7
3.2	AETIOLOGY.....	7
3.4	DIAGNOSIS.....	9
3.5	TREATMENT OPTIONS	9
4	NATIONAL SCAB SCHEMES	11
4.1	UNITED KINGDOM.....	12
4.1.1	Current situation in Wales	12
4.1.2	Scotland.....	12
4.1.3	England.....	13
4.2	OTHER EU COUNTRIES	13
4.2.1	The Republic of Ireland	13
4.2.2	France.....	13
4.2.3	Germany.....	14
4.2.4	Austria	14
4.2.5	Scandinavia	14
4.3	NON-EU COUNTRIES.....	15
4.3.1	Australia	15
4.3.2	New Zealand	15
4.3.3	USA.....	15
4.3.4	South Africa.....	15
4.3.5	Lesotho.....	16
4.3.6	Argentina.....	16
5	BARRIERS TO ERADICATION	17
5.1	SOCIO-ECONOMIC BARRIERS	17
5.2	ENFORCEMENT BARRIERS.....	18
5.3	OPERATIONAL BARRIERS	18
6	COMMON LAND	18
6.1	MYNYDD EPYNT GROUP	19
6.2	DYFFRYN DYFI GROUP	20
7	WELSH INDUSTRY ACTIVITY	20
7.1	“STOP EVERY DROP” CAMPAIGN	20
7.2	INDUSTRY GUIDES.....	20
7.3	DATA COLLECTION	21
7.4	DIRECT FUNDING	21
8	COST BENEFIT ANALYSIS	21
9	EVIDENCE BASE FOR CONTROLLING SCAB IN WALES	22
10	PATHWAY TO ERADICATION: STRATEGY PHASES	24

10.1	PHASE 1.....	24
10.1.1	Creation of Sheep Scab Eradication Management Group	24
10.1.2	Knowledge Transfer Activities.....	25
10.1.3	Reporting farm	25
10.1.4	Diagnosis of sheep scab	26
10.1.5	Contiguous farms	26
10.1.6	Low-risk movements.....	26
10.1.7	Common Grazing.....	27
10.1.8	Repeat treatment.....	27
10.1.9	Tracings	27
10.1.10	Treatment certification	27
10.1.11	Off farm surveillance	27
10.1.12	Treatment preference	27
10.2	PHASE 2.....	28
10.2.1	Knowledge transfer.....	28
10.2.2	Reporting farm	28
10.2.3	Diagnosis of sheep scab	28
10.2.4	Contiguous farms	28
10.2.5	Low risk movements	28
10.2.6	Common grazing	28
10.2.7	Treatment certification	28
10.2.8	Off farm surveillance.....	29
10.2.9	Treatment preferences	29
10.3	PHASE 3.....	29
10.3.1	Off farm surveillance.....	29
10.3.2	Reported farms	29
10.3.3	Contiguous farms	29
10.3.4	Treatment preference.....	29
10.3.5	Knowledge transfer.....	29
10.3.6	Compliance penalties.....	29
11	FUNDING	30
12	SHEEP SCAB ERADICATION PLAN BUDGET	31
12.1	BESPOKE ERADICATION PLAN RESOURCES	32
13	BRIEF SUMMARY OF STRATEGY	33
	APPENDIX 1: FLOWCHART OF THE FIRST PHASE OF THE SCAB PROGRAM.....	34
	APPENDIX 2 - ALTERNATIVE APPROACHES.....	35
	APPENDIX 3: SHEEP SCAB ERADICATION PROGRAMME ACTION REPORT.....	36
	APPENDIX 4: SENSITIVITY ANALYSES.....	38
	APPENDIX 5 MODELLING A LIKELY SPREAD OF SCAB IN WALES.....	41

1 Executive Summary

Sheep scab is a highly contagious and insidious disease. Although the Welsh sheep sector has seen several programmes and initiatives designed to eradicate the presence of this disease over the years, these programmes have, to date, been largely unsuccessful.

By utilising recent research and by evaluating sheep scab programmes from other countries, the proposed strategy aims to lessen the impact of many of the problems discovered in previous programmes. These include lack of engagement, inappropriate treatment and the spread of disease to contiguous premises.

By providing an engagement incentive in the form of free diagnosis and treatment, the proposed strategy aims to increase engagement from more reticent sheep keepers. Furthermore, by co-ordinating treatment with premises contiguous to an outbreak, the proposed strategy aims to mitigate, as far as possible, the oft-quoted issue of re-infection. The strategy also aims to ensure that appropriate treatment is deployed by establishing technical expertise which will oversee the use of both OP dips and injectables. This should provide both treatment accountability and robustness. Finally, it is hoped that the use of farmer focus groups will not only aid in identifying risky neighbouring premises, but will also allow for the facilitation of wider discussions on flock health planning and biosecurity.

The proposed strategy has been established as a two phase approach and full details on each of the phase components can be found in section 10 entitled 'Pathways to Eradication'. The first phase can be broadly categorised as follows:

- Creation of a Sheep Scab Management Group.
- Information Cascade: Including knowledge transfer activities.
- Sheep Scab Status: Determination of farms that voluntarily report suspected scab outbreaks: including confirming the diagnosis and treatment of the reporting farm.
- Treatment Co-ordination: Including the use of focus groups to identify contiguous farms, diagnosis on contiguous farms and treatment preferences
- Surveillance Mechanisms
- Alternative Mechanisms: Including a provision for direct to slaughter and other low-risk movements
- Facilitation of Risk Based Trading: including treatment certification

A flowchart of Phase 1 can be found in Appendix 1.

The second phase of the proposed strategy mirrors phase 1. However the notable difference between the two phases is that contiguous premise treatment can only occur when all farms contiguous to a reporting farm engage in the farmer focus group. The change in phase 2 has been specifically designed to increase sheep keeper accountability and to facilitate behavioural change through increased social pressure.

Notwithstanding the above, it is highly unlikely that any voluntary sheep scab eradication strategy will be able to fully eradicate sheep scab from Wales. Voluntary programmes are only as strong as their weakest participant and therefore cannot fully mitigate the chance of reinfection from reticent unengaged sheep keepers. This proposed strategy therefore aims to work towards sheep scab eradication by improving knowledge and awareness and by reducing the incidence of this disease in Wales prior to discussions on future legislative measures

2 Introduction

The AHWS Steering Group was made up of relevant stakeholder organisations, facilitated by the Welsh Government, and aimed to work in partnership to take forward the implementation of the 2004 – 2014 GB Animal Health and Welfare Strategy¹ in Wales. The Welsh Government has developed a new Welsh Animal Health and Welfare Strategy. This succeeded the current Great Britain Animal Health and Welfare Strategy which ended in 2014. The AHWS Steering Group was succeeded by a new Animal Health and Welfare Framework which will be implemented through an Animal Health and Welfare framework Group. The previous AHWS Steering Group identified Sheep scab as a key priority disease and the current Animal Health and Welfare Group will be well placed to receive the report of the recommendations from the Sheep Scab Sub group. The Sheep Scab Sub Group was established by the Animal Health and Welfare Strategy (AHWS) Steering Group to make recommendations to the AHWS Steering Group and Welsh Ministers on the eradication of Sheep Scab in Wales.

The sheep scab subgroup is composed of individuals from the farming unions, levy boards and industry experts. This report is the culmination of the work of all of these groups and individuals and is presented to the Animal Health and Welfare Framework group for consideration.

3 Current Situation

3.1 Background

The sheep industry is an iconic industry for Wales; with some 14,000 farms holding sheep in all areas. Exports of lamb are worth 121 million pounds per year and these exports reflect 93% of lamb production in Wales. The Welsh flock represents 29% of the total UK flock². There are 4.65 million breeding ewes and around 4.9 million lambs. Flock sizes range from 1-5 animals to flocks with 2000 animals or more. The average flock size is around 700 including all classes of sheep.

The Welsh sheep sector has seen several programmes and initiatives designed to eradicate the presence of sheep scab. However, previous Welsh and UK scab eradication programmes have been largely unsuccessful and it is notable that deregulation in 1992 led to an 'exponential increase' in the incidence of this disease in both Wales and the UK³. UK estimates suggest that the number of outbreaks per annum could range from 100 to 7000. Data on the prevalence of sheep scab in the Welsh sheep sector remains varied and is largely dependent on the results of farmer surveys. Some studies in Wales have mooted a prevalence of around 24%; with 36% of producers having a recognised scab outbreak within a 5 year period. It is estimated that the cost of sheep scab to the industry in Wales could be in excess of 5 million pounds per annum.

3.2 Aetiology

Sheep scab is one of the most contagious diseases of sheep in Wales and is a major health and welfare concern. Sheep scab is a skin disease caused by the parasitic mite *P. ovis*. The mite lives on the skin surface skin and feeds on the fluids and skin cells of the sheep. When the mite defecates in the skin, the antigen in these faeces promotes a hyper sensitivity reaction. Infected sheep suffer from an intense pruritus which they will attempt to relieve by scratching to the point of ignoring all other activity and causing significant self-harm.

¹ <http://wales.gov.uk/topics/environmentcountryside/ahw/animalhealthandwelfarestrategy/?lang=en>

² John Richards, pers comm. www.hccmpw.org.uk

³ Wall R. et al. (2017) The prevalence and distribution of sheep scab in Wales.

Development of the scab mite from an egg to an egg laying adult takes just 14 days and the mite can survive off the sheep host for 18 days. Adults can lay 2-3 eggs per day and the disease can spread rapidly between individuals in a flock. Clinical signs are generally observed around 40-50 days post-infection and the disease may spread significantly in that time.

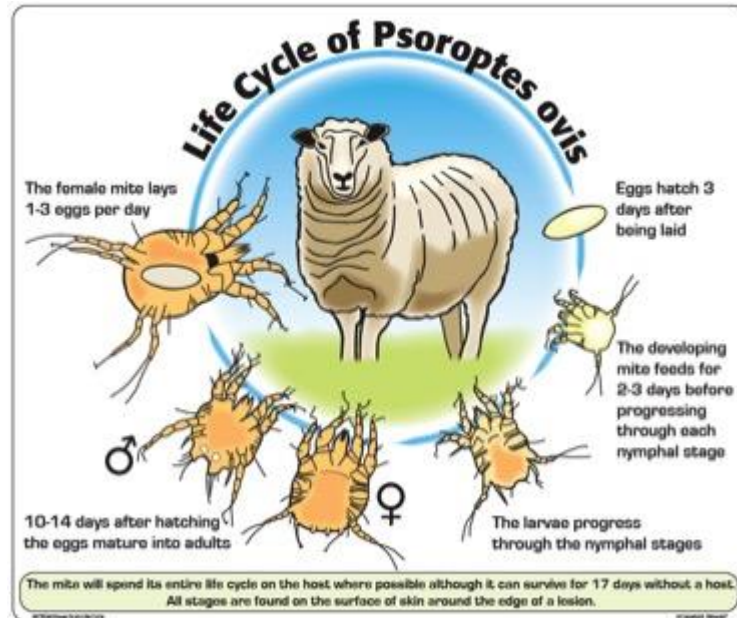


Figure 1 Sheep Scab lifecycle - picture courtesy of Bimeda

Whilst sheep scab can occur throughout the year, it typically peaks in the autumn and winter months due to increased fleece length and housing.

