**‘’It’s a lung story’’ Analysing stakeholders’ perceptions of *Dictyocaulus viviparus*:**

**An exploration of attitudes towards lungworm and understanding of effective, sustainable control in dairy cattle**

**by**

**TIMOTHY MARK PASS**

**Being a thesis submitted in partial fulfilment of the requirements for the MSc Degree in Veterinary Pharmacy**

**2022**

**RESEARCH PROJECT ASSESSMENT FORM**

**Student Declaration Form for Submission with Major Projects (R7052)**

**Section 1**

This section must be completed by the student and then handed in with the THREE copies of the Major Project.

|  |  |
| --- | --- |
| **Candidate’s Name** | Timothy Mark Pass |
| **Candidate’s Number** | 05382900 |
| **Degree Programme** | MSc Veterinary Pharmacy |
| **Supervisor** | Dr Emma Bleach |
| **Major Project Title** | ‘’It’s a lung story’’ Analysing stakeholders’ perceptions of *Dictyocaulus viviparus*:An exploration of attitudes towards lungworm and understanding of effective, sustainable control in dairy cattle |
| **Word Count** | 19,776 |
| **Confidential?** | No |

|  |
| --- |
| ***In submitting this Major Project I acknowledge that I understand the definition of, and penalties for, cheating, collusion and plagiarism set out in the assessment regulations. I also confirm that this work has not previously been submitted for assessment for an academic award, unless otherwise indicated.*** |

**Signature of student**:…T m pass…………………………………….

**Date:** …27-07-2022…………………………………………………………

**Section 2**

This section will be completed by the University.

|  |  |
| --- | --- |
| **Project Manager** |  |
| **Internal Examiner** |  |
| **Final Percentage Mark** |  |
| **Date** |  |

# **Acknowledgments**

I’m extremely grateful to my supervisor Dr Emma Bleach of Harper Adams University, for the support and feedback throughout my project which has been invaluable.

This endeavour would not have been possible without the guidance and support from Dr Stephen Mansbridge of Harper Adams University.

I would like to express my deepest gratitude to Mrs. Guda Van Der Burgt of APHA, Mr. Colin Mason of SRUC and Dr Katherine Baxter-Smith of MSD Animal Health for their support through personal communication during this project.

The author would like to thank all the stakeholders for kindly giving up their time to participate in this project.

Thanks, should also go to Mark Proctor MRCVS and Dr Alison Pyatt who impacted and inspired me, along with lots of encouragement.

Lastly, id like to mention my family, particularly my wife Becky, and my children Fraser and April who have not only given me support but extra motivation throughout the study.

**Table of Contents**

Summary……………………………………………………………………………………………1

1. Introduction………………………………………………………………………………….....2

2.0 Literature Review……………………………………………………………………………...4

2.1 What is Lungworm………………………………………………………………………….....4

2.2 Clinical Signs of Lungworm…………………………………………………………………..4

2.3 The Financial Impact of Lungworm………………………………………………………….5

2.4 Long Term Damage to The Animal………………………………………………………….6

2.5 Diagnosis……………………………………………………………………………………….6

2.6 Immunity, Treatment (Anthelmintics) and Control…………………………………………8

2.7 Observations on Product Usage…………………………………………………………...10

2.8 Stakeholder’s Attitudes to Lungworm Control…………………………………………….12

2.9 The Health Plan is Not Just a Tick Box Exercise………………………………………...13

2.10 Barriers To Disease Prevention…………………………………………………………..13

2.11 Environmental Impact……………………………………………………………………...14

2.12 Milk Contracts………………………………………………………………………………14

2.13 Importance of Quarantine & Carrier Animals……………………………………………14

2.14 Gaps in Research…………………………………………………………………………..15

2.15 Research Hypothesis………………………………………………………………………15

2.16 Aims………………………………………………………………………………………….16

3.0 Methodology………………………………………………………………………………….17

3.1 Study Design ………………………………………………………………………………...17

3.2 Data Collection……………………………………………………………………………….18

3.3 Data Analysis…………………………………………………………………………………18

4.0 Research Results and Analysis…………………………………………………………….20

4.1 Theme 1: Stakeholders Perceptions and Understanding of *Dictyocaulus viviparus* (Lungworm)……………………………………………………………………………………….22

4.1.1 Subtheme: Passion for Parasitology……..................................................................23

4.1.2 Subtheme: How Dairy Farmers Perceive the Risk…………………………………….25

4.1.3 Subtheme: Farmer Observation & Awareness…………………………………………25

4.2 Theme 2: Epidemiology, Outbreaks of Lungworm and Professional Involvement on Dairy Farms Including Herd Health Planning………………………………………………….26

4.2.1 Subtheme: Outbreaks of Lungworm and the Age of Animals that its Seen in and Immunity…………………………………………………………………………………………..28

4.2.2 Subtheme: Farmers driven by Growth rates and Financial Gain…………………….30

4.2.3 Subtheme: Long Term Damage and Impact on the Business………………………..30

4.3 Theme 3: Barriers to Vaccination, Restrictions to Implementation……………………..31

4.3.1 Subtheme: Anthelmintics…………………………………………………………………33

4.3.2 Subtheme: Grazing management & Climate Change…………………………………35

4.3.3 Subtheme: Farmer Motivation Around Treatment……………………………………..36

5.0 Discussion…………………………………………………………………………………….38

5.1 Stakeholder’s Perceptions and Understanding of Lungworm…………………………..38

5.2 Education and Resources…………………………………………………………………..38

5.3 Passion for Parasitology…………………………………………………………………….39

5.4 How Dairy Farmers Perceive the risk……………………………………………………...39

5.5 Observation and Awareness………………………………………………………………..40

5.6 Outbreaks of Lungworm and Professional and Para-Professional Involvement on Dairy Farms Including Herd Health Planning………………………………………………………..40

5.7 Outbreaks of lungworm and the Age of Animals that its Being seen In and Immunity…………………………………………………………………………………………..41

5.8 Farmers Driven by Growth Rates and Financial Gain…………………………………..41

5.9 Long term damage and the Impact on the Business…………………………………….42

5.10 Barriers to Vaccination, Restrictions to Implementation……………………………….42

5.11 Administration and Handling………………………………………………………………44

5.12 Anthelmintic Treatment…………………………………………………………………….44

5.13 Grazing Management and Climate Change and Diagnosis…………………………...45

5.14 Farmer Motivation – Supermarket Milk Contracts Drive for Change Including Sustainability, Environment and Dung Beetles……………………………………………….45

6.0 Conclusion……………………………………………………………………………………46

References………………………………………………………………………………………..48

Appendices………………………………………………………………………………………..59

Appendix 1:……………………………………………………………………………………….59

Appendix 2:……………………………………………………………………………………….62

Appendix 3:……………………………………………………………………………………….64

**List of Tables**

Table 1: Diagnostic techniques and their uses for cattle lungworm, *D. viviparus*…………7

Table 2: Anthelmintics that lungworm (*Dictyocaulus viviparus*) are susceptible to, however, the list is not exhaustive……………………………………………………………...9

Table 3: Summary of participating stakeholders……………………………………………...19

**List of Figures**

Figure 1: Lifecycle of *Dictyocaulus viviparus* is diagrammatic form showing the stages within the bovine and those on pasture…………………………………………………………4

Figure 2: A lungworm case diagnosed on a adult dairy cow from a post-mortem at APHA during September 2021…………………………………………………………………………..7

Figure 3: Thematic map displays the connection between the three themes, subthemes emerged throughout thematic analysis of the 22 Interviews………………………………...21

**Summary**

Cattle lungworm (*Dictyocaulus viviparus*) also known as “Husk” is a parasitic bronchitis of cattle. Infestation causes mild to severe respiratory distress, inappetence, and in severe cases death.

Typical presentation is in first season grazing cattle on permanent or semi-permanent pasture, typically from July to September.

However, it can affect all ages of cattle including more recent and frequent incidences in adults. Outbreaks have also been reported from early May until December. Young animals exposed during their first grazing season are most at risk due to lack of immunity. The cornerstone of developing immunity relies on trickle exposure to a sparse number of larvae which keep the immune system vigilant and prevent clinical disease onset.

This qualitative study considers why lungworm outbreaks have been high over the last three decades and whether there any influences such as stakeholder’s opinions, climate patterns and control techniques. Furthermore, we should understand why outbreaks of lungworm are becoming increasingly more common in adult dairy cows.

To explore further, semi-structured interviews were held in Spring 2022 with 22 stakeholders including 12 dairy farmers, 4 practising Vets, 2 Laboratory based Vets and 4 SQP’s (Suitably Qualified Persons). All were found to play important roles.

Using thematic analysis and applying grounded theory principles, data collection and analysis were employed.

Three major themes and subthemes emerged.

1. Stakeholder’s perceptions and understanding of Dictyocaulus viviparus.
2. Professional involvement on outbreaks on dairy farms.
3. Barriers to vaccination and suggested management plans.

Dairy farmers attitudes to lungworm control are influenced by disease recognition, herd performance and monetary loss/gain. Some are seeking alternative treatment and control options and will accept changes to their management, possibly driven by milk contract restraints or assurance scheme requirements.

It is apparent that communication and engagement can be lacking between farmer, vet and SQP on parasitology in general but especially regarding lungworm. Additional education is undoubtedly required.

Six Barriers to vaccination were identified:

1. Vaccine cost relative to wormers
2. Two dose regime compared with other one-dose products
3. Timing of dosing at Spring turnout
4. Oral administration – handling difficulty/labour issues
5. Vaccine not available early enough in the year
6. Vaccine benefit understanding often lost when Vet, SQP and farmer communication is poor.

**1.0 Introduction**

Bovine lungworm caused by the nematode *Dictyocaulus viviparus* has long been recognised as a serious risk to cattle and causes potentially fatal disease. The respiratory condition (McLeonard and Dijk, 2017) caused by lungworm is not only a serious welfare concern but also a notable economic issue (McCarthy, 2020). Understanding of its clinical and economic significance improved hugely in the 1950s (McCarthy, 2020) leading to the development of a live irradicated larval vaccine which was soon a valued control measure (McCarthy and Van Dijk, 2020).

With the rising popularity of long acting anthelmintics treating both roundworms and lungworms, vaccine use fell in the 1980’s (Matthews, 2008).

However, despite these innovative anthelmintics and with limited evidence of lungworm anthelmintic resistance in the UK, the number of cases of lungworm reported remains high (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manager of SRUC). There has also been a significant rise in recent years in older dairy cattle (Holzhauer et al., 2011).

The epidemiology is complex, and outbreaks are often extremely unpredictable (McCarthy, 2020). Years differ, with climatic conditions being a major factor. Warm summers with higher-than-average rainfall, or rainfall concentrated in short and intense periods significantly increase incidence (Forbes, 2018).

Furthermore, we are experiencing milder winters allowing lungworm larvae to overwinter on pasture facilitating infestation early in the forthcoming grazing season (Van Dijk, 2004). Over-wintered infective larvae then transmit to spring turnout stock which are often younger animals, with no immunity and well suited to perpetuating the lungworm lifecycle (Timothy, 2020).

Limited larval exposure as youngstock (Taylor, 2010) or in any previous six months period are significant risk factors for clinical disease when the cattle encounter against high pasture larval challenge (Forbes, 2018). Geographical spread of lungworm clinical cases in the UK is not equal, with the wetter and more cattle dense west being overrepresented in the literature (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC).

Lungworm in adult dairy cattle arises from primary lungworm infection or re-infection. Immunity to lungworm may be short-term. It has been hypothesised (Taylor, 2010) that without seasonal exposure and immune stimulation, cattle of all ages remain vulnerable to clinical lungworm bronchopneumonia. Vaccinated animals when challenged with overwhelming larval numbers can also succumb (Forbes, 2018).

The changing picture of lungworm prevalence to include adult dairy cattle, has prompted a suggested link with liberal use and over-reliance on preventative anthelmintics (Baxter-Smith, 2021)

We should consider ever changing grazing strategies whereby dairy heifers’ access to pasture is permitted only after they are confirmed pregnant around 16 months old (Shortall, 2022). Such heifers (especially if not vaccinated) will be naïve to larvae when they join the adult milking herd and are then susceptible to clinical lungworm (Baxter-Smith, 2021).

The objective of this research was to investigate stakeholder’s perceptions towards lungworm control in dairy cattle. Stakeholders including dairy farmers, vets in practice and UK vets working as veterinary centre managers and veterinary investigation officers employed in veterinary investigation centres and veterinary laboratories undertaking post-mortems were interviewed to ascertain their attitudes towards lungworm control. Their current understanding of the epidemiology of lungworm and how they perceive the risk from *D. viviparus* was explored.

**2.0 Literature Review**

Cattle lungworm (*Dictyocaulus viviparus*) is a parasite that causes parasitic bronchitis in cattle.

**2.1 What is lungworm?**

Colloquially known as lungworm, or ‘Husk’ it can affect all ages of cattle with a wide-ranging expression of clinical disease usually in the grazing season (Aiello and May, 2010).

Lungworm has a direct lifecycle as shown in **Figure 1**.



**Figure 1**, Lifecycle of *Dictyocaulus viviparus* is diagrammatic form showing the stages within the bovine and those on pasture (NADIS, 2022).

*D. viviparus* is prevalent in northwest European countries such as the UK (McLeonard and Dijk, 2017), Netherlands (SaatKamp et al., 1994) and Germany (Schunn et al., 2013)

Larval spread is assisted by the fungus *Pilobolus* which flourishes in wet and warm conditions, growing naturally on the surface of dung pats. Larval attachment to the spores occurs and when the spores erupt larvae can be propelled up to three metres away on the pasture (McLeonard and Dijk, 2017). In more drought like conditions, the larvae are contained in the dung pat and only released following rainfall. Hence it is not unusual for clinical outbreaks to occur about three weeks after such a weather pattern giving larvae time to find hosts and mature (Taylor, 2010).

**2.2 Clinical Signs of Lungworm**

Prompt diagnosis and rapid treatment is essential for reducing clinical and welfare effects of lungworm (Holzhauer et al., 2011). Marked inflammatory changes usually occur by day 8 post exposure, when larvae migrate through the lung alveoli. Mortalities commonly follow by day 15 when thousands of immature worms can cause sufficient inflammatory changes to compromise respiratory function (Timothy, 2020). Common differential diagnoses include Infectious Bovine Rhinotracheitis (IBR) and other pneumoniae of bacterial origin (either primary respiratory or secondary hematogenous spread, often from the liver) (Dorso et al. 2021) (McLeonard and Van Dijk, 2017),

The symptoms of lungworm range from mild to severe (Elsheikha, 2017). They Include:

* Coughing
* Laboured Breathing
* Neck Outstretched
* Loss of condition
* Rough coats
* Reduction in milk yield
* Reduction in weight gain
* Off feed
* Nasal Discharge
* Frothy mouths
* Pneumonia
* Death

Animals with a mild burden may only exhibit occasional coughing often exacerbated by moving youngstock or when the adult dairy herd is milked. Such occasions are often the best opportunity for stockmen to suspect lungworm (Elsheikha, 2017). Heavily affected animals will cough at rest with hyperventilation evident. Seriously affected animals may have laboured breathing and spend extended periods with the head and neck outstretched (Holzhauer et al., 2011).

**2.3 The Financial Impact of lungworm**

Lungworm continues to cause severe disease in all ages of cattle and has a significant effect on animal welfare as well as a major economic impact on UK farm’s (Van Dijk, 2004).

Financial losses in a severe lungworm outbreak in growing youngstock range from £50 to £100.00 per animal due to weight loss, poor daily weight gain, poor future fertility, and treatment costs. Depressed milk yield in adult dairy cattle can extend to £3.00 per cow per day and additionally there may be an increased calving interval (Small, 2022). The economic loss in young dairy heifers is greater if they fail to reach weight target at the proposed time of serving (Boulton et al, 2017) (Bennett and Ljpelaar, 2005), and of course significantly higher if any deaths occur (Holzhauer et al., 2011). Literature reviews suggest that affected cattle suffer a noticeable loss of body condition up approaching 10% of bodyweight, with typical growing dairy heifers losing 20-40kg (Lloyd, 2017).

The budgetary impact of lost stock, replacement costs, lost production, and the cost of Veterinary treatment all must be faced, not to mention the emotional impact and burden of carcass disposal (Holzhauer et., 2011). Cost estimates may be conservative at £140.00 per adult cow with an average reduction in milk yield of 4kg/cow/day. This only represents up to 50% of total costs, with the remainder being met through treatments, lab costs, disposal of dead animals and extra inseminations (Holzhauer et al., 2011).

There may also be long term damage to lung tissue and respiratory capacity which leaves susceptibility to secondary diseases and infections, thus reducing the long-term productivity and performance of the animal (McCarthy, 2020).

**2.4 Long Term Damage to The Animal**

Current understanding regarding post patent parasitic bronchitis mortality is limited due to the modest referral rate for necropsy, and any mortality rate quoted will likely be an underestimate (McCarthy, 2020) (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manager of SRUC).

Recovering severe cases will retain tenable respiratory function but with scarring and reduced lung volume leaving animals liable to developing secondary bacterial and viral infection (Lloyd, 2017).

Even in seemingly recovered animals there can be significant lung damage that will decrease lifetime productivity and profitability due to reduced milk yield and poor fertility which add to the initial veterinary costs (Borsberry, 2012).

Achieving growth rates in dairy youngstock of 0.8kg/d is very important to the dairy farmer but challenging to achieve, particularly with the long-term damage from lungworm (Archer, 2021). If this target is met heifers can calve at approximately 23-24 months and enjoy herd longevity and enhance herd profitability through improved lifetime milk yield (Boulton et al, 2017). Thus, lungworm outbreaks significantly hit economics and welfare on many dairy farms (Ozols, 2022).

**2.5 Diagnosis**

Cattle at grass showing clinical signs of respiratory disease from June until November often raise suspicion of lungworm. There are numerous tests for lungworm diagnosis in cattle available to clinicians alongside monitoring clinical signs and ascertaining farm grazing history.

Treatment

Often farmers may treat on first signs of coughing following advice from an R-SQP (registered qualified person) although the R-SQP must not and cannot diagnose. In most cases a few tests may be needed to gain a definitive diagnosis by the Vet (SRUC, 2022).

**Table 1** Diagnostic techniques and their uses for cattle lungworm, *D. viviparus*

|  |  |
| --- | --- |
| **Diagnostic** | **Important Points** |
| Baermann examination of faeces for lungworm L1 larvae.  | The most common method of confirming lungworm disease, however, the results can take a few days to come back, so the uptake is not always that high due to vet/farmer preference for immediate treatment. |
| Serology, determines if any exposure has taken place. | Antibody titres increase 4-6 weeks following infection and stay elevated for 3-4 months.  |
| Eosinophilia  | Demonstrates a non-specific immune response to parasitic infection. |
| Postmortem examination | Worms may easily be seen in the bronchi and bronchioles (Selman et al., 1977) Diagnosis can also be confirmed from histopathology. |
| ELISA bulk milk test no longer commercially available (Mearns, 2022. Pers. Comm. Mrs R. Mearns is the Veterinary Advisor of Biobest). | Although this test had limitations for lungworm, it was useful for determining exposure in the milking herd (Klewer et al., 2012) particularly for R-SQP’s and Vets to use, and further engage with the dairy farmers a (Joined up approach). Previous studies have looked and quantified these results in production losses (McCarthy et al., 2019). |

 (APHA, 2021) (Lurier et al., 2018).

**Figure 2**, A lungworm case diagnosed on an adult dairy cow from a post-mortem at APHA during September 2021(Van Der Burgt, 2022. Pers Comm. Mrs. G Van Der Burgt is the Veterinary Investigation Officer of APHA).

**2.6 Immunity, Treatment (Anthelmintics) and Control**

Cattle produce an immune response to lungworm larvae and adult worms, although, this immunity will wane after just a few months (Farm Health, 2018) unless the cattle are re-exposed to a small amount of contamination on pasture. If exposure is extremely high this may still overcome the cow’s immunity and cause disease (Forbes, 2018).

A dichotomy emerges as exposure can be too low to generate an immune response, yet high exposure can overwhelm the animal. Moderate exposure is the key to optimal immunity (McLeonard and Dijk, 2017).

There is a highly effective vaccine available for cattle in the UK called Bovilis Huskvac POM-V (MSD animal health), which contains irradiated L3 lungworm larvae. Vaccination is the most reliable method of establishing herd immunity (Noah Compendium, 2022). Huskvac stimulates a solid foundation of immunity at onset of grazing, which may then be maintained in a controlled way by offering cattle grazing on low-level contaminated pasture (McLeonard and Dijk, 2017).

In this way, vaccination ensures that the level of lungworm on the pasture is prevented from reaching uncontrollable levels thereby lowering the risk of disease (Forbes, 2018). Huskvac can be administered to cattle from 8 weeks of age utilising two doses orally approximately 4 weeks apart resulting in onset of immunity 2 weeks after the finalisation of the primary course. The farmer must not turn-out vaccinated animals until two weeks after the 2nd dose of vaccine has been given, furthermore unvaccinated animals should not be mixed with vaccinated animals for 2 weeks after vaccination (preferably not at all). There is the opportunity for the farmer to give a single dose prior to turn out in the second grazing season, this will boost immunity from the previous primary course where natural exposure has not occurred (Noah Compendium, 2022). The vaccine can be given to adult milking cows and is also safe to give when the cow is in calf. Furthermore, it’s vital to understand that the vaccine can be given when animals are bought-in from lungworm naïve farms. Immunity should be considered by talking to the vendor regarding the history of their farm. Any animals that are considered to be naïve should be vaccinated with Huskvac before going into a herd holding carriers (McLeonard and Dijk, 2017).

As with all vaccines, correct storage and administration is key and improper use is a severe risk factor for perceived vaccine failure (MSD, 2020), with some preferring the easier option of pour-on anthelmintics (Matthews, 2008). It’s important that both Vets, SQP’s and farmers understand that vaccination can be used successfully alongside anthelmintic treatments, however, most anthelmintics should not be administered until at least 2 weeks after the second vaccination has been given and immunity been established (Noah Compendium, 2022). Yet to be published data from the VMD, primarily suggests that the active ingredient Ivermectin must not be given within 28 days of the lungworm vaccination being administered.

MSD animal health have a small production window for Bovilis Huskvac plus a short shelf life because of its live contents (Baxter-Smith, 2022. Pers Comm. Dr K. Baxter-Smith is the Veterinary Advisor of MSD Animal Health), so it’s vital that a plan is put in place with the farmers Vet well in advance before turn-out, if this is not undertaken, stock may get turned out before the vaccine is available (Howe, 2022. Pers Comm. Mr R. Howe is a Vet of LLM Farm Vets).

**Table 2**, Anthelmintics that lungworm (*Dictyocaulus viviparus)* are susceptible to, however, the list is not exhaustive.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Active Ingredient** | **Route of Administration** | **Target stage of the lifecycle** | **Persistency of Product (Protection against infection or re-infection of *Dictyocaulus viviparus*** | **Cattle Milk & Meat Withdrawal Period** |
| **Dairy Youngstock** |  |
| Oxfendazole (*Autoworm First Grazer Bolus*) | Pulse Release Oral Bolus | Pulse Release at Intervals of approximately 3 weeks. The First Dose being released around three weeks after administration. Adult and Immature | 21 Weeks (First Grazer Bolus) | 8 Months Milk & Meat |
| Fenbendazole | Continuous Release Oral Bolus | Aids in Control | 140 Days | 200 Days Milk & Meat |
| Albendazole | Oral Drench | Adult | No Persistency | 60 Hours Milk & 14 Days Meat |
| Levamisole | Injection | Mature and developing immature forms | No Persistency | This product must not be used in cattle producing milk for human consumption. Meat 28 Days |
| Levamisole(*Levacide Low Volume*) | Oral Drench | Mature and developing immature stages | No Persistency  | This product must not be used in cattle producing milk for human consumption. Meat 14 Days |
| Ivermectin (*Ivomec Classic*) | Injection | L4 & Adult | 28 Days | 60 Days Milk & 49 Days Meat |
| Ivermectin (*Ivomec Classic*) | Pour-On | L4 & Adult | 28 Days | 60 Days Milk & 15 Days Meat |
| Doramectin | Pour-On | L4 & Adult | 42 Days | 2 Months Milk & 35 Days Meat |
| Doramectin | Injection | L4 & Adult | 35 Days  | 2 Months Milk & 70 Days Meat |
| Moxidectin | Pour-On | Adult | 42 Days | 6 Days Milk & 14 Days Meat |
| Moxidectin | 10% LA Injection | L4 & Adult | 120 Days | 80 Days Milk & 108 Days Meat |
| **Lactating Dairy Cows** |  |
| Eprinomectin | Pour-On | L4 & Adult | 28 Days | Milk Zero Hours. Meat 15 Days |
| Eprinomectin | Pour-On | L4 & Adult | 28 Days | Milk Zero Hours. Meat 10 Days |
| Eprinomectin | Injection (Now POM-V (Vet Only) | L4 & Adult | 14 Days | Milk Zero Hours. Meat 63 Days |

 (Noah Compendium, 2022).

**2.7 Observations on Product Usage**

It’s essential to understand farmers perceptions, attitudes and practices of anthelmintic usage. Levamisole and Benzimidazole based anthelmintics lack any persistent activity, so, only kill worms present at the time of treatment. If either of these are used then best practice is to move the cattle to clean grazing to prevent immediate reinfestation. Alternatively, the ML based products do feature persistent activity, treat infestation, and prevent re-infestation until effective persistency runs out (Matthews, 2008).

Another alternative when the farmer sees an outbreak of lungworm is to immediately house the cattle. Unlike for roundworms where selective treatment of animals may take place following weighing of the cattle, best practice for lungworm is to treat all animals with anthelmintic. It is unachievable to distinguish between prepatent and patently affected animals, furthermore, herd or group treatment also lowers the possibility for further pasture contamination (APHA, 2021).

It is also essential to understand the attitudes of Suitable Qualified Persons and ascertain if they contact the farm’s Vet at point of giving advice. Severely affected animals can benefit from NSAID and antibiotic treatments to reduce any secondary infection and inflammation (APHA, 2021).

Over the years Levamisole injection and oral drench have been utilised to treat youngstock with clinical signs of lungworm and then at times retreated again three weeks later. On rare occasions when animals have been treated with an ML (Macrocyclic Lactone) based product, they have deteriorated and even died. The concern being that total destruction of all the larval stages in the animal can increase the clinical signs whereas this does not appear to happen with Levamisole (Matthews, 2008).

However, there is evidence that oral medicinal products should not be administered to animals with respiratory distress to prevent inhalation of product.

Furthermore, Levamisole cannot be used in cattle producing milk for human consumption (Noah Compendium 2022).

Unlike the macrocyclic lactones that are available as easy to apply pour-ons, Levamisole products are only available in oral drenches or injection form. ML group wormers can be highly effective as part of a good preventative control program against lungworm as they have persistent activity, however, this use must be in conjunction with some natural exposure to assist immunity. The ML wormers will cover the animal for the duration of the active period, but the animal cannot build an immunity during that time (Matthews, 2008).

Alternatively, there are pulse release boluses from the 1-BZ group that contain Oxfendazole, which offers extended roundworm and lungworm protection during the grazing season in dairy heifers. This is a useful option alongside the use of Bovilis Huskvac lungworm vaccine, allowing the farm to rotate into an alternative class of anthelmintic (Damory, 2021). Alternatively, there is the continuous release bolus from the 1-BZ group that contains Fenbendazole that aids in the control of lungworm (Noah Compendium, 2022).

Some dairy farmers (McCarthy, 2020) continuously treat for gut worms, thereby also treating lungworm and therefore preventing natural immunity from developing. As a result, cattle remain at risk of lungworm when the wormer activity ends (Baxter-Smith, 2021).

Anthelmintic resistance to roundworms has been a hot topic in recent years (Kelleher et al., 2020), and there is a risk of increasing the rate of development of resistance with the continuous use of long acting anthelmintics. For this reason, it is vital that the farmer discusses with their animal health advisor the implementation of a parasite plan. It must cover full lungworm control, including grazing management, vaccination and anthelmintics (Baxter-Smith and Simpson, 2020). Cattle are now moved around the country/Europe more than in previous decades so, freshly purchased animals may be at significant risk of lungworm, particularly if their previous grazing and vaccination history is unknown (McLeonard and Dijk, 2017).

The aforementioned grazing strategy changes afoot and the push for 2-year-old heifer calvings may possibly affect the epidemiology of lungworm (Statham et al., 2021).

Significant numbers of dairy heifers are now housed until they are confirmed pregnant meaning that they have less exposure to lungworm when young. There are more heifer rearing contactors used away from the main farm and more dairy heifers and cows are being purchased from other parts of the UK and other European countries (AHDB, 2022). These animals may have never been exposed to lungworm previously (Osteras et al., 2007).

Interestingly, particular groups of animals may spend more time at grass through their first two years of life compared to other groups, depending on when the animal is born. This can affect vaccination protocols as vaccination may then be given to autumn born calves the following spring. However, spring born calves may go out to grass before an animal is even old enough to have the two doses of vaccine (Forbes, 2018). Similar problems may arise on farms calving all year-round, as, some animals may go out in the autumn for the first time, when the annual vaccine production has ceased, as the vaccine is normally only available from late January until early August (Baxter-Smith, 2022. Pers Comm. Dr K. Baxter-Smith is the Veterinary Advisor of MSD Animal Health).

So, husbandry changes by UK dairy farmers may have led to more lungworm outbreaks in older dairy heifers and adult cows through lack of natural immunity (Mason, 2022. Pers Comm. Mr C Mason is the veterinary centre manager at SRUC). Further work is needed to understand current dairy farmers attitudes to grazing management.

**2.8 Stakeholder’s Attitudes to Lungworm Control**

It is especially important that dairy farmers, Vets and SQP’s are alert to the threat of lungworm in both youngstock and adult dairy cattle. It is highly pathogenic posing a significant impact on productivity and welfare of cattle. In northern England and Scotland anecdotal incidence of clinical cases has increased in recent years (McCarthy, 2020). Therefore, the implementation of worm control plans on dairy farms should be pivotal. The preparation of a lungworm master plan before turn-out in late winter and throughout the grazing season is therefore the most likely means of preventing losses and mediocre performance. Planning requires supporting a cautious balance between exposure and immunity, which is vital in the prevention of lungworm (McCarthy, 2020).

There is an emerging trend of farmers, Vets and SQP’s engaging together to formulate herd health plans. Control of Lungworm disease in all ages of cattle fits in snugly here, as the lungworm vaccine is a vet controlled POM-V medicine while the majority of anthelmintics in the UK are prescribed and dispensed by SQP’s. The POM-VPS categorisation of most livestock anthelmintics means they can be prescribed by a SQP with no Vet involvement at all (Baxter-Smith and Simpson, 2020).

In some situations, the farm Vet will be actively involved with herd health planning, yet it will often be the SQP who prescribes and advises on most of the treatment and control of lungworm. Therefore, engaging the farmer, Vet and SQP into a team may be challenging if commercial rivalry exists. There is lots of evidence that this unique joined-up approach works well and is crucial moving forwards (Baxter-Smith and Simpson, 2020).

Drawing on existing work, it is vital we understand dairy client’s behaviour and expectations.

They involve numerous people within their business to enhance and improve productivity and efficiency and will be key to bringing Vets and SQP’s to the table together for herd health discussions (Pyatt et al., 2020). A better understanding of their attitudes and perceptions to how lungworm is controlled on dairy farms now and in future years is needed (Svensson et al., 2019).

Co-operation between Vets and SQP’s can facilitate beneficial knowledge transfer and may encourage SQP’s to charge for their advice on farm, rather than relying on selling medical products. Reducing un-necessary sales of medicines driven by commercial interests but replaced with fees for advice has to be the route forward (Atkinson, 2010).

It is conceivable that a farmer has had a lungworm problem in the last 12 months, treated the animals with product purchased from a merchant’s outlet, had some SQP involvement but the farms vet had not been alerted to the outbreak. Such a potential lack of unified approach is unhelpful for the client long term even if a short-term saving is made. There has to be trust and respect from all three parties so that the dairy farmer has the confidence to invest time and money (Pyatt et al., 2020).

**2.9 The Health Plan Is Not Just a Tick Box Exercise**

Whilst previous literature has touched on health planning (MSD, 2021), there are few published studies that have explored farmers and Vets’ attitudes to herd health plans and a joined-up approach between the farmer, Vet and SQP.

Vets must ensure that lungworm is fully covered within the ‘Herd Health Plan.’ Profound consequences may ensue if its overlooked, as there have been previous financial claims by dairy farmers against Vet practices regarding a delayed diagnosis of lungworm (Van Der Burgt, 2022. Pers Comm. Mrs G Van Der Burgt is the Veterinary Investigation Officer of APHA). Vets and farmers can no longer look at a herd health plan as a tick box exercise to comply with red tractor or the supermarket milk contract. Lungworm should be fully covered with a control plan that includes vaccination, diagnostics available and treatment (VDS, 2021).

Vets should be strong advocates for the lungworm vaccine, Bovilis Huskvac, which is the only vaccine available in the UK for lungworm. It is complex to manufacture and due to its live nature, a delicate vaccine to transfer to end users (Baxter-Smith 2021. Pers Comm. Dr K. Baxter-Smith Veterinary Advisor for MSD Animal Health). There is also the disadvantage of a small duration of early season production, so a plan needs to be put in place in the late winter well before turn-out in the spring. The health plan should be updated on a regular basis ensuring that lungworm is not overlooked. There is an inherent responsibility for Vets and SQP’s to make sure that plans are properly refreshed annually rather than relying on minor edits of historic plans (AHDB, 2022)

Every herd health plan has a short lifespan, and parasitology including lungworm must be discussed at length (VDS, 2021). Effective herd health plans have evolved as a foundation of good farm animal practice and can be critical in avoiding any future issues (Kaler and Green, 2013)

It is perhaps disappointing that Huskvac (formerly “Dictol”) sales have remained stable at around £1 million yearly, equating to around 230,000 doses. Historic sales post initial launch in the 1960’s and well into the 1990’s, were much higher. When the long-acting macrocyclic lactones group 3 anthelmintic products were brought to market in the mid-90’s, Huskvac sales dropped considerably and have remained lower ever since (Baxter-Smith 2021. Pers Comm. Dr K. Baxter-Smith Veterinary Advisor for MSD Animal Health). The ease of pour on wormer application and relatively low cost have significantly challenged Huskvac’s market penetration.

**2.10 Barriers to Disease Prevention**

Motivation and barriers to effective disease control have been identified in UK sheep farmers controlling footrot (Best et al., 2021), and lameness in dairy cattle (Main et al., 2012) mastitis in dairy cows (Down et al., 2016) and also general implementation of sustainable agricultural practices (Rodriguez et al., 2008).

Cost as a major limiting factor has emerged in much of the literature, (Main et al., 2012). On dairy farms, the current milk price will most likely influence farmers decision making as cash flow is key (Barkema et al., 2015).

The need for good handling facilities is paramount on UK farms, as handling cattle invariably associates a risk of injury particularly when administrating a medicinal product, from kicking, crushing to accidental (HSE, 2012), this also features in the work of (Best et al. 2021) when handling sheep.

The severity of parasitic bronchitis as a cause of serious loss should be made clear to clients and the emphasis shifted away from cost towards the cost benefit of vaccination.

An effective vaccine has been there for dairy farmers for decades, so, why is lungworm within the UK still problematic? (McLeonard and Dijk, 2017). A starting point would be to understand what percentage of dairy farmers are vaccinating for lungworm, and if they are not vaccinating, why not? We should explore any barriers to vaccination and understand what training and educational needs remain even after 60 years of vaccine availability.

**2.11 Environmental Impact**

Recent studies have explored the negative effects that the ML group of wormers have on the environment (BCVA, 2022).

It is probable that there is widespread lack of awareness of anthelmintic over-use, stewardship requirements and emerging resistance (Sands and Wall, 2016). There has been renewed interest in the vaccine Bovilis Huskvac from many UK farm animal vets in the last couple of years due to the negative effects of ML products on dung beetles which are essential for pasture health and fly control (Beynon, 2015). (Baxter-Smith, 2022. Pers Comm. Dr K. Baxter-Smith is the Veterinary Advisor of MSD Animal Health),

Taking a pro-active sustainable approach to prevention, and treating outbreaks promptly, can lessen the negative impact on herd productivity and reduce costs, whilst also improving animal welfare and the environment (McLeonard and Dijk, 2017).

**2.12 Milk Contracts**

As farm animal health planning has become a mandatory requirement in recent years (Red Tractor, 2020), milk buyers have also pushed best practice, and similar to antibiotic resistance, milk buyers are now looking at anthelmintic resistance and environmental effects. Increasingly, milk contracts require dairy farmers to evaluate their parasite control and this includes the use of the lungworm vaccination (Arla, 2018).

**2.13 Importance of Quarantine and Carrier Animals**

Best practice to avoid introducing lungworm to the farm is to quarantine all incoming replacement stock on arrival, whether adult cattle or calves. Equally farms that introduce naïve replacement stock challenge the balance of the herds immunity. Bought in stock should ideally be vaccinated if the timing of vaccine availability works and the right pasture is available. These bought in animals may have come from low-risk areas with no exposure to the lungworm parasite (McLeonard and Dijk, 2017).

Up to 20% of cattle may carry and shed larvae. Carrier animals hold onto many infective larvae or adults in the lungs that remain dormant until the next grazing season and these carrier animals are thought to be the seed source of next year’s lungworm (Van Dijk, 2004).

When naïve cattle are turned out onto land grazed by carrier animals, contamination will often be low until the arrested larvae restart their development and produce patent infections. Lack of rotation of pasture grazing may lead to substantial pasture build up and contamination (Vercruysse, et al., 1995).

Transmission among cows is most troublesome if animals of different immunity levels are mixed. An example being when bought-in animals from Europe which have not been exposed to lungworm, enter the herd or heifers join the adult cows (Schunn et al, 2013).

Carrier animals are a different threat as they will not show any clinical disease so potentially posing more problems for the dairy farm. However, whilst these carrier animals may act as a route of infection of larvae from one grazing season to the next, they may help ensure herd level immune memory (McLeonard and Dijk, 2017).

**2.14 Gaps in Research**

Outbreaks in older cattle may arise if there is a conflict between host immunity and larval challenge. Reduced vaccination and (or) an excessive or inappropriate use of the ML group of anthelmintics may be detrimental to development of natural immunity (Borsberry, 2012) for all these reasons, outbreaks of lungworm in adult dairy cattle are becoming more common (Holzhauer et al., 2011). Further exploration is needed to understand why the number of outbreaks in adult dairy cows is considerably high. There is also a need for further study into improving quarantine and biosecurity particularly around parasitology, and investigating dairy farmers current management procedures (Maunsell and Donovan, 2008).

As health planning has become a requirement of health and welfare schemes in recent years, there is a need to continue to explore how this can be more of a success for dairy farmers in the short and long term. A joined-up approach on farm by both the vet and SQP, especially around parasitology is required. More engagement from both is needed in the future to help lungworm getting lost between the vet and SQP (Pyatt et al., 2020). However, for this to happen extra education on parasitology is needed for both vets and SQP’s.

Although some work exists, there are very few studies around anthelmintic usage (in relation to D. viviparus) on dairy farms in the UK and what drives these practices. Particularly with the dairy farmers ever increasing milk contract pressures focusing on rotating anthelmintic groups and only treating when necessary, making farmers more aware of sustainability, with a focus on anthelmintic resistance and the environment.

Many studies have reviewed frequency of lungworm cases confirmed annually by Veterinary laboratory and investigation centres. The knowledge gap centres on how farmers deal with outbreaks: treat cattle themselves versus engaging Vets or SQP’s. All this skews the data. Importantly, are diagnostics being used enough? (Charlier et al., 2015).

**2.15 Research Hypothesis**

Cost and ease of application would be a significant factor influencing farmers decision making in the control of lungworm on their farm, where-as, non-dairy farmer stakeholders would perceive the reduction in vaccination and an over-reliance, misuse of anthelmintics for lungworm as a significant factor why the UK are seeing a high number of cases reported.

Performance including growth rates and milk yield would be important to dairy farmers and to achieve this, anthelmintics could be overused. Concern for the impact that some anthelmintics have on the environment plus any concerns about anthelmintic resistance would be less of a priority. Conversely stakeholders particularly vets and vet allied practitioners would feel the overuse of anthelmintics in a preventative way is why animals cannot build up immunity during that time.

Vets and para-professionals would feel lungworm is underdiscussed, due to a lack of involvement on farm, where as dairy farmers may feel that they don’t need to receive any more education on lungworm.

**2.16 Aims**

The aims of the study are to analyse the epidemiology of lungworm (history of infection) and the current risk period and to investigate why lungworm outbreaks in dairy cattle have continued to be high over the last three decades (McLeonard and Dijk, 2017) and whether there is any pattern demographically between outbreaks and factors such as stakeholders’ opinions, climate and control techniques. Furthermore, to understand why outbreaks of lungworm are becoming increasingly more common in adult dairy cows (Holzhauer et al., 2011).

1. **Methodology**

This study was approved by the Ethics Committee at Harper Adams University Shropshire UK. All invited interviewees including dairy farmers, vets working in practice, SQP’s and vets working in laboratories and veterinary investigation centres were invited for an interview by letter and or a telephone call. All interviewees were provided with a plain language statement (Appendix 1) explaining the purpose of the research and the aims of the study, along with a consent form (Appendix 2), consenting to recording of the interview and use of any direct anonymised quotes taken from the interviews.

**3.1 Study Design**

A qualitative research process was used to explore stakeholder opinion and their current understanding of *Dictyocaulus viviparus*. The methodology was selected as a useful technique to value the attitudes, perceptions and opinions (Saunders et al., 2017) towards lungworm control in dairy cattle and stakeholder current understanding of the epidemiology of lungworm and how they perceive the risk from *D. viviparus*, while also ascertaining how stakeholder advice and understanding (particularly veterinary) influence the key decision pathways of dairy farmers. Qualitative methodologies have been used before in research looking into farmer opinions and attitudes towards management decisions and disease control on farm (Brennan et al., 2016). Quantitative research, mainly using questionnaires has been carried out regarding management practices (Baxter-Smith and Simpson 2020). However, using a questionnaire was not considered an appropriate research method for this thesis since statistical data cannot describe individual experiences, perceptions and understanding (Rose et al., 2018).

The purposive sampling technique was used for this study this involved selecting interviewees from contacts and acquaintances that the researcher had made within the animal health industry working as an R-SQP (Etikan et al., 2016). Participants were selected by virtue of their knowledge or experience of lungworm in dairy cattle, plus they were selected within the north west so that similar climatic and economic pressures were standard to all and so that in person collection could take place within the researchers time frame. Data saturation was deemed to have been achieved once no new themes emerged from interviews (Urquhart, 2013). For the purposes of this study the final, mixed sample of stakeholders (Table 3) was considered to be a good representation of views on the topic within the time frame available. All dairy farmers interviewed were responsible, or shared responsibilities for making management decisions with the herd. All farms grazed majority of their cattle through some part of the grazing season, with farms running indoor grazing dairy production systems excluded from the data set due to the lifecycle of *D. viviparus* needing pasture as explained in the section ‘’what is lungworm’’.

An interview guide was developed which included a set of initial and follow up questions consisting of open and closed questions (Appendix 3) following the example set by (O’Keeffe et al., 2016). The open questions allowed interviewees to give opinions and introduce other topics to the discussion which the researcher had not originally considered. The closed questions made the interviewees answer the questions particularly relating to what the researcher was trying to find out. Similar questions were presented to vets, SQP’s and dairy farmers alike, however, the interview language was changed for example the word Lungworm or Husk was used for dairy farmers whilst *Dictyocaulus viviparus* was used at times for vets and SQPs (Bard et al., 2019). Pilot interviews were conducted with both a vet and dairy farmer to ensure that the questions and language used were correct for each stakeholder group. This allowed for feedback on the order of the questions and how best to conduct the interviews.

**3.2 Data Collection**

Interviews were conducted by the primary researcher (MP), between March and May 2022. MP received training on qualitive interview methodologies at Harper Adams University. Data collection involved conducting 22 qualitive semi-structured interviews, with twenty of them being face to face at the participants place of work, whilst two were conducted by telephone. Face to face semi-structured interviews are well suited to gather rich, detailed data from participants who are asked questions designed to explore their personal experiences, attitudes and perceptions related to a research topic (Tong et al., 2007). Interviews averaged 40 minutes in duration, to investigate, stakeholder’s perceptions of lungworm control in dairy cattle in the UK. Twelve dairy farmers were interviewed from the following counties, Cheshire, Shropshire, Lancashire and North Wales, these farmers were from different dairy farming systems and herd size such as, calving all year round and block calving both in the spring and autumn, rearing their own herd replacements. Further stakeholder participants included, four R-SQP’s, four Vets in practice and two vets working in veterinary investigation centres and veterinary laboratories (Table 3).

Data collection was iterative with interviews being conducted, transcribed by the researcher MP and analysed using NVivo qualitive software (QSR International Limited Cheshire UK) before the next interview took place. Data collected was anonymised and coded by stakeholder code: for example, dairy farmer has become DF within this study. Using the NVivo qualitive software key themes were identified from the transcripts. All the interviews were audio-recorded using a SONY IC Recorder, with interviewee’s permission which included a signed consent form to facilitate transcription of the discussion post interview, this was only for the benefit of the (MP) researcher, the interviews averaged 40 minutes in length ranging from 20-60 minutes. The files were stored on a password protected laptop.

**3.3 Data Analysis**

Interviews were transcribed directly by MP and stakeholders were coded to preserve confidentiality. All the answers from the interviews were used and put into transcripts and analysed, Qualitive analysis was carried out by MP using the NVivo qualitive software (QSR International Limited Cheshire UK). (Braun and Clarke, 2006) suggest that an accessible method for novice researchers is thematic analysis as it does not require formalised theory generation and can be used within a range of theoretical frameworks, including critical realism. Theoretical thematic analysis was used to identify key themes and patterns from the data, to address the objectives of the research. Transcripts were analysed using continual collation techniques in-accordance with the six key stages of thematic analysis (Braun and Clarke, 2006).

1. MP became familiar with the data by reading the transcripts repeatedly before coding.
2. Codes were generated for important themes by MP.
3. Key themes and themes were identified by MP.
4. All the themes were reviewed to make sure they reflected the data.
5. MP defined the themes.
6. MP wrote-up the themes and sample quotes were used to give additional detail to qualitative themes identified.

**Table 3. Summary of Participating Stakeholders**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Stakeholder/Code (a)** | **Occupation** | **Calving Pattern if applicable**  | **Herd Size (c)** | **Age of Interviewee (b)** | **Location** | **Method** |
| DF1 | Dairy Farmer | All year Round | 400 Cows | 30-40 | North Wales | Face-to-face |
| DF2 | Dairy Farmer | All year Round | 300 Cows | 40-50 | North Wales | Face-to-face |
| DF3  | Dairy Farmer | All year Round | 450 Cows | 30-40 | Cheshire | Face-to-face |
| DF4 | Dairy Farmer | All year Round | 250 Cows | 40-50 | Shropshire | Face-to-face |
| DF5 | Dairy Farmer | Autumn Block Calving | 400 Cows | 40-50 | Shropshire | Face-to-face |
| DF6 | Dairy Farmer | Spring Block Calving | 500 Cows | 40-50 | Shropshire | Face-to-face |
| DF7 | Dairy Farmer | Spring Block Calving | 400 Cows | 50-60 | