Focus Site Project Review

Trialling fluke habitat assessment tools, and improving farmer awareness of rumen and liver fluke incidence on their farms –taking a habitat approach.

Mark Jarvis, Gelli Goll, Llansannor, Cowbridge, CF71 7RW

Annie James, Hafod, Bancyffordd, Llandysul, SA44 4SD

Dafydd Rhys Owen, Brwynog, Llanddeusant, Holyhead, LL65 4AT

Jack Lydiate, Tynyberth, Abbeycwmhir, Llandrindod Wells, LD1 6PU

Prepared by Helen Ovens

Loree Jones

ADAS UK Ltd

Unit 10D

Cefn Llan Science Park

Aberystwyth

SY23 3AH

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Email: helen.ovens@adas.co.uk

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1 Summary

A series of repeated surveys were carried out on five participating farms, examining fluke snail, liver fluke and rumen fluke presence in farm habitats, in livestock and evaluating the survey techniques usefulness in detecting and managing risk of liver and rumen fluke infection. Participating farms were Aberkin, Brwynog, Gelli Goll, Hafod and Tynyberth. All farms had previously identified the presence of liver fluke in either their cattle or sheep and have chosen to take action in tackling this parasite.

All farms were keen to identify the level of infection on individual fields to provide actionable information to adapt and tailor grazing management, with the expectation that this in turn would reduce the risk of infection. To ensure the project is not only useful for those participating but also the wider industry the long term goal of the project was also to trial the use of an environmental DNA (eDNA) technique for identifying snail presence or otherwise in water courses. It is hoped that through the development and then roll out of such a tool, fluke risk would be more accurately assessed on farms, helping improve management advice. This would be of benefit to the wider agricultural and veterinary industry.

The knowledge base around the incidence of rumen fluke on farms in Wales is very low currently, and this project provided an opportunity to 1. Assess rumen fluke incidence and risk on participating farms, and 2. in doing so, raise awareness of the emerging concerns around rumen fluke presence.

Individual farm information is in Section 2 – Business Review.

Focus Farm Project Aims:

1. Evaluate the usefulness of providing information to farmers through a series of snail surveys
2. Contribute to the development of an eDNA assay for mud snail and liver fluke parasites
3. Identify the level of infection on individual farm habitats
4. Provide information for tailored grazing management
5. Highlight the role snail habitats play in the life cycle of rumen and liver fluke

1.1 Project Conclusions

The data was collected over a number of visits to all 5 participants, where information was recorded on the current fluke status and ongoing infection levels on each farm. Snail presence and infection status of those snails was also recorded with eDNA samples –an emerging technique not commonly used for snail detection- which is hoped to be further developed as a robust method for recording the presence of fluke snail and parasite DNA. IBERS was then able to analyse all collected and recorded data to provide information on farm infection status.

1.1.1 IBERS conclusions

As expected the study found the presence of fluke snails to be a clear risk factor for fluke infections in livestock, with snails being an integral element within the fluke's lifecycle. Habitats containing both snails and fluke were found to be highly likely to pose risk of infection to livestock during the past grazing season, with the likelihood that this may continue into the following grazing season.

It was suggested that habitats with evidence of snail presence, but no observed detection of fluke infection, would be less likely to pose a major risk to livestock during the past grazing season. However, they may pose a risk in the following grazing season if infected with fluke eggs shed by livestock late in the grazing season.

It was interpreted that habitats where no traces of snails were detected were less likely to pose a risk to livestock during the past grazing season, with this reduced risk likely to continue at least into the early part of the following grazing season. Although it is suggested that if these habitats represent favourable habitats for snails there is the risk that those areas may become colonised by snails in the future.

The project was able to identify habitats that contained fluke snails and identified those that were likely to be infected with fluke. It was noted that although intervention to reduce contact between livestock and fluke can be costly when erecting fences and improving in-field drainage systems, these practices are valuable management strategies when reducing the immediate risk and managing future cases of fluke infection.

The project confirmed that fluke snail presence does not necessarily mean fluke presence, but it certainly increases the risk of fluke becoming present in that habitat, unless prevention measures are put in place.