Scab infection can be introduced to a farm through contact with infected sheep which have been brought onto farm without appropriate measures being applied in order to protect existing stock. Sheep which have been recently infected with this ectoparasite may not display clinical signs and introduced animals should always be considered a source of infection. Blood testing for exposure, applying appropriate treatments or buying from certified free flocks can reduce the risk of infection.

Other sources of infection include exposure to mites in contaminated fields or through fomites such as handling facilities, shared equipment and transport.

3.3 Economic Impact

Alongside the associated welfare issues, failure to properly treat a scab infection can cause significant economic losses due to rapid loss of body condition, low birthweights, higher lamb mortality from infected ewes and the downgrading or condemnation of carcasses at slaughter.

The price received for finished lambs can be affected by numerous factors. These include the production system used, the breed of animal, weather conditions, supply and demand dynamics, the exchange rate and the volume of imports and exports. However, profitability in the sheep sector is general volatile and seasonal. The highest prices tend to be received in late spring, with prices falling in the summer months. Whilst prices can rise towards winter, figures for 2017

demonstrate that 2017 prices were lower than in the preceding 3 years⁴. The volatility and low profitability experienced on lowland sheep farms will therefore be exacerbated by scab infection.

3.4 Diagnosis

The differential diagnosis of a pruritic sheep includes lice, sheep scab, and some other skin diseases. Definitive scab diagnosis is essential as some treatments, such as those for lice, will not work on a scab infestation (and vice versa) and can therefore lead to apparent treatment failure.

Definitive diagnosis of sheep scab is by microscopic examination of a skin scrape on the edge of the lesion on the sheep's skin. The presence of a live mite in the sample is diagnostic of sheep scab. The presence of a dead mite does not indicate active infection in either the individual animal or the associated flock as it may indicate the animal has been treated. All Vets carrying out farm work will have microscopes capable of sufficient magnification in order to make the diagnosis. Alternatively the use of microscopic examination is available at all Veterinary Diagnostic labs.

A blood test is currently available through one commercial laboratory (Biobest)⁵. This can demonstrate infection before clinical signs (for example as part of a quarantine protocol) or it can be used to demonstrate that a flock or management group is free from disease.

A negative result on the blood test indicates no exposure to the disease (though there is a 2 to 4 week lag phase in developing antibodies). Testing 12 sheep per management group of up to 2000 sheep will allow the determination of disease presence or absence in that flock. It should be noted that 20% of animals in the flock would need to be infected for 12 animals to be sufficient to demonstrate disease. Due to the infectivity of the disease it is expected that this figure will be reached by two weeks. A single positive test amongst the twelve would be considered indicative of *P.ovis* infection and justification to treat.

At present, sheep scab eradication is heavily reliant on the passive reporting of disease. The development of a new strategy provides an opportunity to deliver a more active surveillance system that should allow proactive, rather than reactive, treatment on some farm premises. Moreover, the presence of expert observers on farm could allow active surveillance to confer additional 'free' benefits such as the identification of other health and welfare issues on the farm.

3.5 Treatment options

Current treatments for sheep scab infestations rely on either injectable endectocides based upon macrocyclic lactones (MLs) or organophosphate dips. Both types of treatment come with associated advantages and disadvantages and these have been summarised in table 1. In either case, the use of products to counter a scab infection will lead to lengthy and inconvenient meat withdrawal periods. These periods can be doubled for organic producers and can significantly hinder the ability of farm businesses to move or trade animals.

A. Macrocyclic lactones are broad spectrum anthelmintics. Those licensed for scab are administered by injection only. The use of MLs may inadvertently increase resistance to wormers amongst the nematode parasites in the Welsh flock and care must therefore be taken when utilising this injectable. Some ML products provide a level of protection post administration

⁴ Farm Incomes in Wales 2017-17. <https://gov.wales/docs/statistics/2017/171213-farm-incomes-2016-17-en.pdf>

⁵ Correct at the time of writing – Sept 2018

when used according to the datasheet. However this is not true for all and selection of the specific macrocyclic lactone must be therefore made with care. Accurate dosing at the appropriate time is critical to the success of injectables and there remains a concern that inaccurate dosing has increased in frequency over recent years. A full list of the available scab treatments can be found in table 2.

It has been suggested that there is a potential adverse effect on terrestrial insects but there is little supporting evidence for this assertion.

There is evidence of resistance in *P. ovis* isolates from Wales suggesting that this treatment may not be successful on some farms.

B. An organophosphorus dip can be used to successfully treat sheep scab, lice and a number of other external parasites. The significant health and environmental risks associated with this product means that usage requires a good technique to be followed to avoid operator injury, environmental contamination and post dipping lameness. The Health and Safety Executive (HSE) provides advice for farmers and others involved in dipping sheep⁶. This advice covers planning, the use of precautionary measures and product disposal advice. However, given that dipping remains an effective method of controlling sheep scab, these concerns must be balanced appropriately against the mitigation of disease spread.

Dipping must be carried out correctly in order to have the best effect and work is being carried out to accredit mobile dippers throughout the UK. Increasing the number of mobile dippers will be important in helping this programme.

Product	Advantages	Disadvantages
Macrocyclic Lactones	Product Choice No Human Health Risk No Environmental Contamination Risk	Lengthy Withdrawal periods Potential Drug Resistance Conferred for both Mites and Nematodes
Organophosphorus dip	Protection Against Other Parasitic Infections Does not Contribute to Drug Resistance	Lengthy Withdrawal Periods Human Health Risk Environmental Contamination Risk

Table 1. A comparison of the current antiparasitics appropriate for the treatment of sheep scab in Wales.

⁶ HSE Publication URL: <http://www.hse.gov.uk/pubns/ais41.pdf>

Trade name	Active ingredient	Route of administration	Treatment or prevention	Duration of protection	Withdrawal period (Meat)	Requirement to move post treatment
Osmonds Gold fleece dip	Diazinon	Dip	Both	60 days	49 days	NO
Paracide 62	Diazinon	Dip	Both	4 weeks	70 days	NO
Cyductin 1%	Moxidectin	Injection	Both	28 days	70 days	NO
Cyductin 2%	Moxidectin	Injection	Both	60 days	104 days	NO
Dectomax 10mg/ml	Doramectin	Injection	Both	14 days	70 days	YES
Ecomectin	Ivermectin	Injection	Treatment only	N/A	42 days	YES
Ivomec classic	Ivermectin	Injection	Treatment only	N/A	37 days	YES
Noromectin 1%	Ivermectin	Injection	Treatment only	N/A	42 days	YES
Panomec	Ivermectin	Injection	Treatment only	N/A	37 days	YES

Table 2. Current sheep scab treatment options approved for use in Wales. The majority of treatment choice relates to macrocyclic lactones.

It should be noted that a draft genome assembly of *P. ovis* was recently published by Burgess and co-workers in April 2018. Work on the development of a scab vaccine and the identification of novel drugs may therefore begin in the future. Initial attempt to stimulate protective immunity has shown promise. However, these remain longer-term aspirations and, at present, MLs and OPs remain the only viable option for sheep keepers wishing to control scab.

4 National Scab Schemes

Sheep scab has been reported in approximately 150 countries worldwide. In many of these countries, sheep scab remained notifiable until the mid-1980s. However, as with the UK, many countries have deregulated this disease and this has led to variable results. Several of these programmes are reported below and a summary of the main strategy constituents can be found in table 3. In general, the main risks associated with the spread of sheep scab can be classified as (1) movement of animals onto the farm; (2) contact with neighbouring animals; (3) contact at market / in transit; (4) common grazing and (5) shearing and scanning contractors.

It should be noted that several of the barriers recorded in table 3 represent early attempts to control the disease and do not represent the current situation in the country of interest. Nevertheless, such barriers are important when considering those policies or measures which could be used within a Welsh context.

4.1 United Kingdom

Previous UK eradication programmes designed to combat sheep scab were successful; with eradication being achieved in 1952. The UK remained free of sheep scab until it was reintroduced from Ireland in 1973. From then until 1990 a renewed campaign was undertaken to control the disease. However, efforts made to eradicate this disease in some of the devolved administrations have remained unsuccessful due to a variety of barriers to eradication. These can be broadly categorised into (1) Enforcement; (2) Socio-economic and (3) Operational issues. A full list of disease eradication barriers can be found in section 5.

In recent years, the differing devolved administrations have embarked on various levels of sheep scab control and these will be discussed in more detail below.

4.1.1 Current situation in Wales

The UK sheep scab order 1997 applies in Wales making it an offence to leave a sheep infected with scab untreated. Moving an infected sheep is also illegal. The Animal health and Welfare framework group has made sheep scab one of its priority. The Welsh government has published guidance notes to encourage a consistent approach to enforcement by local authorities. The enforcement of this legislation appears to be patchy and of low priority for most local authorities.

4.1.2 Scotland

The end of compulsory dipping in 1992 saw a steady rise in the number of cases of sheep scab in Scotland. Concerns surrounding issues such as rising scab incidence and the public perception of the Scottish sheep sector, led to the establishment of the Scottish Sheep Scab Initiative in 2003. This 3 year initiative aimed to raise awareness of scab in Scotland and to promote and support best practice in both preventative and reactive disease control. The initiative had broad support amongst all stakeholders and was largely industry led.

The Scottish Sheep Scab Initiative was a precursor to the development of legislation. The end of this initiative saw the genesis of a Scottish Sheep Scab Industry Working Group in 2007. This group comprised government and industry policy makers to steer the development of new legislation.

Scottish sheep scab regulation places a legal obligation on any person who has reason to believe that sheep in their possession or care have sheep scab to notify their local Animal and Plant Health Agency (APHA) office as soon as possible. Enforcement action can be taken against those owners and keepers whose sheep are suspected of having scab, but who repeatedly fail to take appropriate treatment action.

Scottish scab regulation also makes provision for movement restrictions to be placed on infested flocks until sheep are either treated/slaughtered or disease is ruled out via veterinary confirmation. The regulation also covers sheep scab identified at market or exhibition and scabby sheep identified on common land. For the latter, all persons keeping sheep on the affected common may be required to treat or remove sheep.

Sheep scab remains notifiable in Scotland.

4.1.3 England

As in Wales, English local authorities can force the treatment of scab infected sheep or can take other action if the disease is present in a flock and appropriate steps are not undertaken. However, budgetary constraints mean that there is a lack of proper policing and scab infested flocks can therefore go unnoticed for significant periods of time. Such flocks represent a source of infection to neighbouring flocks and compliant sheep keepers could face multiple reinfections from apathetic or reticent neighbours.

In the English (and Welsh) Sheep Scab Order 1997, a sheep is 'visibly affected' with sheep scab if it exhibits clinical signs of the disease. However, it is notable that, in Scotland, the Sheep Scab (Scotland) order 2010 applies to affected sheep and affected carcasses of sheep. 'Affected' means 'affected or suspected of being affected' with sheep scab and this can allow for the forced treatment of flocks contiguous to a scab outbreak.

The Sheep Scab Order gives English and Welsh Local Authorities (LAs) powers to improve the control of this disease by preventing the movement of sheep visibly affected with sheep scab and enforcing the treatment of sheep visibly affected with sheep scab. It also confers powers which allow LAs to deal with sheep scab on common land.

An RDPE funded awareness campaign entitled 'Stamp Out Scab' was carried out in England. This knowledge transfer campaign included roadshows for veterinarians and SQPs, awareness campaigns, best practice advice, treatment options and common treatment mistakes. The campaign aimed to engage the entire supply chain and to combat barriers to eradication such as misdiagnosis and inappropriate dosing.

However, whilst the strategy sought to foster 'shared responsibility' for scab, a lack of regulatory enforcement means that the initiative continues to lack focus and treatment remains uncoordinated. The lack of suitable incentives to diagnose and treat scabby sheep means that compliant farmers continue to be vulnerable to reinfection from untreated neighbouring flocks. It remains unclear whether this strategy has resulted in any decline in the level of sheep scab in England.

It is expected that future sheep scab eradication in England will make use of funds provided under the Rural Development Programme will complement those proposed under the Welsh strategy.

4.2 Other EU Countries

4.2.1 The Republic of Ireland

Unlike mainland UK, sheep scab has never been eradicated in the Republic of Ireland. Regulation pertaining to this disease included compulsory notification and sheep dipping orders. However, compulsory dipping ended in 1994 and the control of this disease now rests with the sheep keeper or veterinarian.

With the exception of flumethrin, an early synthetic pyrethroid licensed in the UK, treatments for sheep scab are akin to the UK.

4.2.2 France

Sheep scab was a notifiable disease in France until the mid-1990s, however it remains compulsory to treat infected flocks. Compliance with legislation prior to deregulation was deemed to be patchy and compliance was not widespread.

French industry bodies have engaged in several national-level awareness campaigns in order to promote sheep scab treatment and prevention amongst the farming community. France has perhaps the greatest amount of choice for treating sheep scab, including dipping, injectables and jetting. However, inappropriate treatment has led to poor results and a lack of faith in the ability of current treatments to combat scab. Some of the treatments currently utilised in France, such as the use of a singular intramuscular dose of doramectin, have been shown to be ineffective in the UK at the dose rate used in France.

Following treatment, biosecurity measures include spraying equipment and premises with an acaricide and leaving empty for 10 days.

In more recent years a regional approach has been applied in areas where transhumance is practiced which sees around 20 percent of the national flock engaged in compulsory scab treatment programmes. Treatment of infested sheep is carried out under veterinary supervision.

4.2.3 Germany

Following near eradication in 1948, sheep scab was reintroduced into Germany some 25 years later. Prior to the 1970's, eradication programmes included annual dipping to treat and prevent sheep scab.

Following reintroduction, the disease spread to areas which had high stocking densities, close contact between flocks and poor forage. The time between dipping lengthened considerably and legislative requirements were not met. Sheep scab was further spread by common grazing which was established in North Friesland. Compulsory notification of this disease ended in 1991.

Sheep scab remains a problem in Germany; with continued flock expansion in some areas. Authorised treatments include sebacil (phoxime) plunge dipping and double injections of ivermectin. Farmers using injectables must also wash housing with acaricide.

4.2.4 Austria

Sheep scab remains a disease of economic importance in Austria and is notifiable. Infected sheep can be treated using ivermectin injectables or must be dipped using either organophosphate dip or (phoxim) sebacil. Sheep which are deemed to be severely infected must receive keratolytic treatment and low value individuals must be slaughtered. Where sheep are to be introduced into the flock, they must undergo quarantine and must be treated for sheep scab twice, 6 days apart.

4.2.5 Scandinavia

Whilst Norway and Sweden eradicated sheep scab in 1984 and 1934, minor sporadic outbreaks of this disease continue in Denmark.

Sheep scab was previously eradicated from Denmark in 1929 and this country remained scab free for around 50 years. Danish sheep flocks generally have a low incidence of disease and this is attributed to the proactive role of private vets in health planning.

4.3 Non-EU Countries

4.3.1 Australia

Sheep scab was first introduced into Australia in 1788. Despite some successes, the disease was reintroduced in 1882 and 1884. However, the spread of scab was minimised at this time due to the quarantine of infected premises and the culling of infected sheep and contacts.

P. ovis was finally eradicated from Australia by 1896. This was achieved by the development of effective dips and dipping equipment and appropriate legislation to support the control of disease. Scab policy also saw the culling of strays and infested sheep. However, it should be noted that strong demand for tallow at this time led to a high demand for carcasses and thus high prices. Prices for infected sheep declined as eradication progressed.

The disease is currently kept out of the continent by a ban on the import of live sheep into Australia.

4.3.2 New Zealand

Scab was imported from Australia in the 1840s. Legislation to control the movement of infected sheep in unfenced areas was introduced in 1864, 1868 and 1878 and, as in Australia, a campaign of dipping was utilised alongside a legislative programme. The Sheep Scab Act consolidated previous disease eradication attempts and meant that farmers could be fined for having the disease in their flocks. Where disease was found to persist, such as North Canterbury, infested sheep were culled. Wild sheep were also culled during a two year high intensity programme.

The introduction of barbed wire fencing is regarded as a key development allowing the control of sheep scab.

4.3.3 USA

Embryonic disease programmes in the USA were largely unsuccessful. This was, in part, due to a lack of co-ordination and poor communication.

Scab eradication was given more serious consideration following the closure of Australian and European sheep markets and early treatment included lime sulphur dipping as part of a federal programme of control. However, despite some in-roads, sheep scab remained an issue and a more intensive federal programme emerged to tackle the disease. This new campaign was flanked by new treatments, quarantine procedures for brought in animals and funding for enforcement officers. The eradication campaign, which backed regulatory procedures, promoted industry buy-in and was conducted in a manner which ensured sheep keepers understood their responsibilities.

Scab eradication was achieved on a state-by-state basis and the USA was declared officially scab free in 1973. However, it must be noted that the eradication of scab resulted in a significant drop in the number of sheep.

4.3.4 South Africa

There is a long history of regulation pertaining to sheep scab in South Africa. The continued spread of the disease resulted in a compulsory dipping programme which was established in the early twentieth century. Several outbreaks were reported during the years of compulsory dipping, however these were largely due to non-compliance and illegal sheep movements.

In more recent years, concerns relating to the high levels of insecticide used caused the authorities to moot deregulation. However sheep scab remains notifiable in South Africa and is an increasing issue. Nevertheless, whilst it remains compulsory to treat ectoparasitic infections and to have permanent dip tanks, official policy is fractured and enforcement is poor. Moreover, producer apathy, conflicting husbandry methods and a declining sheep sector have functioned to present significant barriers to eradication.

4.3.5 Lesotho

A decade long campaign saw the eradication of sheep scab in Lesotho in 1935. The funded programme saw the provision of more than 200 dip tanks which were used under the control of more than 40 Livestock Improvement Centres situated around the country. Specialist staff were available in each of the Livestock Centres and the swift implementation of further scab control following reintroduction of the disease in the 1970's is, in part, attributed to the existing infrastructure and staffing levels.

The dipping policy introduced resulted in the single dipping of infected and contact flocks after shearing. However, identifying all infected flocks proved problematic due to the unrealistic and expensive level of personnel required. Furthermore, sheep keepers consistently opposed the plunge dipping of contact sheep that appeared to be scab free and noncompliance was manifest in keepers moving animals to avoid dipping in their region. There were no mechanisms for producers to 'buy out' of testing by demonstrating freedom from scab.

The spread of sheep scab between 1975 and 1986 led to a National Simultaneous Dipping Campaign. The campaign included regulatory measures for movements and shearing conditions and also included improvements in dipping facilities. The approach to dipping followed three approaches: (1) Preliminary dipping in badly affected flocks was paid for by the sheep keeper (2) Free dipping in areas deemed to be infected with the disease and (3) National free dipping.

It is somewhat unsurprising that the uptake of paid for preliminary dipping was poor. Sheep keepers tended to wait for free dipping, even if this contributed to a higher mortality rate in infested flocks. The national free dipping was the most successful of the three approaches in reducing scab incidence, however many keepers did not undertake the subsequent dipping required and this undermined the programme. Sheep scab remains a problem in Lesotho.

4.3.6 Argentina

Plunge dipping was the historic treatment of choice against sheep scab in Argentina. However, early control of the disease was ineffective due to operator error. The use of new insecticides promoted better treatment and scab was almost eradicated from Argentina by 1960.

Reports of drug resistance hindered further scab eradication in Argentina and this was compounded by variable animal husbandry standards which were not conducive to disease eradication. However, scab remains a notifiable disease in this country.

A degree of funding has been applied to scab programmes in Argentina, however the level of funding applied has seen a steady and significant decline. A voluntary programme, involving key players in the supply chain, has seen better co-ordination and this programme has a cost recovery basis. The initiative involves sharing best practise, treatment for scab in co-ordinated farmer groups and some financial assistance to pay time and direct costs. Whilst sheep scab has not been eradicated in Argentina, the majority of outbreaks reside in farms which are poorly managed.

5 Barriers to Eradication

Numerous studies have highlighted the operational, regulatory and socio-economic reasons for the failure of national eradication programmes to deliver disease eradication. Many of these barriers have been documented in more than one country and some of these have been listed in Table 3.

