Parasite Management Project
Final Project Report

Report prepared for Farming Connect by -

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1. Introduction

Internal parasites are one of the most common and important diseases that livestock farmers must deal with on a daily basis. The Parasite Management Project was set up to monitor parasite burdens on 10 focus sites throughout Wales and report the findings on a regular basis through the Farming Connect website and social media channels. The project focused on the gastro intestinal parasites (roundworms) with regular faecal egg counts (FEC) used to monitor worm burdens in both sheep and cattle. This final report summarises the outcomes of the project including the burdens found through the season, efficacy of wormer treatments and any changes to worm control on farms.

Each of the farms received bespoke consultancy to implement the latest advice and recommendations from the SCOPS (www.scops.org.uk) and COWS (www.cattleparasites.org.uk) initiatives. Where possible, each farm tested for wormer resistance / efficacy and this enabled our focus farmers to manage situations where multiple resistance is present.

The project ran from March to September 2019 and was delivered on behalf of Farming Connect by Techion UK.

Project aims and objectives: **Implement on-farm changes**

- To work with a network of farmers throughout Wales to:
  - Implement the latest advice and recommendations from SCOPS and COWS
  - Implement regular monitoring of worm burdens through faecal egg counts using the FECPAK^{G2} platform, which was used on-farm by each focus farmer.
  - Test for anthelmintic resistance / efficacy and enable farmers to manage situations where multiple resistance is present.
  - Improve stock performance by better managing parasite burdens and resistance.
  - Slow down the development of resistance to other wormers – especially the new 4th and 5th generation wormers.

2. Key findings

- A good uptake of FEC testing by most farmers, with regular monitoring throughout the season.
- The timing and extent of parasite burdens wasn't what farmers always expected.
- Significant lack of efficacy to wormers recorded, which surprised participating farms.
- Large variability in extent of wormer efficacy, however, encouraging to see those who have been following SCOPS principles in the long term had the better results.
- Frequency of wormer treatments reduced on most farms, with some seeing significant reductions.
- An improvement in performance was observed across many farms, although this was difficult to always credit to better parasite control
- No decline in performance despite changes to parasite control and less worming.

3. Farmer background and project participation

This project investigated whether using technology to make on-farm FEC testing more accessible and easier can help participating farmers monitor FEC on a more regular basis. Each farm used (or had access to) the FECPAK^{G2} system and were provided training on how to use it. All farms received consultancy visits from Eurion Thomas of Techion, who advised on the latest parasite control guidelines and when to monitor FEC.

Background to the FECPAK^{G2} system

FECPAK^{G2} is a complete on-farm or lab-based parasite assessment tool (FEC). FECPAK^{G2} generates results quickly, so informed parasite management decisions can be made on-farm. The platform is comprised of equipment for preparing a faecal sample, a micro imaging unit (Micro-I) and software to enable the processing and communication of sample images and sample related data to the internet. The sample images are analysed online by a skilled technician. When completed, the results are emailed simultaneously to the farmer, vet or advisor.

Platform features

- Simple FEC processing on-farm – no microscope required
- Samples do not have to leave the property (submitted online)
- Prompt FEC results and support via email
- Online access to all FEC information via a user portal
- No special technical skills or knowledge needed
- Easy to use, fully auditable, centralised FEC information reporting and sharing options

Farmer participation

- A total of 10 farms were recruited throughout Wales and are listed in Table 1 below.
- Three farms focused primarily on parasite control in cattle, while the other 7 focused on sheep.
- One farmer (David Lewis, Halghton Hall) couldn't be set up with the FECPAK^{G2} system on-farm as he had no internet coverage at all at the premises. The system was, therefore, loaned to Daleside Vets, who are the farm's vet practice, and David took samples to them to test.
- One farmer (David Jones, Hardwick Farm) decided he didn't want the FECPAK^{G2} system on-farm and opted to send samples to Techion's lab instead.

Farmer Name	Farm name	Address	County	Primary Focus	No. Samples Submitted
David Lewis	**Halghton Hall**	Bangor on Dee	Wrexham	Sheep	17
James Powell	**Dolygarn**	Llanbadarn Fynydd	Powys	Sheep	16
Irwel Jones	**Aberbranddu**	Pumsaint	Carmarthenshire	Sheep	19
Glyn Davies	**Cothivale**	Crugybar	Carmarthenshire	Sheep	10
Rhodri Lloyd-Williams	**Moelgolomen**	Talybont	Ceredigion	Sheep	19
Hywel Davies	**Celyn Mawr**	Llanwddyn	Powys	Sheep	21
Nicola Drew	**College Farm**	Trefecca	Powys	Sheep	16
John a Ianto Pari	**Fferm Carreg Plas**	Aberdaron	Gwynedd	Cattle	13
David Jones	**Hardwick Farm**	Abergavenny	Monmouthshire	Cattle (Dairy)	3
Gareth Thomas	***Tregyrnig***	*Cemaes Bay*	*Anglesey*	*Cattle*	*3*

Table 1

The first measure of success was how farmers adapted to the technology and used it. The simplest measure of this is how many samples they submitted, which is recorded in Table 1. These are only a record of the tests submitted for routine FEC monitoring and don't include the samples used in the wormer efficacy trial. We set a target of 15 samples minimum from March to September, and as can be seen, 6 farmers reached that target, and another was close at 13. A total of 8 farmers out of 10 provided enough data to be of interest and result in changes to their historic parasite control. This result was pleasing overall, although it is worth mentioning that some farmers needed more support than others to achieve this. The challenges of adoption are discussed more in the summary section.

Gareth Thomas had to withdraw from the project halfway through as a period of ill-health meant he couldn't carry out any farm work. David Jones, Hardwick Farm only submitted 3 samples in total, which was disappointing, and as mentioned previously, they opted to send samples to Techion, which shows that even that option wasn't that easy for them. Unfortunately, this meant we couldn't get meaningful outcomes from 2 out of the 3 farms that were focusing on cattle.

An individual case study report has been written for each of the 8 farms where we had good participation. These case studies can be found on the Parasite Management Project Page on the Farming Connect website. The rest of this report attempts to give an overall summary of what was found. Due to project withdrawal and lack of involvement, no individual reports were done for Gareth Thomas or David Jones.

4. FEC monitoring results – sheep

A total of 118 sheep samples were submitted collectively over the course of the project.

FEC monitoring lambs

The majority of samples (84) were taken from lambs, which is not surprising as these are the most vulnerable stock class and where wormers are mostly targeted. The FEC levels recorded are summarised in the graph (*Figure 1*), with the coloured bars denoting the difference between the strongyle and nematodirus counts.

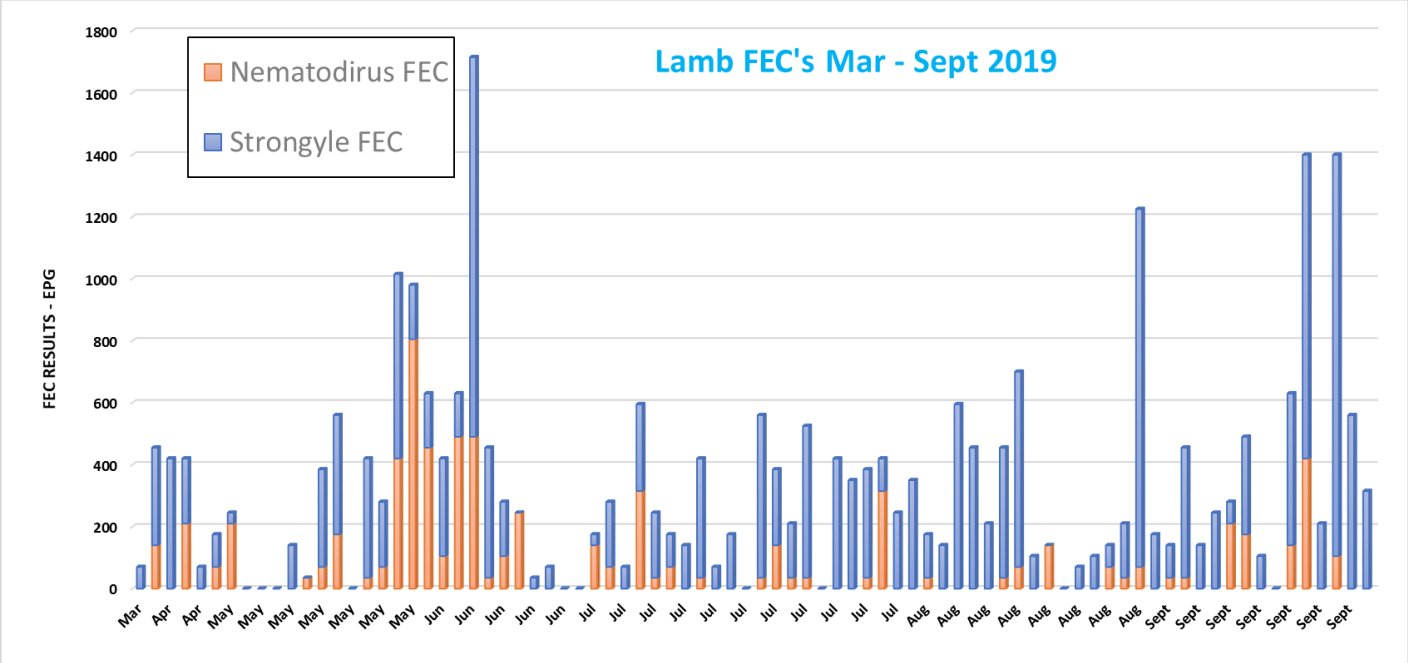

Figure 1

- To help understand the results and potential impact on animal performance, the guidance for FEC thresholds are as follows:
  - **< 200 epg** - Unlikely to treat (there are exceptions)
  - **200 epg – 500 epg** – Possibly treat. Consider other factors such as growth rates, condition.
  - **> 500 epg** – Likely to treat
- Analysis shows that 43% of results were in the 'Unlikely to treat' category, 38% in the 'Possibly treat' category and only 19% in the 'Likely to treat' category.
- It's important to note that some of the tests analysed may be post treatment checks and within the period after treatment, where we expect to record zero or low egg counts.
- Although difficult to pick out a distinct and clear pattern, there does seem to be lower egg counts recorded in the mid-summer months of June, July and August, with counts rising again in the autumn.

- The distribution between strongyle and nematodirus counts is also interesting to note. Historically, it was found that nematodirus would be the dominant species of worms in spring (April and May in particular) with the strongyle group of worms becoming more prominent early summer onwards, and it was rare to see nematodirus later in the season. As you can see, this pattern has changed (a trend seen widely across the UK over the last 10 years or so) which shows the distribution of worm species has been altering.
- We can see evidence of nematodirus throughout the season, with some quite high levels recorded at times in the autumn. There have been reports of an autumn outbreak of nematodirus that can cause performance issues similar to those during the spring.
- In contrast, it is observed from the graph that strongyle worms are often found much earlier in the spring than anticipated. This is hugely important when considering the choice of wormer for the first dose of lambs as elaborated here:

The spring worming dilemma:

- The major worm species that lambs first encounter is widely accepted to be nematodirus. This can be a particularly devastating worm for young lambs since most nematodirus eggs hatch in the spring to coincide with when vulnerable young lambs start grazing. The norm across the country is to dose with a white wormer (Group 1BZ); there are two reasons for this:
    1. Although white wormer resistance is widespread against the strongyle group (all worms other than nematodirus), it seems to remain fully effective on most farms against nematodirus (there are only a few exceptions in the UK).
    2. It's a cheap option when there are many lambs on the ground to dose – and is a good option as this will kill earlier stages of the parasite than other wormers.
- Many will advise not to FEC test at this time of year as nematodirus can cause significant problems for lambs before the adults start laying eggs. However, although we agree with the reasoning, we have been encouraging our project farmers to test as we can still get valuable information which may alter the wormer choice.
- As mentioned, although nematodirus is what we all focus on, the dominant worm species in April and May lamb counts are strongyles.
- Many of our farmers know white drench isn't fully effective against those strongyle worms and are, therefore, able to change to use another group which would work better for both.
- We do, however, need to be very careful at this time of year when interpreting counts as even though results may be in the low / medium category (below 500 epg), we still advise to worm against nematodirus if there is a known history of it and the conditions are correct.
- The nematodirus forecast on the SCOPS website (www.scops.org.uk) is also a useful resource to help with decision making.
- If there are no significant strongyle counts, then white wormer would be the most appropriate choice in these scenarios.

FEC monitoring ewes

The role of FEC, other than for lambs in the grazing season, is often overlooked. One of the key times when we think about ewes and internal parasites is in the spring, around the lambing period. Indeed, for most farmers, this is probably the only time when worming adult sheep can be justified. Due to the nutritional strain on ewes during late pregnancy / early lactation and the stress of parturition, the ewes' normally strong immune system can be compromised. Any worms that the ewes have harboured over the winter as inhibited stages of worms, or new infections picked up from overwintered larvae on pasture, may well flourish under these conditions. This is what is referred to as the peri-parturient or spring rise. If this is the case, then these ewes can be a major source of contamination of pastures where we expect lambs to perform well off grass later in that season. Therefore, worming them at lambing can be justified, as if managed correctly, we can help reduce pasture contamination.

However, there are two questions that we need to ask:

1. When does this contamination occur? When does the spring rise peak? How does this relate to late and early lambing flocks?
2. Do all ewes cause pasture contamination, therefore, do we need to worm all the ewes?
    a. Do all ewes suffer the same amount of stress?
    b. Were the pastures that ewes were grazing on during the previous autumn / winter have a significant worm population they may harbour as inhibited worms over the winter?
    c. Are fields grazed on in spring, carrying a parasite challenge that overwintered on the pasture?

What was interesting during the on-farm consultation was the varied policy on worming ewes around this period. Some would worm mid-winter or before lambing; some would worm just after lambing (for indoor lambing systems) and some would leave worming until 4 to 6 weeks post lambing to coincide with ewe crutching and earmarking time.

Each farm was, therefore, encouraged to FEC test ewes on or around this lambing period and see if this changed the policy for worming. The FEC results for ewes tested between March and May are represented in Figure 2.

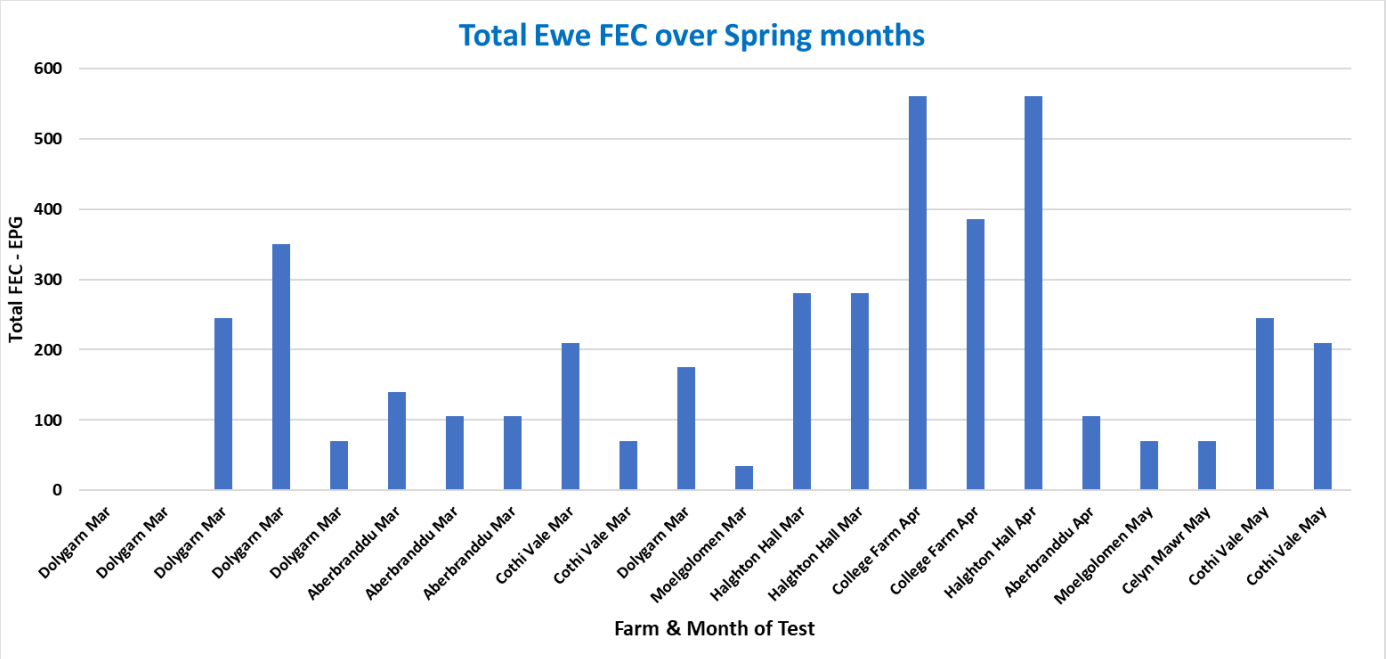

Figure 2

These results show the importance of FEC testing to determine the best treatment plans. During the spring, it's easy to assume that one group and / or farm will be very much like another, and the above shows that isn't the case. This resulted in different outcomes / findings for each farm as summarised here:

- **Dolygarn** - Instead of worming all ewes as normal just before lambing, James was able to target wormer to the groups that needed it as follows: 1) most ewes in the 3 low FEC results groups weren't wormed; 2) wormed 80% of the fat twins and 3) wormed all of the thins and triplets.
- **Aberbranddu** – Following low FEC's, **no ewes** were given a pre or post lambing wormer and these hadn't been wormed since the previous spring. The ewes were in very good condition and on good quality grass, supplemented with a high-quality protein feed, which means they could maintain their immune status despite the nutritional demands and stresses of parturition.
- **College Farm** - The twin ewes were all wormed at turnout from the lambing shed, and FEC results confirmed that the wormers were needed. Only the poorest looking singles were wormed at turnout as the FEC in that group was lower.
- **Halghton Hall** – As they are an early lambing flock, the project only started towards the end of lambing. Most ewes had already been wormed with Cydectin drench at turnout. However, multiple FEC's taken on treated ewes between 3 and 5 weeks post treatment showed positive FEC's. This raised concern over the efficacy of Moxidectin, as if fully effective, no eggs should be seen for 8 weeks post treatment due to its longer acting nature.

5. FEC monitoring results - cattle

As discussed previously, of the 3 farms selected to test cattle, only one of the farms (Fferm Carreg Plas) provided enough data for us to be able to use as a case study. A few of the other farms who also have cattle did submit the odd cattle test as well. This resulted in a total of 17 samples submitted in total for cattle over the course of the project, and these are summarised in Table 2.

The FEC thresholds for cattle are much lower than for sheep and are as follows:

- **< 50 epg** - Unlikely to treat (there are exceptions)
- **50 epg – 100 epg** – Possibly treat. Consider other factors such as growth rates, condition.
- **> 100 epg** – Likely to treat

As can be seen, parasite burdens were very low as none of the results recorded fell in to the 'Likely to treat' category and only 2 samples were in the 'Possibly treat' category.

More details of the impact at Fferm Carreg Plas can be found in their individual case study, but in summary, the low FEC's resulted in a 43% reduction in wormer treatments, and yearling cattle still hit their growth targets of 1kg / day.

Date Collected	Farm Name	Stock Class	Total EPG
28/03/2019	Fferm Carreg Plas	Cattle (R2Y)	40
14/05/2019	Tregyrnig	Steers	20
20/05/2019	Fferm Carreg Plas	Cattle (R2Y)	40
13/06/2019	Fferm Carreg Plas	Cattle (R2Y)	60
13/06/2019	Fferm Carreg Plas	R2Y	20
14/06/2019	Fferm Carreg Plas	R2Y Heifers	0
10/07/2019	Hardwick Farm	Cattle	0
23/07/2019	College Farm	Cattle	0
23/07/2019	College Farm	Cattle	20
25/07/2019	Fferm Carreg Plas	Heifers	0
25/07/2019	Fferm Carreg Plas	R1Y Steers	0
13/08/2019	Cothi Vale	Cattle	60
22/08/2019	Fferm Carreg Plas	R2Y Heifers	40
22/08/2019	Fferm Carreg Plas	R2Y Steers	20
19/09/2019	Hardwick Farm	R2 Y	20
24/09/2019	Fferm Carreg Plas	Calves	20
15/10/2019	Fferm Carreg Plas	Calves	20

Table 2

6. Wormer efficacy

Part of the project was to determine the efficacy of the four main classes of wormers. A simple efficacy test (referred to as WormerCHECK by Techion) was carried out in a controlled manner by Techion's technicians and based on pre and post pooled samples. WormerCHECK is a simple and relatively cheap way of determining the efficacy of wormers based on percentage reduction in egg count, but they aren't as accurate as the more detailed full Faecal Egg Count Reduction Test (FECRT). Therefore, caution must be exercised with interpreting treatment failures in terms of whether it is due to wormer resistance or not, as much depends on sampling and treatment accuracy.

Reduction tests are normally expressed as the percentage reduction in eggs counted between the pre and post treatment (7 or 14 days) periods. A treatment that is 100% successful would result in all worms being killed and egg counts at day 7 or 14 would be 0. In this case, the reduction would be 100%. In other words, the higher the percentage (%) figure, the better the treatment has performed. When the reduction percentage has dropped below 95%, we start getting concerned about the usefulness of that treatment and the result is classified as being ineffective.

The WormerCHECK protocol requires that the starting strongyle FEC is a minimum of 500 epg for sheep (140 epg for cattle) before the test can be carried out. While all endeavours are made to have all animals involved with the evaluation at 500 epg or higher, due to natural composite mob FEC distribution some treatment groups may have FECs lower than the optimal 500 epg minimum. A starting FEC of 500 epg or higher is required to be able to deliver results with a high level of confidence.

Due to these constraints, of the 8 farms who engaged with the project, only 6 of the farms (all sheep) had pre monitoring FECs high enough for us to be able to run the WormerCHECK tests. For Halghton Hall, due to most lambs being sold quickly and remaining lambs having low FECs thereafter, the planned efficacy test couldn't be completed. At Fferm Carreg Plas, where the efficacy test was planned for cattle, it couldn't be completed due to

low FEC levels throughout the season on the R2 cattle and the low post-weaning FEC in calves coupled with the fact they had to be wormed against lungworm.

A summary of the results for the 6 farms we were able to test can be found in Table 3. The results shown are only for the strongyle group of roundworms. No resistance to nematodirus species of worms was recorded, and often nematodirus levels were too low to test this. However, evidence of wormer resistance to nematodirus worms is rare in the UK and currently not a great concern in the sheep industry. The results are listed from the best efficacy recorded on the left, moving towards poorer efficacies on the right. A full detailed report on the wormer efficacy was provided separately for each farm.

	Percentage Reduction - Strongyle Worms					
Wormer Tested	**Irwel Jones, Aberbranddu**	**Rhodri Lloyd-Williams, Moelgolomen**	**Hywel Davies, Celyn Mawr**	**Nicola Drew, College Farm**	**James Powell, Dolygarn**	**Glyn Davies, Cothi Vale**
Benzimidazole (1BZ) *'White'*	82%	50%	67%	50%	60% ?	32%
Levamisole(2LV) 'Yellow'	90%	78%	95%	-22%	60% ?	67%
Ivermectin (3ML) 'Clear'	100%	93%	60%	30%	-50% ?	-133%
Moxidectin (3ML) 'Clear – long acting'	100%	96%	86% ?	100%	33% ?	56%

Table 3

As the protocols for this test were the easier but slightly less accurate method, we must be careful in interpreting the numbers as they will have wide confidence intervals (e.g. a 50% result could, in reality, be in a range from 70% down to 30%). This is particularly true when results fall in the 90% to 95% bracket. Therefore, we often talk about these in terms of treatment efficacy rather than anthelmintic resistance. However, the treatments and set up of the tests were done under strict protocols by Techion's technicians, so it is safe to assume that the lack of efficacy is more than likely to be down to the presence of resistant worms in most cases. The results for James Powell, in particular, are reported with a high level of caution, as the day 1 pooled FEC test results for each treatment group were well below the recommended threshold of 500 epg. But at least 2 eggs were counted post treatment in each group, which does suggest a problem with each of them.

Wormer inefficacy was found on all 6 farms for Benzimidazole (1 BZ); 5 out of 6 farms for Levamsiole (83%); 4 out of 6 farms for Ivermectin (66%) and 2 out of 6 farms for Moxidectin (33%). ***Note:*** *the Moxidectin result for Celyn Mawr (86%) and Ivermectin result for Moelgolomen (93%) weren't included as just below thresholds and lower confidence in results.*

The results are a concern as they do show widespread inefficacy. The results are, however, comparable to previous levels of resistance or inefficacy reported in the UK, namely HCC's WAARD project and the Sainsbury's FECPAK^{G2} Project, both of which were also managed by Techion.

It is interesting to note that the farm with the best efficacy results (Aberbranddu) had already been applying some of the SCOPS principles and had been monitoring FEC for over 10 years now. It's a good sign that following the guidance provided by SCOPS over the years has helped protect against multiple resistance development. In contrast, the two farms with the poorest efficacy (Dolygarn and Cothi Vale) hadn't really put the same emphasis on changing worming policy and routinely monitoring FEC, with Cothi Vale, in particular, still following a traditional regular treatment pattern for both lambs and ewes.

Although aware, we were likely to find some issues. Nicola, James and Glyn were all surprised at the extent of lack of efficacy we found on their farms. This, again, underlines how many farmers in Wales are still using wormers while being completely in the dark if those wormers are working or not.

7. Impact on anthelmintic use

The use of FEC on all farms resulted in changes to wormer use, whether that be:

- Reduction in number of treatments
- Change in timing of treatments
- Change in choice of wormer / anthelmintic group.

Several farms reported a significant reduction in number of treatments, and we have listed the biggest impact ones here:

- **Fferm Carreg Plas** – Group of 41 yearling heifers wormed once per season versus 3 times and 17 steers twice instead of 3 times. 43% reduction in wormer treatments.
- **Halghton Hall** – 2 to 3 fewer treatments per lamb and 1 less treatment per ewe in the autumn.
- **Cothi Vale** - Removed the normal pre-tupping wormer – 550 fewer ewe doses. Also, savings on dosing ewe lambs in autumn.
- **Aberbranddu** – No worming of ewes needed at all since spring 2018. 850 fewer ewe doses.
- **Dolygarn** - Removed the normal pre-tupping wormer – 1050 fewer ewe doses.
- **College Farm -** All lambs on farm at end of September had 1 less wormer treatment over the whole season.

8. Stock performance

On many of the farms, an improvement in stock performance was observed during 2019 in comparison to previous years. It is, however, difficult to put this down to improved parasite control alone. It's worth noting that the end of spring and early summer saw long spells of dry, hot weather which means poor conditions for worm development on pasture, and when we consider the prolonged drought of 2018 would have also helped reduce overall worm burdens on farm. It is, therefore, hypothesised that a lower parasite challenge was likely to be a significant factor in better stock performance early in the season for many farms.

The biggest observed impact on lamb performance was seen by David Lewis, Halghton Hall after he changed the choice of wormer group in May, following FEC testing and advice from Techion. The change came about as early testing showed unexpectedly high strongyle counts and David's normal treatment choice was targeted just at nematodirus, and it appears that it may not have been that effective at controlling strongyle species. Changing to a different anthelmintic group meant most lambs being sold before middle of August versus 150+ lambs being left on-farm until the autumn and winter. David did stress that a few other things have changed with newer reseeds on the farm, better grass growth this year and the influence of performance recorded sires becoming more dominant. But he does believe that getting a better control of worms was the final key that unlocked the farm's potential. There were significant benefits for the farm in this improved performance (detailed in the farm's case study) which include £1,000 increased lamb value, £1,400 less creep feed used and £200 in reduced labour. It is worth remembering that this was also coupled with noticeably fewer wormer treatments being required.

Many farmers were unknowingly using ineffective wormers before the efficacy test was carried out, and if their use coincided with a time of high burdens, then this would result in significant loss of performance and income. This has previously been estimated by Techion in the Sainsbury's FECPAK^{G2} Project as costing as much as £11.93 per lamb in lost performance.

Interestingly for Cothi Vale, where we found evidence of multiple wormer inefficacy, the crossbred lambs in the early season have performed better than normal, and many lambs were finished off grass alone by early autumn despite having been wormed with ineffective treatments. It is important to remember that wormer resistance will only affect performance when lambs have a worm challenge that needs sorting. However, as the weather changed later on, so has the worm challenge, and the group of lambs used for this test hadn't performed well despite being wormed – which isn't a surprise as the counts post treatment were still high, meaning they were still harbouring a fair burden. Coming into the autumn, the farm would always rely on creep feed to help finish the last lambs off, and in normal years, this would be over 200 lambs. This is a time of increasing worm burdens

and it will be interesting to note if better worm control through use of effective wormers would result in lambs doing better off grass and less creep needed at the end of the season.

Most importantly, none of the farms recorded a decline in performance after changing their worm control policy, and in most cases, reducing the frequency of wormer treatments. This is an important message to convey as some farmers may not engage with activities like FEC monitoring as they are worried that regular worming is required for optimal performance, where in fact, it's proven here that this is not the case as long as it carried out properly and backed up by evidence.

9. What the farmers said

Below are the quotations that each of the 8 farmers provided for their case studies, to provide a snippet of what the farmers thought.

"Since we changed to a yellow wormer for the second dose based on FEC results and Techion's advice, the lambs have just flown, and most have been sold as finished lambs by the middle of August."

"Monitoring on a regular basis and having quick results back via email, without me needing to leave the farm, means I can keep on top of the situation. Although I don't dose often, I have been able to dose earlier on the back of FEC results and avoided big drops in growth rates."

"Testing for wormer efficacy is well worthwhile, and we had some interesting results with the Levamisole issue, in particular, an unexpected one. It's scary to think how many of us farmers pay for wormers that simply don't work."

"The extent of resistance is worrying and shows why our previous policy needed to change. We will have to work harder now to ensure we can maintain good stock performance off grass."

"Although we must take the efficacy results with a pinch of salt, it really has opened my eyes to some of the issues we might have on-farm with our wormer usage. Going forward, I will have to be very selective and careful on which wormers I use."

"I have learnt a lot about the importance of regular monitoring. It turns out, worms aren't as much of an issue for our yearling cattle as assumed, and this has saved a lot of work and cost on unnecessary treatments. I still need to make more use out of it and get into the routine better, as weeks go past without realising, and sometimes the gap between testing is too long. The more I use the FECPAK^{G2} system, the easier it gets. I will definitely continue to monitor, as it gives valuable insight."

"As with most testing, nothing is black and white; but it provides valuable information to help make treatment decisions. I need to keep better records of treatments and comments against submissions. When looking back at data over the season, it helps me realise that we still have a big parasite challenge here which will be difficult to reduce under organic restrictions."

"It has been a real eye-opening experience for me. FEC testing has certainly helped us time the dosing of lambs much better. Now we know we have issues with White wormer and Ivermectin wormers, we can avoid using them and hopefully see an improvement in lamb performance."

10. Summary & Discussion

The project was successful in terms of monitoring and sharing the parasite burden from farms geographically dispersed throughout Wales. Eight of the farmers carried out considerably more FEC testing than they had done previously, and they all found it useful. As reported, this also resulted in implementation of several on-farm changes which resulted in many positive outcomes. These included lowering the reliance on anthelmintics, and in many cases, an improvement in performance, which for a farmer, would be the main goals.

Despite good success, there were still challenges in adopting the latest advice and new technology. Those who engaged best with the project tended to be the ones who had already applied some changes. One of the farms in particular didn't provide enough samples for us to report any findings on, and quite a few others needed a lot of persuading / reminding to go out and collect the samples. It is important to note that the technology being used was a newly released version of the FECPAK^{G2} system, and a few experienced some teething issues that comes with the deployment of new technology, and this may have hindered uptake in some instances. However, some participants were also slightly averse to using technology and this led to its own problems. The use of precision and smart technology is becoming more available to farmers as the industry embraces the digital revolution, and to help capitalise on this, it is suggested that farmers require more IT support and training.

Finding time to apply the advice and to monitor was another strong feedback we received. It was, however, interesting to note that a few who said they didn't have time to test, could find enough time to continue worming on a regular basis. This is simply a change in mindset that is required, and we need to make activities like FEC testing the routine instead of treating. Change takes time and requires a great deal of support to embed it as permanent improvement and projects like this need to be aware of this.

There are also other positive outcomes of this project which are difficult to measure, but nonetheless, important to consider. The first one is the impact on emissions in food-producing animals. Findings by SRUC and the Moredun Research Institute showed parasite infections in lambs can lead to a 33% increase in methane output, and that parasitism is one of the top three livestock diseases which increase greenhouse gas (GHG) emissions and is cost effective to manage. In addition to reducing performance (in particular feed conversion ratio (FCR) meaning animals take longer to finish at lower weights), the research shows animals with worms release more methane per day due to the upset they cause to the digestive system. It is fair, therefore, to assume that the changes these farmers implemented will have helped reduce emissions from their production systems.

Reducing the frequency of wormer treatments will also impact positively on the immediate environment as regular exposure to anthelmintics is proven to have a detrimental effect on soil flora and fauna. When worming, not all of the wormer is absorbed by the body and some of the anthelmintic chemical is excreted in the faeces and can kill other invertebrates. For example, dung beetle numbers are known to decrease on fields grazed with stock regularly exposed to anthelmintic. Not only are dung beetles hugely important for local ecosystems, but they are vital engineers who help break down dung and transport it down into the soil helping to improve soil fertility and health. So, several of our farms have significantly reduced this exposure, and if this is continued, the permanent change should help soil flora and fauna flourish.

Addressing the environmental impact of red meat production is arguably one of the biggest challenges the sector faces, and improving parasite control is one simple way farmers can proactively work towards this, while improving business profitability and efficiency of production.

The outcomes also fit the criteria of what is required by the supply chain as consumers become ever more aware of how their food is produced. The future of livestock production will focus more on forage grown on the farm, and we need to reduce reliance on purchased feeds containing soya and cereals that are deemed as inefficient in terms of food production. Relying more on forage and grass will bring its own challenges, one of which will be dealing with parasitic infections.

Hopefully, this short-term project will lead to longer-term improvements on participating farms. Most of the farms have vowed to continue monitoring and hope to do even more as they now realise the importance of this. We hope to see incremental benefits as they apply what was learnt this year to future seasons. For example, the efficacy testing was only done towards the end of the project, and any performance impact from changing wormer groups will only be realised in future years. It is advised that the farms work closely with their vets and / or SQP's, and the information from this project was shared on a regular basis. It would be interesting to continue monitoring these farms to try and evaluate some of the potential longer-term benefits.

The project has also shown that there is still considerable work to do in helping the industry tackle the growing issue of anthelmintic resistance, and we need many more farmers to engage with these activities and latest advice in order to see widespread changes. The efficacy levels reported here are of great concern, but, unfortunately, aren't surprising as they fall in line with previous reports of anthelmintic inefficacy / resistance in the UK. It's obvious that wormer resistance is potentially a significant cost to the red meat industry and something that needs to be addressed. The 2015 WAARD Project surmised that the potential loss to the sheep industry in Wales, through poorer lamb performance, may be between £20 million and £53 million per annum.

However, it is clear that considerable improvements are possible with the appropriate advice and implementation of latest recommendations, and advancements in technology could well help achieve this.

11. Acknowledgements

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