The challenge facing the industry is what would be cost effective long term, balancing the value of livestock to the business, the cost of installing infrastructure with a view to reduce fluke infection and the sustainability/availability of alternative treatment options (with resistance to flukicides being an emerging issue).

1.1.2 Gelli Goll Conclusions

Results: fluke snail, rumen and liver fluke presence found.

Table 1 provides a summary of the Gelli Goll results. Both rumen and liver fluke infections were found to be established in fluke snail populations across several habitats on the farm. Rumen fluke infection levels were recorded as being particularly high in May, with levels being as high as the highest observed in a recent Wales-wide study.

Table 1: Gelli Goll Liver and Rumen Fluke Results

Sample number	Visit	Eggs Per Gram Liver Fluke	Eggs Per Gram Rumen Fluke
C1 (Cattle)	1 (May 2017)	0	29
C1	1 (May 2017)	10.5	28
C3	1 (May 2017)	0	0
C7	1 (May 2017)	2	30
C9 (Cattle)	2 (September 2017)	0	5.2
C10	2 (September 2017)	1	8.5
C10 a	2 (September 2017)	0.25	0
C12 (Sheep)	2 (September 2017)	0	0
C13	2 (September 2017)	2	17

1.1.3 Hafod Conclusions

Results: fluke snail, rumen and liver fluke presence found.

Sampling conducted at Hafod concentrated on one particular area of concern. This area is adjacent to a stream on the farm boundary which sees many wet marshy areas protruding into grazing fields. Being a suitable habitat for fluke snails there was evidence of their existence in the majority of samples with the snails also being easily found by the surveyor.

The number of both liver and rumen fluke infected snails across some habitats of the farm suggested that those sources of infection posed significant risk to grazing cattle. Rumen fluke was found to be well

established in the herd. Results did not confirm the presence of liver fluke in any cattle. However, it is likely a potential infection outbreak would take place in the summer/autumn period.

Table 2: Hafod Liver and Rumen Fluke Results

Sample category	Visit	Eggs Per Gram Liver Fluke	Eggs Per Gram Rumen Fluke
Dairy Herd	1 (May 2017)	0	47.6
Calves	2 (July 2017)	0	0.5
Dairy Herd	3 (October 2017)	0	7

1.1.4 Brwynog Conclusions

Results: low fluke snail presence found in habitats.

Sample collection for Brwynog farm actually took place on two alternative land parcels, one being Henbont, the other at Manaw. Results show low levels of both rumen and liver fluke across both parcels. However, it was concluded that recent drainage works conducted at Henbont are likely to have influenced this. In many habitats no evidence of snails were found, likely due to recent disturbance from ditch opening and cleaning operations. No fluke was found in FEC sampling of livestock later in the study, which corresponds with the lack of fluke snails found in habitats. However it was concluded that the livestock treatment regime at Brwynog could have contributed to this low incidence, helping break the reproduction cycle.

The study confirmed local populations of fluke snails on the farm as seen in table 3. IBERS however concluded that there was no guarantee that levels would remain as low as seen throughout the project as populations may recover and increase.

Table 3: Brwynog Liver and Rumen Fluke Results

Sample number	Visit	Eggs Per Gram Liver Fluke	Eggs Per Gram Rumen Fluke
B1	1 (May 2017)	3.9	0
BB1	1 (May 2017)	0	2
BB3	1 (May 2017)	0	0
B1	2 (August 2017)	0	0
BB1	2 (August 2017)	0.5	2.25
BB3+BB4	3 (October 2017)	0.5	1.3
B1-4	3 (October 2017)	0	0
B1-3	4 November (2017)	2.5	0
BB1-4	4 November (2017)	2	0

1.1.5 Tynyberth Conclusions

Results: fluke snail presence found in habitats.

Fluke species were found in FEC sampling and fluke snails within the majority of habitats. Large numbers of snails were found over August/September sampling which is typical of that time of year and at the farm's altitude. The majority of habitats sampled were wet, boggy areas with running water. These features provide habitat for high snail numbers across all seasons, with it being likely that infection risk is present from early on in the grazing season in some habitats on the farm.

However, actual fluke incidence (not snail incidence) was relatively low, as indicated in the sample results below.

Table 5: Tynyberth Liver and Rumen Fluke Results

Sample	Visit	Eggs Per Gram Liver Fluke	Eggs Per Gram Rumen Fluke
E1	1 (May/June)	0	0
E3	1 (May/June)	0	0
E4	1 (May/June)	2	0
E CATTLE	1 (May/June)	0	0
E2 Sheep	2 (July)	0	0
E2 cattle	2 (July)	0	0
E4	2 (July)	0	1
E2 + E3 Sheep	3 (August/September)	1	0
E2 + E3 Cattle	3 (August/September)	0	0
E4	3 (August/September)	0	0

1.2 Take Home Messages to the Industry

Challenge yourself with:

- Are you in control of liver fluke on your farm? Do you know where and when it is most abundant?
- Could you use FECs and habitat mapping to implement a strategic grazing management strategy?
- Do you have a quarantine strategy in place? Is it effective?
- Does the flukicide used work effectively? (e.g. do you know if you have resistance issues?)
- Do you ALWAYS treat correctly at the right dose?
- Could you apply other control methods to control liver fluke[1]

1. Identification of all fluke snail habitats will help implement effective grazing management programmes and ensure landowners are in control if an outbreak occurs.

When grazing wet and muddy areas of fields livestock are at risk of ingesting the infective stage of the liver fluke parasite – the metacercariae. Ingesting at this stage can lead to 25,000 eggs per day being shed by the host's faeces[2].

Acidic wet areas with slow moving water present are areas of the highest risk.

Permanent habitats including banks of ditches and streams, edges of small ponds and pools around water troughs are also deemed suitable habitats for the mud snail host *Galba truncatula.*

Pipes and water troughs should be maintained to minimise threats posed by pools created from leaking pipes.

If snail habitats are localised those areas can be fenced off completely or not grazed during periods of high risk. This may lead to reduced stocking rates and is not always a viable alternative so should be carefully considered[3].

Extensive wet areas will often require drainage works, although expensive in the short term, this works as an excellent preventative management tool and is likely to be beneficial in the long term.

2. Knowledge of the fluke life cycle will influence present and future infection.

Liver fluke control should act as part of a wider flock/herd management strategy with actions coordinated between the farmer and professional veterinary advisors. A wider livestock management strategy should include actions to tackle other health issues, nutrition, body condition scoring and grazing and forage management.

Action should be taken to address issues as and when they occur with routine monitoring providing an up to date health status. The prevalence of the parasite should be monitored each year and used to drive

[1] AHDB. 2016. *Worm Control in Sheep for Better Returns.* AHDB. Available from: http://beefandlamb.ahdb.org.uk/wp-conatent/uploads/2016/08/BRP-Worm-control-in-sheep-manual-8-170816.pdf. (Accessed 23rd January 2018).

[2] Rees, E. 2012. *Control of Endo and Ecto-Parasites in Organic Beef Cattle Production Systems.* Farming Connect. Available from: https://businesswales.gov.wales/farmingconnect/sites/farming/files/092012-control-of-endo-and-ecto-parasite-in-cattle.pdf. (Accessed 3rd April 2018).

[3] Rees, E. 2012. *Control of Endo and Ecto-Parasites in Organic Beef Cattle Production Systems.* Farming Connect. Available from: https://businesswales.gov.wales/farmingconnect/sites/farming/files/092012-control-of-endo-and-ecto-parasite-in-cattle.pdf. (Accessed 3rd April 2018).

effective control measures for the following year with regimes tailored to individual farms, whether this be by treatment or management practices[4].

3. The importance of being informed and pro-active in gaining professional advice

- Check resistance through laboratory testing.

An indication as to whether treatment has been successful can be conducted via laboratory testing of faecal samples using FEC from 5-10 sheep once treatment has been administered. Any perceived drug failures should be investigated through a series of FEC tests to help ascertain whether the lack of efficacy is due to drug resistance. Tests should be repeated at intervals as part of an ongoing monitoring process within a flock/herd health plan and seeking veterinary advice is strongly recommended.

- Ask for professional advice when choosing a treatment product.

Choosing the correct product to target liver fluke correctly should result in a reduction in treatment frequency, saving time and money as previously discussed, in addition to reduced stock stress. When sourcing a product it is advised that professional advice from a veterinary practice is taken to ensure the chosen product is most effective and treatment protocols are suitable[5].

4. Identification of product resistance and ensuring a practical and timely management approach is adopted. This will reduce associated costs and allow for a productive and profitable flock/herd.

- Avoids use of costly but ineffective treatments.
- Ensures effective treatment at required time.
- Adjust quantity of dose according to weight whether this be by weighing individuals or weighing the largest animal, and dosing for this weight on a whole flock/herd basis.
- Correct calibration of drench/pour on gun.
- Those administering the drug should fully understand it's mode of action.
- Be aware of withdrawal periods when using flukicides on dairy cows or livestock destined for meat.

SCOPS principles should always be adhered to. A combined flukicide and nematocide approach can lead to wormer resistance, if one of the active ingredients is not actually required[6]. Avoiding the introduction of fluke into livestock by adhering to quarantine procedures is also important (holding new or infected livestock on the yard for treatment instead of releasing directly onto pastures –this reduces the drop of contaminated eggs via faeces into the field environment).

There is growing concern associated with resistance to flukicide products, particularly those containing triclabendazole (TCBZ). TCBZ is currently the only active agent available that works effectively on both adult and migrating stages (older than 1 week) of the fluke lifecycle, and therefore its resistance to treatment will likely have a significant effect on many farmers in Wales. This resistance should be considered when utilizing alternative active agents only effective on adult stages of the lifecycle, as many farmers –for ease and convenience- will carry out an annual treatment only, which may be administered

[4] Farming Connect. 2018. *Parasite Control: Liver Fluke.* Farming Connect. Available from: https://businesswales.gov.wales/farmingconnect/posts/parasite-control-liver-fluke. (Accessed 3rd April 2018)
[5] XL Vets. Not dated. *Sheep Worm Control and Resistance Management.* X L Vets. Available from: http://www.xlvets.co.uk/sites/default/files/uploads/files/Wormer%20imposed%20VF%20LOW.pdf. (Accessed 23rd January 2018).
[6] HCC. 2012. *Controlling Liver Fluke on Welsh Farms.* HCC. Aberystwyth.

at an ineffective time (convenient to the farmer, but not maximising the efficacy of the drug), leading to younger parasites surviving initial treatment[7].

2 Farm Profiles

2.1 Gelli Goll

Gelli Goll in Llansannor, Cowbridge is a mixed lowland beef and sheep farm, which Mark Jarvis farms alongside his wife and father. The total farmed ground comprises of 320 acres of permanent grassland, 70 acres of arable and 10 acres of rough grazing, thus equating to 400 acres, with some owner occupied and some rented. With 700 breeding ewes and 150 store cattle, the farm is currently within a Glastir advances scheme and has 8 acres of SSSI.

With the presence of fluke increasing on the farm, Mark was aware that more needed to be done in addition to the FEC sampling previously conducted. 30 ewes were lost in autumn 2016 when fluke resistance to triclabendazole was discovered. Although an adapted routine treatment programme is in place, it is hoped participation in the project will increase awareness of the implementation of management practices that will help alleviate parasite presence.

2.2 Hafod

Annie James farms alongside her husband and father at Hafod, Bancyffordd, Llandysul. A 120 acre farm with an additional 100 acres rented on short term let for silage production. They milk 150 cows whilst rearing approx. 50 replacement heifers.

Having purchased the farm fairly recently, Annie wanted to gain a broader understanding of the fluke presence on the farm and where high risk areas were located. With the farm being very wet and young stock often seen grazing wetter ground, improved animal health was the main reason for participating in this project.

With improved knowledge and understanding of their own personal circumstances this will allow management alterations to be made to help reduce problems, instead of solely relying on flukicides.

2.3 Brwynog

Farmed by Rhys Owen and his father, Brwynog comprises of 285 acres of owned and 100 acres of rented ground. The farm is not within an agri-environment scheme. With 1100 breeding ewes and 100 store cattle, this beef and sheep farm previously suffered severe outbreaks of liver fluke with cases being particularly bad 2 years ago.

Having gained control of the problem through treatment and routine flock/herd assessment Rhys wanted to participate in the project to gain a greater understanding of the parasite that could prove fatal if contracted by his livestock. Location of fluke snails, rumen fluke presence and beneficial management strategies were all aspects which Rhys hoped to gain further knowledge through his participation in the project.

[7] Farming Connect. 2018. *Parasite Control: Liver Fluke.* Farming Connect. Available from: https://businesswales.gov.wales/farmingconnect/posts/parasite-control-liver-fluke. (Accessed 3rd April 2018).

2.4 Tynyberth

Jack Lydiate farms in partnership with his mother and father at Tynyberth, Abbeycwmhir, Llandrindod Wells. The 500 acre beef and sheep farm currently keeps 7 breeding cows, whilst rearing 3 replacements heifers, in addition to 520 breeding ewes with 120 ewe lambs. In recent years the woodland at Tynyberth has been expanded with an additional 150 acres of woodland planted on previously rough grazing land. This organic farm is currently in Glastir Advanced having completed a Glastir Entry contract last year and has 2 SSSIs present on the farm.

With a number of recent fluke outbreaks, Jack hoped his participation in the project would enable him to gain a greater understanding of their current fluke status, to gain further control of what was rapidly becoming an increasing problem within their flock. It is likely that fluke presence has built up over a number of years with participation in the project allowing for implementation of effective control measures and treatment strategies.

3 Farmer perspectives of the project

All participants were very positive about participating in the project and intend to continue with the management strategies suggested by the project. Participants also highlighted how the project had not only given them a greater understanding of both liver and rumen fluke but had also reiterated the importance of understanding on farm liver fluke conditions.

Mark Jarvis of Gelli Goll found the project to be beneficial to his sheep enterprise which has already witnessed the damage caused by fluke. Although Mark had some awareness of fluke presence on the farm and the habitats they survived in, project findings informed him of the level of rumen fluke, which came as a surprise. With a fluke status far higher than desired, Mark plans to adapt his management protocols to manage current levels and will be seeking professional advice when formulating a plan, whilst also continuing with practices associated with the project. Mark also felt that such research will provide opportunities for the wider industry where fluke is proving to be particularly damaging.

Appreciating that fluke was indeed present on the farm, **Annie James of Hafod** routinely examined abattoir feedback to assess current fluke issues. Annie was aware that relying on reports of this form may come too late and was keen to consider and support the development of alternative methods of fluke status assessment, in particular ones that were at least in real time or proactive in nature. Aware that wetter areas of the farm suffered from higher levels of fluke, the project provided Annie with greater information on specific habitats where fluke was present. In addition the project raised Annie's awareness of the presence of rumen fluke which led to management protocols adapting to protect against both strains of fluke. Annie highlighted how assisting with sample collections improved her understanding of the snail life cycle, something which is integral in combatting the infection. She felt this understanding will help when planning livestock grazing and implementing management practices that alleviate fluke damage.

Aware of one particular area that often caused problems, **Rhys Owen of Brwynog** was surprised at how specific snails were when choosing their habitat; he learnt this as a result of assisting with sampling work. Rhys was not only shocked by the number of snails found, but where the snails where located, thus giving Rhys a clearer idea of the current status of the farm. Having previously relied on a number of management practices to assess the presence of fluke, such as BCS scoring, abattoir feedback and

routinely checking for ewes with white eyes, Rhys felt his suspicions regarding infection had been reinforced as a result of project participation. The project highlighted to him the importance of taking these steps and provided clarity to continue with those measures already being implemented. Rhys felt findings had raised his awareness of the need for improved drainage on the farm, this being a management practice that would be prioritised. Rhys felt the project could provide the industry with further opportunities to address fluke issues, particularly as eDNA testing would allow identification of cases in the field before any damage is done. It was felt that the next step would be ensuring such information is filtered through the industry appropriately to maximise benefits.

Aware that fluke is both present and increasing on the farm, **Jack from Tynyberth** was surprised at areas where snail presence was found. Understanding that snails are not always attracted to wet, boggy areas highlighted the need for continual monitoring of the whole farm. Having previously completed no fluke testing, Jack felt the project had increased his awareness of the need for frequent treatment until fluke is under control and manageable.

He felt that gaining a greater understanding of where fluke was present enabled him to act upon management strategies that would reduce the likelihood of livestock grazing infected pastures. Jack highlighted that land can still remain viable if grazing no longer takes place, through planting woodland as an alternative means of income on those infected pastures. He felt that implementing strategies to tackle fluke in the long term whilst working around fluke in the short term can ensure that actionable practices are implemented to overcoming the financial burden caused by the parasite.

4 Project Review

4.1 Project aims and methodology

1. Identify the level of infection in individual farm habitats.

2. Evaluate the usefulness of providing information to farmers.

2. Complete a series of repeated surveys of snails within on-farm habitats.

3. Develop an eDNA assay for both the mud snail and the liver fluke parasite to assess habitat infection levels.

4. Reinforce and highlight the crucial role that snail habitats play in the life cycle of rumen and liver fluke.

5. Communicate and disseminate project findings to the wider livestock industry via open days, progression events and social media.

4.2 IBERS involvement in the project

The project set out to provide information to participating landowners on the infection status of on farm fluke snail habitats by conducting surveys for *Galba truncatula* 'fluke snails' whilst developing an eDNA assay to detect their presence in water from the habitats. All the farms were visited between 2-4 times and between 4 and 9 wet habitats were repeatedly surveyed on each farm during each visit. Water from the habitats was filtered through eDNA filters and snails were collected for DNA analysis. In addition, faeces from livestock grazing the fields surrounding the habitats were collected.

During the course of the project IBERS identified livestock groups with liver fluke and rumen fluke infection via faecal egg counting and by the end of the project IBERS was able to determine whether fluke snails were likely to be present within habitats and whether liver fluke and rumen fluke DNA were also present.

The presence of fluke snails is a clear risk factor for fluke infections in livestock as the snails are integral to the fluke's lifecycle.

With time IBERS was able to identify those habitats where fluke snails were likely to be present, in addition to gaining an idea of liver and rumen fluke presence through DNA. With snails being an integral part to the fluke's lifecycle, identification of these fluke snails would increase the understanding of snail presence in order to reduce associated risk.

Categorisation following careful analysis allowed IBERS to analyse results in preparation to give detailed advice on possible control methods that could be adapted by each individual farm. Careful observation led to IBERS writing individual reports based on conditions specific to all farms whilst also providing advice on widespread findings discovered throughout the project.

As a result of this work, IBERS was able to categorise the habitats into:

- habitats with no fluke snails
- habitats where fluke snails were observed or where fluke snail DNA in water was detected, but fluke DNA was not
- habitats where either fluke snails or their DNA in water was detected, and where fluke DNA was detected in either snails or water

4.3 SWOT analysis

STRENGTHS	• Greater understanding of the fluke life cycle, influencing management protocols. • Greater understanding of specific farm fluke status and areas of infection. • A better understanding of rumen fluke presence on-farms, both by the industry support bodies and the participating farmers. • An opportunity to reiterate that timely dosing achieves effective treatments and reduces cost/labour requirement. • A greater awareness of the value of using quarantine methods, accurate dosing techniques and the use of resistance testing via the FEC pack.
WEAKNESSES	• Variation in summer and winter rainfall areas means every farm is unique. • Variable weather makes it difficult to predict the prevalence of the parasite. • Management practices such as drainage and fencing are costly. • Lack of snail free land on many livestock farms in Wales means high risk areas are needed to meet grazing requirements and ensure business remains profitable. • Making management decisions on FEC results if only undertaking FEC on an ad-hoc basis may not be effective. • An increase in resistance means other management techniques will need to be considered, which the business may not be able to implement (restricted grazing or installing fencing/drainage). This situation may then in turn further accelerate the journey to high levels of parasite resistance to treatments.

OPPORTUNITIES	• More informed grazing, quarantine and treatment regime decisions. • Graze livestock on pasture assessed as low risk and avoid wet areas around ponds and ditches or with slow running/standing water. • Map areas where high risk habitats are located, ensuring management practices such as fencing and drainage costs are kept to a minimum. • Improved management practices through drainage works and fencing off high risk areas –high cost, but with longer term gains.
THREATS	• Habitats suitable for fluke snails with no current evidence of presence may become colonised in the future. • Fluke snails with no evidence of infection can become infected in the future. • Lack of rain resulting in a poor growing season, meaning livestock have to be located to wherever there is grass available. • Poor grass growing season resulting in poor lamb growth rates. • Resistance to flukicide, particular issues addressing adult and migrating fluke if resistance to TCBZ develops.

4.4 Alignment to the sector's strategic goals

This work contributes to the Welsh Red Meat Sector's strategic objectives[8], specifically in relation to:

- Improving on-farm output from the red meat sector by at least 7% by 2020, by helping to contribute to increasing the national average flock/herd performance.
- Develop and encourage flock/herd health planning, parasite prevention and effective quarantine practices to improve biosecurity and reduce the impact of fluke.
- Enhance industry understanding of economic benefits of optimising animal health and improving efficiency through effective husbandry.
- Increasing the average weight of lambs produced per ewe in Wales, by at least 10% (to 56kg).
- Develop new business focussed programmes to improve the management, efficiency and profitability of Welsh red meat businesses.

5 Impact on the industry

5.1 Impact on individual business

This is covered in the 'farmers' perspective of the project' section of the report in Section 3.

5.2 Impact on wider industry

Refer to the Take Home Points for the Industry section in the Summary section of this report.

There is scope for the project concept to be replicated over other livestock farms in Wales. The results from all 5 participating farms are excellent examples of how farmers can increase in their knowledge base and parasite management expertise, resulting in a more proactive approach to fluke, via testing, grazing management, avoiding wetter areas, fence erection and improving drainage.

[8] Hybu Cig Cymru – The Strategic Action Plan for the Welsh Red Meat Industry

These farmers should see a return on their investment in the longer term, via an increase in productivity per animal. The adoption of such an approach across Wales should lead to an increase in productivity and profitability throughout the entire industry[9].

5.3 Impact on Welsh Government's cross cutting and priority themes

5.3.1 Climate Change

Changes to the climate have brought warmer, wetter weather patterns. Such conditions are predicted to cause periods of intense infection which are likely to happen more frequently[10]. Rainfall may alter the size of primary habitats and migration distances of the snails leading to increased areas of contamination and influencing cases of infection[11].

Climate change presents us with production challenges – the need to maintain production from as low carbon emissions base as possible. Effective fluke control plays an important part in optimising the outputs from our livestock, by reducing the impact of infection on growth rates, feed requirements and time to finishing, as well as by reducing use of chemical treatments through implementing practical management protocols.

5.3.2 Animal Health and Welfare (AHW)

Poor fluke control in livestock can result in major adverse effects on the flock/herd.

Exercising good disease and infection control and management promotes good animal health and welfare, resulting in reduced ill thrift and mortalities. Thereby achieving a higher % of healthy flock/herds and successful beef and sheep enterprises.

[9] Hybu Cig Cymru. Not dated. *Flukicide resistance at Bryncaws – taking a strategic approach to ensure effective treatment.* Hybu Cig Cymru. (Accessed 4th April 2018). Available from: http://hccmpw.org.uk/publications/farming_industry_development/animal_health_and_welfare/.

[10] Hybu Cig Cymru. 2012. *Controlling Liver Fluke on Welsh Farms.* Hybu Cig Cymru. Aberystwyth.

[11] Knubben-Schweizer, G & Torgerson, P. 2014. Bovine fasciolosis: Control strategies based on the location of Galba truncatula habitats on farms. *Veterinary parasitology.* (298) 77 – 83.

5.3.3 Future Generations

Controlling on farm infection and parasite burdens through adopting a routine monitoring system and adapted management practices will reduce reliance on flukicides. With many farms facing challenges associated with resistance, having a range of fluke identification practices should help future generations manage fluke more effectively. Reducing challenges faced by the industry should help inspire future generations to pursue or continue a career within the agricultural industry.

5.3.4 Tackling Poverty

Focusing on improving animal health on farm is a livestock management tool, reducing overall losses and resulting in higher productivity. Although some management practices may seem costly to begin with these will ensure long term gains and improved profitability. Improving productivity is likely to influence on farm profitability and therefore act as an influencing factor in tackling poverty in agriculture. Businesses running a cost efficient, sustainable system have the potential to increase returns through increased income both on and off the farm.