In general terms, voluntary proactive animal disease initiatives will only be as successful as the weakest participant. Livestock keepers who do not currently undertake measures to proactively protect against disease proliferation are known to cite treatment costs, time and resource shortages, strict environmental compliance regulations and lengthy withdrawal periods as some of the factors precluding participation in disease management. Furthermore, a fear of reprisals and a lingering tendency to equate a disease outbreak with poor husbandry may also make livestock keepers reticent to engage in voluntary programmes. Other factors include the perception that there are no real disease production losses and no added value for disease free animals. A summary list of these socio-economic factors can be found below.

5.1 Socio-Economic Barriers

- Withdrawal periods too lengthy causing issues with sheep sales. This is especially pertinent for organic producers.
- Farmer apathy due to continual reinfection from neighbouring farms.
- The unsustainable, resource intensive, and unpopular notifiable disease procedures in the face of an increasing number of cases.
- Movement controls and segregating treated and untreated sheep poorly received by the industry.
- No added value for scab free sheep within the supply chain.
- No perceived disease losses.
- The presence of sheep scab on a farm can be seen as an indicator of poor farmer ability. This makes farmers reticent to go public. Privacy - "It's no one's business".
- Farmers do not want to report another sheep keeper to Local Authorities and the expectation is that any organisation will require reporting. There is a fear of a lack of anonymity.
- Conversely those farmers that are willing to report express frustration that the authorities take no action to resolve the issue. This can lead to apathy if such farmers continue to get reinfected.
- The costs of injectable treatments is quite low and therefore the need to prevent may be more difficult to justify to some farmers.
- Knowledge transfer may not have a direct application to the farm and this can lead to generic discussions which have no real 'take home' messaging.

The ability of non-participatory keepers to undermine voluntary disease strategies is significant as they can act as a source of reinfection to other farms. Innovative strategies which engage these sheep keepers are therefore well warranted.

Voluntary disease programmes can be legitimised and energised by the threat of potential legislation in future years. This was the premise of Gwaredu BVD and the voluntary stage of this RDP funded programme has been met with a large degree of success. Regulatory measures can increase participation by increasing the costs of non-compliance above that of a voluntary initiative.

However, regulatory measures are not without inherent difficulties. A list of some of the main enforcement barriers, as relating to sheep scab eradication, have been listed below.

5.2 Enforcement Barriers

- Lack of proper policing due to budgetary constraints.
- Varying degrees of noncompliance in different parts of Great Britain leading to reinfection and disease spread within and between borders.
- Lack of a reliable sheep identification and tracing system.
- Lack of a proper mechanism to implement risk based trading.

One of the fundamental components of a sheep scab eradication strategy will be to maximise post-outbreak engagement and treatment co-ordination. Current UK licensed products for scab treatment and control have differing periods of protection; ranging from 21 to 60 days. Moreover, different treatment protocols – such as the requirement of some injectables to have multiple injections at set intervals – can complicate co-ordination between neighbouring premises. A lack of post-outbreak transparency could therefore mean that the period of protection conferred on one flock has ended prior to the treatment of a contiguous premise. This must be considered when designing a national sheep scab eradication programme. A summary of some of the operation barriers have been listed below.

5.3 Operational Barriers

- Misdiagnosis.
- Under dosing or some other form of inappropriate treatment.
- Large numbers and movements of sheep.
- Problems fully gathering all sheep within a flock and difficulties treating all sheep within a small enough time window. This is especially true where common grazing occurs.
- The use of some acaricide products can be ineffective as a result of operator error.
- Human health and environmental concerns pertaining to the use of OP formulations. The impact of pollution incidents and the increasing regulatory burden associated with maintaining sheep dipping facilities on farms functions to disincentivise compulsory treatment programmes.
- Treatment results in extended withdrawal periods (37 -104 days) Limiting the farmers ability to sell stock.
- The cost of a licence to dispose of sheep dip (up to £3840).
- Lack of knowledge can lead to infection following some treatments.
- High level of product choice in MLs can lead to misconceptions about preventing resistance through the assumption that a new active compound is being used.
- Resistance in nematodes and mites to macrocyclic lactones can reduce treatment choice.
- Commons grazing – all sheep need to be removed and treated. This can be difficult to achieve.

6 Common Land

Sheep scab is a problem throughout Wales, however incidence is likely to be significant in less Favoured Areas (LFA) and LFA land accounts for around 80 percent of the land mass in Wales. The incidence of sheep scab in LFA areas is partly due to the large proportion of common land in the LFA regions of Wales (see Figure 1), where sheep have a much higher chance of coming into contact with each other due to the absence of fenced boundaries. Without a proper co-ordinated and policed treatment regime, any attempt to reduce or eradicate sheep scab from common land will likely be met with limited success due to persistent reinfection.

Previous attempts to control sheep scab on common land have been met with varying degrees of success. Two notable sheep scab programmes have occurred on the Mynydd Epynt and the Dyffryn Dyfi commons. The former, more successful, strategy benefitted from compulsory co-ordinated treatment procedures which were policed by the land owner.

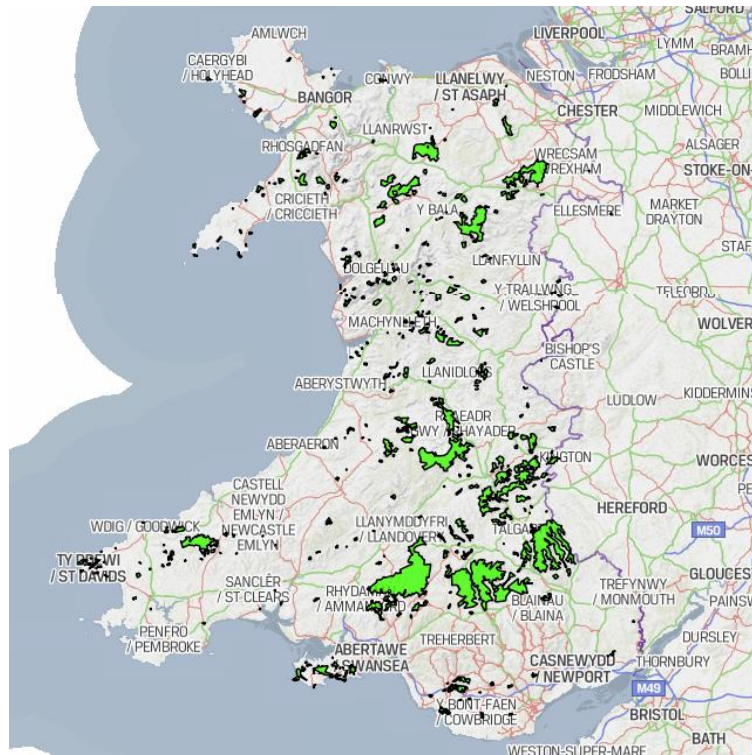


Figure 1. Areas of registered common land (green) in Wales.

6.1 Mynydd Epynt Group

Mynydd Epynt has operated as an army training area since 1940 and there are around 90 farmers with licenses to graze specific areas of the commons. As the current land owner, the Ministry of Defence has control of the eradication of sheep scab on the common and regulations pertaining to sheep scab are contained in the grazing licenses.

Treatment co-ordination is managed by the MoD via a requirement that all sheep are dipped or injected on the dates agreed between the Graziers Committee and the MoD. Any flock found to be infected with sheep scab on the common must be removed until the MoD is satisfied that the infection has been cleared.

The high level of success achieved by the Mynydd Epynt group has been largely attributed to the compulsory co-ordinated treatment periods which are agreed and notified well in advance.

6.2 Dyffryn Dyfi Group

There are around 100 sheep farms within the Dyffryn Dyfi valley. Unlike the Mynydd Epynt common, farms within the Dyffryn Dyfi valley are enclosed with no open areas of common.

A scab outbreak in 2009 saw the genesis of the Dyfi Valley Scab Eradication group. The initial voluntary strategy was designed to get farmers to work together to reduce the incidence of disease by co-ordinating treatment times and products. Differences in treatment timing requirements saw a 28 day window of treatment and this was in line with the period of protection offered by the drug choices agreed.

Falls in the incidence of scab have been attributed to better disease knowledge and treatment co-ordination. However, the valley continues to have sheep producers that will not engage with the strategy and a high level of scab remains. Group members cite that it is difficult for busy farmers to police the area and that a lack of power to force obstructive and reluctant farmers to engage has left the strategy vulnerable.

7 Welsh Industry Activity

Welsh industry activity has been varied and has attempted to combat those specific issues which could impede scab eradication. For example, numerous educational and awareness campaigns have been undertaken by industry stakeholders, such as Farming Unions, Hybu Cig Cymru, Farming Connect and Menter a Busnes. Some of these campaigns relate to generic on-farm management, whilst others are specifically targeted to scab. Moreover, in recent times, concerns surrounding antimicrobial resistance and the use of Critically Important Antibiotics, have widened discussions on inappropriate drug usage. However, both under dosing and misdiagnosis remain barriers to sheep scab eradication in Wales.

Several industry activities pertaining to sheep scab have been listed below.

7.1 “Stop every drop” campaign

The ‘stop every drop’ campaign aimed to control the contamination of watercourses by sheep dip products. The campaign material remains on the Welsh Government website; however deregulation, the decline in the use of OP products and environmental and human health concerns, have perhaps lessened the prominence and significance of this campaign. However, given that dipping remains an effective method of controlling sheep scab, these concerns must be balanced appropriately against the mitigation of disease spread.

7.2 Industry Guides

Commercial companies, such as Bimeda, continue to raise awareness of sheep scab in order to bolster product sales. Bimeda have produced a ‘Goldfleece quick reference guide to sheep dipping and ectoparasite control’ which is available online⁷. This guide aims to bring dipping contractors to farmers’ awareness in order to encourage the uptake of this method of sheep scab control. This company are also co-ordinating a list of dipping contractors.

⁷ Goldfleece Quick Reference Guide, Bimeda. URL: <https://www.bimeda.co.uk/product-guides/sheep-dipping-and-ecto-parasite-control-in-sheep>

Other industry guides include the Hybu Cig Cymru – Meat Promotion Wales funded guide to the correct diagnosis of sheep scab on farm. This is delivered through the Sustainable Control of Parasite (SCOPS).

7.3 Data Collection

Estimates of sheep scab prevalence in Wales remain variable. The most recent attempt to gain prevalence and incidence estimates was undertaken by Richard Wall and co-workers. The methodology involved a questionnaire which was primarily distributed through WLBP. Wall and co-workers cite that 16% of farms stated that they had been affected by scab within a one year period and 30% within a 10 year period (n = 900 farms). It was suggested that there were two hotspots (Powys and North Wales) and that such ‘hotspots’ could be used in a regionalised approach. However, such ‘hotspots’ could represent around half of the land mass of Wales and it would be difficult to ascertain how any eradication strategy could legitimately regionalise either funding or resources.

7.4 Direct Funding

An examination of samples for sheep ectoparasites was being offered free of charge in Wales, between the 15th of December 2017 and the 31st of March 2018. The scheme, supported by Welsh Government, aimed to aid in accurately diagnosing ectoparasite infections.

Testing was undertaken by the newly established specialist parasitology department at APHA Carmarthen VIC, which is also the centre of expertise for disease surveillance of extensively managed livestock. Samples must have been received via a veterinary surgeon and must be accompanied by full clinical history to qualify for free testing.

As been observed in other countries, and domestically with Gwaredu BVD, engagement is high when free disease diagnostic testing is provided. This free ectoparasite testing has been successful (pers comm S. Mitchell).

8 Cost Benefit Analysis

Numerous cost-benefit analyses for sheep scab exist. Scottish estimates place the country-wide cost of this ectoparasite to be in the region of £600,000. However, farm-level cost-benefit assumptions are variable due to the differing control options available and the degree to which scab has infected a flock.

Work by ADAS during the English ‘Stamp out Scab’ campaign stated that quick and effective treatment for a scab outbreak could significantly reduce the costs involved. The costs included payment for scab diagnosis and a treatment cost of £1 to £1.40 per ewe (product and labour dependent). However, it was noted that early diagnosis would lead to a negligible loss in performance. For a 500 head flock, treatment of all ewes would have net loss of around £600.

As part of this work, ADAS also considered the costs of delayed diagnosis, unsuccessful inappropriate treatments and the associated loss in production. They estimated the costs of treating a misdiagnosis followed by the payment needed when using the correct treatment once a definitive diagnosis had been obtained. The production losses were estimated to be in the region of £20 per ewe. For a 500 head flock, the costs of a misdiagnosed and poorly treated outbreak were deemed to be in the region of £10,000.

Similar work by Moredun suggests that an incursion of sheep scab could cost around £12.50 per head whilst the cost of treatment is around £1.65.

9 Evidence Base for Controlling Scab in Wales

As evidenced from national eradication programmes in other countries, sheep scab eradication is possible when eradication programmes meet the aims and objectives of all players. However, current scab initiatives in Wales – which after deregulation have been almost exclusively knowledge transfer based - have not managed to confer disease eradication. This is, in part, due to a lack of funding, multiple competing strategies and a lack of co-ordination since deregulation.

As with the English sheep scab order, Welsh local authorities can currently force the treatment of scab infected sheep or can take other action if the disease is present in a flock and appropriate steps are not undertaken. However, budgetary constraints mean that there is a lack of proper policing and scab infested flocks can therefore go unnoticed for significant periods of time. Reticent sheep keepers therefore continue to ruin the work of compliant sheep keepers and this has led to demotivation amongst keepers with high health and welfare standards. Given that the vast majority of farmers are compliant with the existing regulation, innovative programs which engage a wider farm audience will therefore be of value.

Much of the sheep scab KT in Wales has focussed on the longer-term economic production benefits of controlling sheep scab. However, the success of the Gwaredu BVD strategy has demonstrated that farmers will engage in disease eradication programmes that (1) have an immediate financial benefit and (2) can occur concurrent to existing farm business needs. Knowledge transfer activities which are used to support a specific funded programme, should therefore be more successful.

This proposal is the second of its kind in Wales where the industry has committed to develop and deliver a comprehensive disease eradication programme. The strategy represents the combined efforts and desires of the Welsh sheep sector. The overall aim is to influence change, ensure a more resilient industry and foster an industry that has the confidence to engage in subsequent disease control activities.

Sheep scab has been selected as a suitable disease to deliver these benefits because eradication is achievable within a relatively short time span. The impact of eradicating a disease through working together as an industry should not be underestimated. It will have a positive effect on the industry but also government plans to improve risk based trading and general biosecurity. It will also help strengthen rural community resilience by improving farm viability and sustainability.

The delivery of national strategy and control measures to eradicate sheep scab will undoubtedly improve the relative competitiveness of Welsh agriculture. Sheep scab remains a significant animal welfare issue within Wales and the delivery of an eradication strategy will create a positive image of a healthier Welsh sheep flock; delivering a future marketing edge that has been mooted as necessary following the UK's decision to leave the European Union.

The eradication of sheep scab from the national flock in Wales will result in an increase in the productivity of Welsh sheep. The resultant increase in output from the same sized national flock will result in a reduced carbon footprint per kilogram of red meat produced. This is especially pertinent where there eradication strategy functions to promote earlier detection and treatment (as outlined previously).

The sustainability and resilience of the national flock should be increased following the removal of sheep scab. Improved welfare standards, coupled with better on-farm diagnosis and more appropriate treatment, should result in the reduced use of drugs whose efficacy has been lessened due to potential resistance issues. Reducing the likelihood of selection for resistance should protect the ability of the industry to use anthelmintics in the future.

Increased productivity on farms in Wales as a result of reduced forced losses from contagious diseases equals increased prosperity on farms in Wales. Rural economies in Wales are highly dependent on the profitability of Welsh sheep flocks and intervention will immediately have positive economic and community benefits to the rural areas of Wales. This includes maintaining and increasing employment opportunities on farms which in turn aids in improving rural community resilience and preservation of tradition.

The establishment of a Wales sheep scab eradication strategy supports the aims of both the (1) Food for Wales, Food from Wales 2010-2020 - A Food Strategy for Wales document and (2) The Well-Being of Future Generations Act 2015.

The sheep scab eradication strategy proposed also meets the objectives of the Welsh Animal Health and Welfare framework. The strategic outcomes of the framework are:

- Wales has healthy productive animals
- Animals in Wales have a good quality of life
- People trust and have confidence in the way food is produced and the way public health is protected
- Wales has a thriving rural economy
- Wales has a high quality environment

The ability of the sheep scab eradication strategy to meet the 5 principles of the Welsh Animal Health and Welfare Framework is listed in table 4 below.

In the generation of this strategy a number of alternative approaches were considered and rejected – these are discussed briefly in appendix 2

Principles	Ability of a Sheep scab eradication strategy to meet the 5 principles
1. Promoting the benefits of animal health and welfare; prevention is better than cure	<ul style="list-style-type: none"> • Delivering a step change in attitudes towards animal disease prevention and eradication. • Facilitating proper diagnosis ensures farmers know their status and facilitates appropriate treatment. • Disease risk management will be a key element of the strategy including keeping disease out through good biosecurity practices. • Promoting informed purchasing to ensure disease is not bought in with purchased animals.
2. Understanding and accepting roles and responsibilities	<ul style="list-style-type: none"> • Leading the way by being the first Wales industry led animal disease eradication strategy for sheep.

	<ul style="list-style-type: none"> • The strategy will define key roles and responsibilities for farmers, veterinarians and industry leaders. • The ultimate responsibility to eradicate sheep scab lies with the farmer.
3. Working in partnership – critical to the success is increased co-operation and collaboration between the Welsh Government, industry representatives, livestock keepers and other animal owners.	<ul style="list-style-type: none"> • First Wales industry led animal disease eradication strategy for sheep. • The delivery model is based on co-operation between key industry and government people and organisations.
4. Ensuring a clearer understanding of costs and benefits - balance between the taxpayer and the extent industry is held liable for the cost of animal health and welfare.	<ul style="list-style-type: none"> • Protect the good practice currently delivered within the industry • Investment to bring the whole industry up to the desired standard • Industry to maintain disease free standard at own cost.
5. Delivering and enforcing standards effectively	<ul style="list-style-type: none"> • Following the voluntary phase we propose a compulsory stage that is enforceable.

Table 4. The 5 principles of the Welsh Animal Health and Welfare Framework as related to the proposed sheep scab eradication Strategy.

10 Pathway to Eradication: Strategy Phases

10.1 Phase 1

10.1.1 Creation of Sheep Scab Eradication Management Group

The eradication of any disease requires effective central management of activities (as demonstrated by some of the industry activities already described). A team involving members with veterinary expertise and the financial and administration staff to ensure efficient activities will be essential.

In addition to the above, it is envisaged that a technical team of 11 personnel will be responsible for (1) knowledge transfer activities; (2) focus group initiation and development (3) scab diagnosis (4) contiguous farm identification and treatment co-ordination and (5) treatment sign-off and approval.

Activities such as knowledge transfer can occur during the initial phase of the scab strategy and during periods when scab infestation is not at peak levels. Moreover, involving the technical staff in knowledge transfer activities – including a presence at markets and focus groups – should build useful relations between this team and the farming community. It is the aim of the current project that a reporting farm (see 10.1.3) will have already had some contact with the technical team prior to reporting a potential scab outbreak.

Technical team staff may be organised into parishes. However it is imperative that enough flexibility is provided to allow staff to travel to meet asymmetrical reporting and incidence levels across Wales.

10.1.2 Knowledge Transfer Activities

The dissemination of strategy specific activities as well as basic information relevant to protecting the farm from incursion of disease should occur. This information should be made available to all parts of the industry and smallholders who may only have a single sheep.

Strategy specific information includes:

1. Basic biology and epidemiology of *P. ovis*
2. Biosecurity advice on protecting the farm from reinfection
3. Appropriate treatment of flocks afflicted with *P. ovis*
4. Problems of reinfection from contiguous flocks
5. Strategy specific management issues

Knowledge transfer activities can occur on a general basis in public forums such as markets, shows and union meetings. However, knowledge transfer activities will also occur when a scab outbreak is reported and will be tailored to the reporting farm and to contiguous premises via the establishment of focus groups.

The work of the technical team will also involve wider knowledge transfer and biosecurity advice to those businesses, such as sheep scanners, that could potentially spread scab from farm to farm.

10.1.3 Reporting farm

The reporting farm is the first farm that indicates that they have a suspected sheep scab outbreak. By contacting the strategy team this starts the whole process. An example sheep scab eradication action report, which would be initiated following diagnosis of scab on the reporting farm, has been provided in Appendix 3. The first step is to positively identify the disease and treat all the sheep on that farm. This diagnosis will be made through skin scrapes being taken on farm through standard methodology, either by the flock vet or the strategy technical officer. The presence of active mites will be determined by an approved laboratory. Dipping using a contractor is the preferred method of treating sheep scab on all farm premises with a diagnosed scab outbreak. A team of dipping operators will be associated with each sheep scab team member to provide a robust and accountable programme.

Where injectables are to be used, the problem of inaccurate dosing will be mitigated by the provision of scales to weigh sheep prior to treatment. The technical team member will collect the weight data and then provide the sheep keeper with the correct amount of drug based on this information. Farmers will subsequently be required to sign a document stating that all the product provided was utilised for sheep scab treatment.

It is expected that sheep will already be gathered when the technical officer goes on farm to provide the farmer with injectables.



10.1.4 Diagnosis of sheep scab

The diagnosis of an initial sheep scab should be made in a designated laboratory in order to ensure that as far as possible the diagnostic criteria are robust. When a farmer rings the scab technical team, diagnosis via a skin scraping may be made by either (1) a veterinary practitioner or (2) a member of the scab technical team. Where the diagnosis is lice and not scab, the sheep keeper will be informed and the proper treatment advice given. The training provided to the Technical officers will ensure that, where present, lice can be definitively identified.

For both sheep scab diagnosis and treatment, the strategy will aim to evaluate new technologies and approaches for inclusion in the overall programme. Where appropriate, adjustments will be made in order to ensure that the strategy is scientifically robust. In either case, the associated knowledge transfer activities will be updated accordingly.

10.1.5 Contiguous farms

Following positive diagnosis all farms contiguous to the reporting farm are contacted and invited to a meeting organised by the project technical team member. The primary aim of this meeting is to organise the co-ordinated management of all flocks that are at risk (or that may be harbouring the infection unreported). Attendees would be the sheep scab technical team, all farmers involved and their veterinary surgeons. However only the farmers would be considered necessary for the meeting.

Contiguous farms over 100 (including all ovines on the farm) animals will be tested with the antibody test commercially available in order to prove freedom from scab. Those with under 100 animals will be offered treatment as an automatic option.  They do not wish to have their sheep treated then they can choose to pay for blood testing to avoid treating their sheep.  either case a positive blood test will result in treatment of all sheep on the holding.

Whilst the lack of attendance at a focus group meeting does not indicate the presence of scab on-farm, sheep keepers in a given area could use these meetings to identify which of their peers have, or have not, attended. These keepers due to their unknown status would be regarded as high risk.

10.1.6 Low-risk movements

Following diagnosis of sheep scab on a farm premise, or contiguous farm premise, farmers will be allowed a provision to send animals direct to slaughter. This will aid in the accessing of markets at appropriate times, avoidance of lengthy withdrawal periods and will make a positive contribution to minimising unnecessary drug use whilst maintaining low levels of risk.

In order to provide a secondary outlet for finished stock, it may be important to allow for the provision of specific finished stock markets which can sell animals going direct to slaughter without treatment for scab. Alongside animals going direct straight to abattoir, specific 'red' markets would aid in avoiding the current situation which places infected sheep in pens adjacent to uninfected flocks.

Where infected animals are sent direct to slaughter, the slaughterhouse should be informed that sheep are infected with sheep scab. No further action will be required from the slaughterhouse Official Veterinarian following confirmation of infection.

For breeding animals movement will be permitted once treatment has been carried out on farm. Certification of this being carried out may provide reassurance of disease freedom to buyers and markets resulting in an increased price paid for breeding stock.

10.1.7 Common Grazing

Where common grazing is involved then the difficulty of gathering all the sheep is going to be an issue. In order to assist with this drone technology may prove useful in surveying large areas of common grazing and spotting stray sheep. These sheep represent a risk of reinfection and if possible should be gathered but it may not be possible and these animals should be destroyed.

10.1.8 Repeat treatment

Once flock treatment has been completed there is a short period of protection. The length of protection will be dependent on the treatment used (see table). After that the flock can be reinfected. Farmers therefore should use the time that they are protected by the work carried out to deal with risks of reinfection (buying in policy, over the fence contact, etc). This is an example of the type of knowledge transfer activities that will be provided by the technical team.

10.1.9 Tracings

Tracing disease is considered a normal activity in dealing with disease outbreaks (such as Foot and mouth disease). It is not proposed to actively trace sheep movements onto or off the farm in the voluntary phase of the programme. Instead the appearance of disease and local stamping out will be utilised. This should reduce overtreatment of traced sheep that did not in fact have disease. .

10.1.10 Treatment certification

Consideration should be given to certifying dipped flocks to increase confidence of buyers. The technical team will be responsible for promoting the use of these certificates as a method of risk based trading.

10.1.11 Off farm surveillance

There are already active inspections at markets and in the abattoirs and the inspectors will be informed of the project. This reporting and subsequent activity should alleviate the concern that reporting is pointless due to a lack of response. To support and enhance this, project technical officers will attend markets to spot potential cases and work with the markets, trading standards and others to identify the farms and offer help to deal with the *P. ovis* problem in the farm of origin.

Although off-farm surveillance at abattoirs would be a useful inclusion in a reactive sheep scab programme, such work remains outside the scope of the current proposal. However, such surveillance may be a useful addition to a future legislative programme. Consideration will need to be given to the current role of MHS staff and the potential for additional inspection work to reduce line speed.

The English RDPE paper considers abattoir surveillance through blood sampling in order to determine how infected the supply chain is and demonstrate improvement. Appropriate data sharing could be usefully applied to ensure that lambs sent to England could be monitored. This could also provide a UK wide picture.

10.1.12 Treatment preference

The project preference is that an accredited contract mobile dipper should be employed to treat all the sheep on the farm. Many farmers have invested in the equipment, training and licences in order to dip their own sheep and an authorised technical team member would dispense and deliver to the farm the appropriate dip product.

If neither of these are suitable (for example due to heavily pregnant ewes requiring dipping) then administering a suitable macrocyclic lactone would be permitted. This would again be dispensed by an authorised technical team member for the number of animals required by the farm. This allows for investigation of potential treatment failures and ensures best value for the programme

As an example of how phase 1 might work an after action report that might result from the management of a cluster is included as appendix 3.

10.2 Phase 2

The team created in Phase 1 will continue in the activities and responsibilities as before.

10.2.1 Knowledge transfer

As with phase 1 there will be considerable emphasis on knowledge transfer. It is to be expected that a number of farms will have been treated and an emphasis on protecting the gains made by the project will be required.

10.2.2 Reporting farm

As with phase 1 a farmer will contact the sheep scab team and that farm will become the index farm for a cluster.

10.2.3 Diagnosis of sheep scab

The diagnosis of sheep scab will be through a skin scrape demonstrating a live mite at an accredited laboratory. This may change along with the best scientific advice to ensure effective delivery of the strategy.

10.2.4 Contiguous farms

All contiguous farms will once again be identified and the technical team will coordinate testing and treatment in a manner identical to the phase 1 activity. The crucial difference lies in the requirement for all contiguous farms to be present and agree to the plan or no activities will be carried out.

10.2.5 Low risk movements

All low risk movements will be encouraged as for phase 1

10.2.6 Common grazing

As the strategy will have been deployed for some time – where possible and appropriate the voluntary testing and treatment of flocks prior to grazing on the common will be facilitated and encouraged.

10.2.7 Treatment certification

Risk based trading will continue to be encouraged through the use of certification, consideration will be given to incorporating antibody test results as an alternative to treatment in phase 2.

10.2.8 Off farm surveillance

Continuing market and abattoir visits will continue to be a part of the technical teams' responsibilities. As farm out breaks reduce more emphasis will be placed on off farm surveillance.

10.2.9 Treatment preferences

Subject to scientific advice the preferred method of treatment will be dipping carried out by accredited mobile contract dippers.

Other methods will be permitted with sufficient justification.

10.3 Phase 3

10.3.1 Off farm surveillance

Phase 3 of the project will bring much more emphasis on the off farm surveillance with the technical officers being present at the markets and abattoirs. The main focus of attention will be cull ewes as these are more likely to demonstrating clinical signs. This will be in parallel with existing enforcement activities by the trading standards and FSA staff.

10.3.2 Reported farms

Treatment by a contract dipper will be carried out to control *P. ovis* on the farm. As this is now a compulsory national control strategy the identified farm will be liable for costs associated with the treatment of sheep on the farm.

10.3.3 Contiguous farms

Following positive diagnosis all contiguous farms are contacted and invited to a meeting organised by the project team. The primary aim of this meeting is to organise the coordinated treatment of all flocks that are at risk (or that may be harbouring the infection unreported).

If farmers are unwilling to treat an alternative of demonstrating freedom from disease through blood sampling and testing for exposure will be accepted.

10.3.4 Treatment preference

The preferred treatment is for contract dipping and it is unlikely that a disclosed farm will be permitted to choose another methodology.

Treatment choice of the contiguous farms will be the same as those choices provided in phase 1 and 2 . However should they choose to use antibodies to demonstrate freedom then movement restrictions and an increase in the number of animals tested according to an extended schedule will be required.

10.3.5 Knowledge transfer

A continued strategy of knowledge transfer will be undertaken in Phase 3. This will centre around biosecurity requirements in order to protect them from incursion of disease.

10.3.6 Compliance penalties

Legislation should be strengthened or created as appropriate in order that those farms that do not take sufficient steps to control disease are liable for cross compliance penalties. Additionally the legislation should be reviewed to ensure that those involved in a national eradication scheme have the ability to trace disease as required.

11 Funding

The natural home for an application would be the ERDP Wales 2014-2020 fund (or its successor). in a similar manner to the already funded Gwaredu BVD project With the approach of BREXIT new funding streams, such as those that improve resilience, will be assessed by industry with a view to determining whether this plan is suitable for submission under the rules of any new funding mechanism.

Alternatively funds from already collected levies could be diverted to the control of Sheep scab. However this is a decision that would require a change in priorities by the board of the levy body and is an issue out with the scope of this project.

12 Sheep scab eradication plan budget

The table below outlines indicative costs for an eradication programme led by farmers. This budget is based on a 20% prevalence with 6.1 neighbours per sentinel farm, with an average flock (ewes, rams & lambs) of 700 head, assuming a £1 per head treatment cost. For a sensitivity analysis of all the above variables see appendix 4. This is based on the modelling calculations discussed in appendix 5

Sheep Scab Budget		Notes
Sheep Scab Eradication programme Staff	£1,362,189	9 Technical officers, 1 Mgr, 1 Tech champion, 1 Admin, 1 Fin & Mon Tech officers salary £29638 p.a. & 30% on costs (3yrs)
Management & Support	£80,000	To cover lead organisations costs of running the programme (cash flow, senior management, staff recruitment, audit, staff recruitment (3 yrs),
FR15	£216,328	15% of staff & management costs - recognised rate by SMU of Welsh Government
Staff computers & database development	£275,000	Database to record programme activity and facilitate potential certification. Potential links with EID Cymru
Travel & Subsistance	£50,000	£1500 per year per field based staff (2 yr activity)
Communication	£250,000	Key activity of the programme (3 yr activity)
Venue hire	£20,000	To hold farmer meetings
Programme evaluation	£75,000	Requirement of all funded programmes
Diagnosis & Treatment Yr 1	,£2<630,880	Diagnosis & treatment costs
Diagnosis & Treatment Yr 2	£868,190	Prevalence of 33% of year 1 need follow up diag & treatment in Yr 2
Cost of tesing (bleeding on farm) Yr 1	£569,333	5693 farms need testing (Assuming OV employed at £100 per farm)
Cost of tesing (bleeding on farm) Yr 2	£189,778	33% of 5693 farms need testing (Assuming OV employed at £100 per farm) in Yr 2
Standard programme costs	£6,586,698	

12.1 Bespoke eradication plan resources

In addition to the farmer led programme outlined above it is envisaged that additional resources will be required to eliminate infection in particularly difficult cases such as wooded common ground the following resource would be made available to ensure that all sheep were gathered for treatment. This is a bespoke solution by the group to solve an age old problem of incomplete gathering of all sheep off challenging terrain on the hills.

The resources the group envisage as being required include:

Resource	Rationale
Shepherds & dogs	To search common and gather stray sheep
Aerial surveillance (Drones, Helicopters)	To provide search capacity for large areas
Hire of equipment - ATV, Trailers, pick ups	To deliver staff to starting locations on hill and remove carcasses for disposal
Communication kit	To coordinate activity on the common ensuring safe and effective searching
Firearms	For the humane destruction of sheep that cannot be gathered.
Advanced imaging equipment	To aid effective searching

The indicative budget for these additional resources would be £2 million.

The overall budget for this programme is £8,586,698

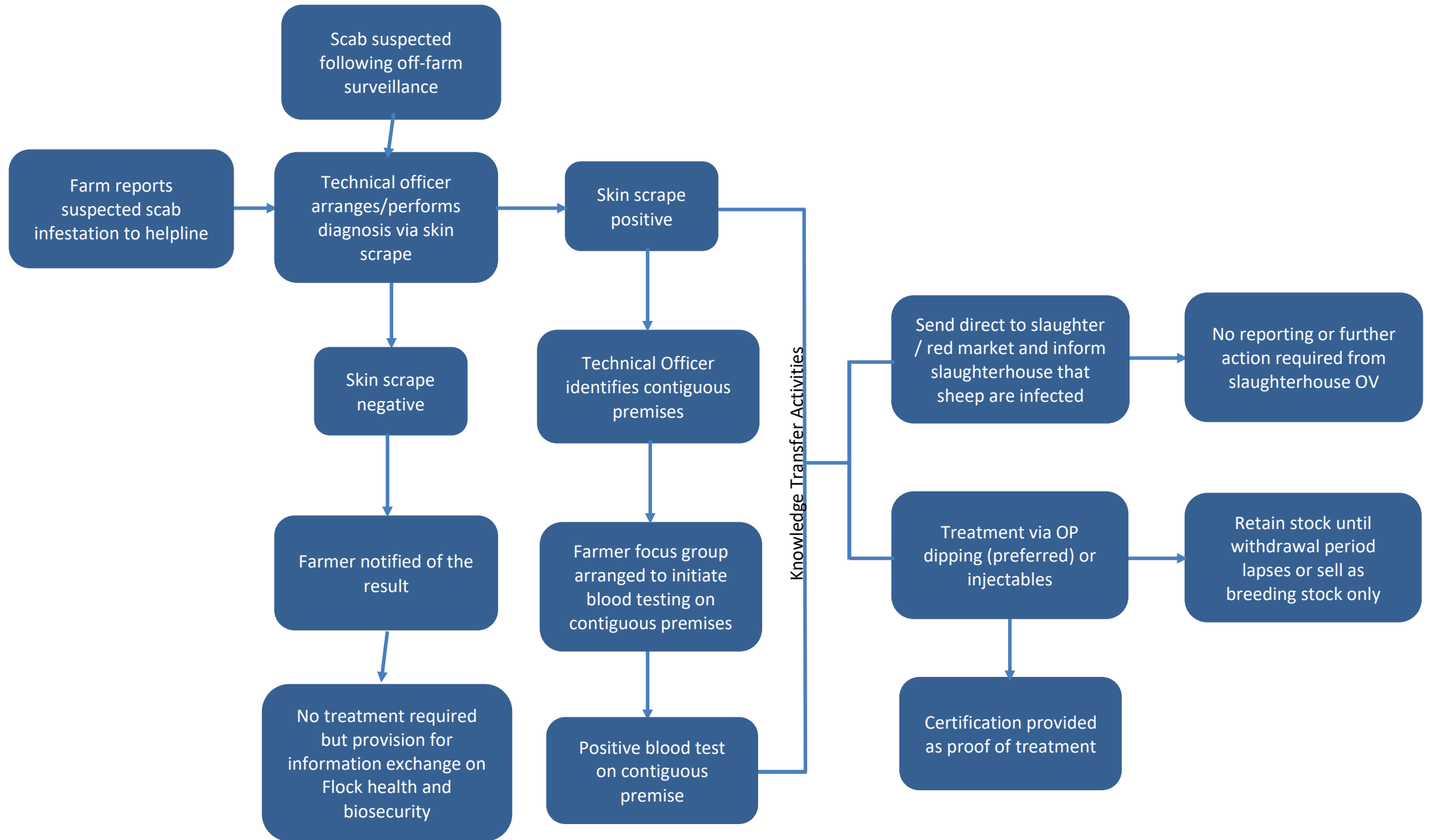
In addition to the above, sensitivity analyses have been calculated for the scab eradication programme in a manner which accounts for various different scenarios. These include various prevalence estimates and different numbers of contiguous farm premises. Sensitivity analyses can be found in appendix 4

Notwithstanding the above, the industry accepts that a percentage of the treatment costs could be borne by the sheep keeper if the present strategy is successful in the acquisition of funding. Further details on this issue will be considered upon a full application and further consultation with industry representatives.

13 Brief Summary of Strategy

1. The aim of any strategy should be moves towards eradication of this disease from Wales
2. A 2 year voluntary strategy followed by an enhanced compulsory phase should be delivered by an industry led group.
3. Reporting of a sheep scab suspicion should be diagnosed as soon as possible and positive diagnosis should trigger treatment of this farm and contiguous farms.
4. Dipping through the use of contract dippers should be the treatment option of choice.
5. Antibody testing can be used by farmers to avoid the need for treatment of the flock.
6. Significant and specific KT will be required to deliver the strategy aims.
7. The strategy will need specific funding and this strategy should be made a priority in the next animal health funding round.
8. Strengthen current legislation to capitalise on and retain gains made through the above strategy and drive further improvements in animal health and welfare in Wales.

Appendix 1: Flowchart of the first phase of the Scab Program



Appendix 2 - Alternative Approaches

Increase Enforcement of Current Legislation.

Legislation exists to treat scab infected sheep but enforcement is frequently cited as lacking. This is most likely due to pressure on trading standards (as the competent authority), budgets and sheep scab being seen as low priority. Increasing this budget (ring-fenced to sheep scab work) could increase enforcement.

As evidenced by control programmes in other countries, eradication programmes which begin with onerous legislative requirements can function to cause disengagement and a lack of industry buy-in. Indeed, as with bovine TB, if sheep scab is seen as a government disease, this could lead to poor farmer engagement with disease control and a lack of disease ownership. Sustainable control of the disease requires farmer engagement with the activities and a premature or unsuitable enforcement approach puts this at risk.

In addition to the above, engagement with any future legislative approaches will be increased where livestock keepers have had the opportunity to (1) Enhance their knowledge of this disease (2) Recognise and react to their own disease status and (3) Improve treatment accuracy. In this way, sheep keepers can minimise any adverse effects of legislation on their own farm premise prior to the genesis of legislative requirements.

Market Driven Approach

Currently the presence of sheep scab in animals presented at the abattoir carries no financial penalty as the meat is considered fit for human consumption. If sheep scab was redefined as a condition that renders meat unfit for consumption (or an alternative mechanism that produces carcass rejection) there is the risk that affected farmers will not present animals at the abattoirs in Wales in order to escape detection (and those that suspect they might will also do so). Where infected animals are present on farm they may be retained and if not treated promptly then may suffer for longer periods as a result of delayed treatment.

As with option 1 there is the risk of no engagement and no overall social change

Compulsory Time Limited Test and Treat All Flocks

Traditionally the eradication of scab was achieved by the compulsory dipping of the entire national flock. With the advent of a serological test then this could be used to test flocks to avoid testing.

Finding a suitable time for dipping on a national basis may be problematic. Alongside this the logistical issues around dipping all sheep in a short timeframe may be insurmountable.

Unless testing is part of the strategy some farmers will be forced to treat animals that are not infected. There is an unfortunate history with OP dips and this may cause resentment and a failure to engage. If this resentment is sufficient than a social change to create a sustainable and successful eradication strategy may not arise.

Appendix 3: Sheep scab eradication programme action report

After action report

Location of the cluster

A farm address (OS Location.....) contacted the Sheep scab technical lead for the area on (Date time).

Actions after contact

The farm was visited on (date time) and a skin scrape was taken according to the protocol (Strategy manual pp --). No Lice or other parasites were observed on the sheep at the time of sampling. The sample was sent to APHA Carmarthen where live psoroptes ovis mites were observed.

Treatment of the sentinel farm was arranged on (date time)

Farms identified as contiguous

6 farms were identified listed below

Name	Address	CPH	OS location
1			
2			
3			
4			
5			
6			

All were contacted and 2 failed to respond.

Cluster meeting

A meeting was held at (date time location) and two farms failed to attend (1 and 3)

Dates and times for blood sampling the 4 farms were agreed. A volunteer (farm no) agreed to visit both farms and try and get their cooperation.

Post cluster meeting follow up

It was discovered that farm 1 had assumed that as he had no visibly infected sheep it was not relevant to him. The other (farm 3) was owned by an elderly farmer who was at the time of the meetings unable to become involved due to ill health.

Farm 1 agreed to test in the schedule agreed with the rest of the farms. Farm 3 was tested as a volunteer from the cluster group alongside the tech team assisted in gathering and testing the flock

Testing results

Farms 5 and 3 were tested positive all others were negative. All flocks were tested within 2 weeks and all results were received within 3 weeks.

Treatment report – Cluster farms

Mobile Dipping was performed on (date) for both farms. Farm 5 was assisted by the tech team and farm staff. Farm 3 was treated with assistance of 2 of the neighbours

Post cluster treatment and follow up

All farms were contacted 1 month follow up. No further disease issues were noted. One farmer stated that he intended to test on arrival any new purchases. Two had coordinated grazing strategies to reduce the risk of spread.

Appendix 4: Sensitivity analyses

The analyses below assess the impact of deviations from the stated assumptions in the budget section for testing and treatment alone.

		Average number of neighbours to infected farm								
		2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1
Prevalence of sheep scab n wales	10%	£ 1,102,640	£ 1,155,840	£ 1,209,040	£ 1,262,240	£ 1,315,440	£ 1,368,640	£ 1,421,840	£ 1,475,040	£ 1,528,240
	11%	£ 1,212,904	£ 1,271,424	£ 1,329,944	£ 1,388,464	£ 1,446,984	£ 1,505,504	£ 1,564,024	£ 1,622,544	£ 1,681,064
	12%	£ 1,323,168	£ 1,387,008	£ 1,450,848	£ 1,514,688	£ 1,578,528	£ 1,642,368	£ 1,706,208	£ 1,770,048	£ 1,833,888
	13%	£ 1,433,432	£ 1,502,592	£ 1,571,752	£ 1,640,912	£ 1,710,072	£ 1,779,232	£ 1,848,392	£ 1,917,552	£ 1,986,712
	14%	£ 1,543,696	£ 1,618,176	£ 1,692,656	£ 1,767,136	£ 1,841,616	£ 1,916,096	£ 1,990,576	£ 2,065,056	£ 2,139,536
	15%	£ 1,653,960	£ 1,733,760	£ 1,813,560	£ 1,893,360	£ 1,973,160	£ 2,052,960	£ 2,132,760	£ 2,212,560	£ 2,292,360
	16%	£ 1,764,224	£ 1,849,344	£ 1,934,464	£ 2,019,584	£ 2,104,704	£ 2,189,824	£ 2,274,944	£ 2,360,064	£ 2,445,184
	20%	£ 2,205,280	£ 2,311,680	£ 2,418,080	£ 2,524,480	£ 2,630,880	£ 2,737,280	£ 2,843,680	£ 2,950,080	£ 3,056,480
	20%	£ 2,150,148	£ 2,253,888	£ 2,357,628	£ 2,461,368	£ 2,565,108	£ 2,668,848	£ 2,772,588	£ 2,876,328	£ 2,980,068
	21%	£ 2,287,978	£ 2,398,368	£ 2,508,758	£ 2,619,148	£ 2,729,538	£ 2,839,928	£ 2,950,318	£ 3,060,708	£ 3,171,098
	22%	£ 2,425,808	£ 2,542,848	£ 2,659,888	£ 2,776,928	£ 2,893,968	£ 3,011,008	£ 3,128,048	£ 3,245,088	£ 3,362,128
	23%	£ 2,563,638	£ 2,687,328	£ 2,811,018	£ 2,934,708	£ 3,058,398	£ 3,182,088	£ 3,305,778	£ 3,429,468	£ 3,553,158
	25%	£ 2,701,468	£ 2,831,808	£ 2,962,148	£ 3,092,488	£ 3,222,828	£ 3,353,168	£ 3,483,508	£ 3,613,848	£ 3,744,188
	26%	£ 2,839,298	£ 2,976,288	£ 3,113,278	£ 3,250,268	£ 3,387,258	£ 3,524,248	£ 3,661,238	£ 3,798,228	£ 3,935,218
	27%	£ 2,977,128	£ 3,120,768	£ 3,264,408	£ 3,408,048	£ 3,551,688	£ 3,695,328	£ 3,838,968	£ 3,982,608	£ 4,126,248
28%	£ 3,114,958	£ 3,265,248	£ 3,415,538	£ 3,565,828	£ 3,716,118	£ 3,866,408	£ 4,016,698	£ 4,166,988	£ 4,317,278	
30%	£ 3,252,788	£ 3,409,728	£ 3,566,668	£ 3,723,608	£ 3,880,548	£ 4,037,488	£ 4,194,428	£ 4,351,368	£ 4,508,308	

Treatment Cost in £												
Prevalence of Sheep scab in Wales		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1	1.2	1.5
	10%	£ 433,440	£ 531,440	£ 629,440	£ 727,440	£ 825,440	£ 923,440	£ 1,021,440	£ 1,119,440	£ 1,315,440	£ 1,511,440	£ 1,805,440
	12%	£ 520,128	£ 637,728	£ 755,328	£ 872,928	£ 990,528	£ 1,108,128	£ 1,225,728	£ 1,343,328	£ 1,578,528	£ 1,813,728	£ 2,166,528
	14%	£ 606,816	£ 744,016	£ 881,216	£ 1,018,416	£ 1,155,616	£ 1,292,816	£ 1,430,016	£ 1,567,216	£ 1,841,616	£ 2,116,016	£ 2,527,616
	16%	£ 693,504	£ 850,304	£ 1,007,104	£ 1,163,904	£ 1,320,704	£ 1,477,504	£ 1,634,304	£ 1,791,104	£ 2,104,704	£ 2,418,304	£ 2,888,704
	18%	£ 780,192	£ 956,592	£ 1,132,992	£ 1,309,392	£ 1,485,792	£ 1,662,192	£ 1,838,592	£ 2,014,992	£ 2,367,792	£ 2,720,592	£ 3,249,792
	20%	£ 866,880	£ 1,062,880	£ 1,258,880	£ 1,454,880	£ 1,650,880	£ 1,846,880	£ 2,042,880	£ 2,238,880	£ 2,630,880	£ 3,022,880	£ 3,610,880
	22%	£ 953,568	£ 1,169,168	£ 1,384,768	£ 1,600,368	£ 1,815,968	£ 2,031,568	£ 2,247,168	£ 2,462,768	£ 2,893,968	£ 3,325,168	£ 3,971,968
	24%	£ 1,040,256	£ 1,275,456	£ 1,510,656	£ 1,745,856	£ 1,981,056	£ 2,216,256	£ 2,451,456	£ 2,686,656	£ 3,157,056	£ 3,627,456	£ 4,333,056
	26%	£ 1,126,944	£ 1,381,744	£ 1,636,544	£ 1,891,344	£ 2,146,144	£ 2,400,944	£ 2,655,744	£ 2,910,544	£ 3,420,144	£ 3,929,744	£ 4,694,144
	28%	£ 1,213,632	£ 1,488,032	£ 1,762,432	£ 2,036,832	£ 2,311,232	£ 2,585,632	£ 2,860,032	£ 3,134,432	£ 3,683,232	£ 4,232,032	£ 5,055,232
	30%	£ 1,300,320	£ 1,594,320	£ 1,888,320	£ 2,182,320	£ 2,476,320	£ 2,770,320	£ 3,064,320	£ 3,358,320	£ 3,946,320	£ 4,534,320	£ 5,416,320
	32%	£ 1,387,008	£ 1,700,608	£ 2,014,208	£ 2,327,808	£ 2,641,408	£ 2,955,008	£ 3,268,608	£ 3,582,208	£ 4,209,408	£ 4,836,608	£ 5,777,408
	34%	£ 1,473,696	£ 1,806,896	£ 2,140,096	£ 2,473,296	£ 2,806,496	£ 3,139,696	£ 3,472,896	£ 3,806,096	£ 4,472,496	£ 5,138,896	£ 6,138,496
	36%	£ 1,560,384	£ 1,913,184	£ 2,265,984	£ 2,618,784	£ 2,971,584	£ 3,324,384	£ 3,677,184	£ 4,029,984	£ 4,735,584	£ 5,441,184	£ 6,499,584
40%	£ 1,733,760	£ 2,125,760	£ 2,517,760	£ 2,909,760	£ 3,301,760	£ 3,693,760	£ 4,085,760	£ 4,477,760	£ 5,261,760	£ 6,045,760	£ 7,221,760	
20%	£ 866,880	£ 1,062,880	£ 1,258,880	£ 1,454,880	£ 1,650,880	£ 1,846,880	£ 2,042,880	£ 2,238,880	£ 2,630,880	£ 3,022,880	£ 3,610,880	

Average flock size in Wales	Prevalance of Sheep scab in Wales								
		10%	15%	20%	25%	30%	35%	40%	45%
	100	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	200	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	350	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	500	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	600	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	700	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	800	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
	1000	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480
2000	£ 1,315,440	£ 1,973,160	£ 2,630,880	£ 3,288,600	£ 3,946,320	£ 4,604,040	£ 5,261,760	£ 5,919,480	

Appendix 5 Modelling a Likely Spread of Scab in Wales.

In order to determine the likely financial implications of any sheep scab strategy in Wales it is necessary to build a picture of the spread at as detailed a level as possible. A previous study on the incidence of sheep scab in Wales by Wall *et al.* suggested that there are scab 'hotspots' in Wales. However on closer examination these are indicated in their paper as approximately 50 percent of the land mass of Wales. This makes it difficult to determine what will happen following a sentinel farm disclosure of sheep scab and, in particular, how many other sheep scab infected farms will be disclosed following the initial sentinel farm.

To determine this we need a number of pieces of information. Firstly we need an indication of the number of farms that a single farm will infect in a given time period (the R0 of a sheep scab infected flock). A study by French *et al.*, which examined scab out breaks from 1973 to 1992. This study produced a contour graph which demonstrated the number of farms infected as time and distance increase. . This information was utilised in the current Welsh strategy in order to justify and streamline budgets.

Knowledge of the number of neighbours that are around any given farm is required in order to understand how many farms will need to be tested in a sentinel and ring testing strategy. To determine this in Wales, the number of farms tested as part of a contiguous testing strategy for TB was considered a good model of what might happen with sheep scab for number of neighbouring farms. Consultation with the Welsh Government TB team found the average number of contiguous farms was 6.1 farms.

From the French *et al* paper it is seen that there is a space and time effect to infection meaning that the area that these farms cover will influence the number of farms that are infected. Using Welsh Government statistics for agricultural land and number of sheep farms, an area of land per farm was generated. A total of 7.1 farms (sentinel farm and neighbours) were then considered to cover an area of Wales and basic geometry (radius of the circle) was used to determine the furthest distance that these farms were apart.

Once the area of farms and distance covered by the circle was determined, looking up the distance on the relevant graph in French *et al* suggested the mean number of infected farms would be 3 (sentinel plus 2 disclosed) within the area covered by neighbouring farms . Looking along the time axis to 24 months suggests that this would have no effect.

It is therefore suggested that if all contiguous farms are tested for every farm identified as a sentinel, then 2 additional scab infected farms will be identified and can be treated. The implication of this is that at any prevalence the number of "hot spots" will be 1/3 the number of farms affected. For example, at a prevalence of 20% of 14000 flocks there will be 2800 infected farms and this will result in 933 "hot spots". In Wales it is possible to fit approximately 2000 units of 7.1 farms. This suggests that our method will cover 50% of the land in Wales which is consistent with the findings of Wall *et al.*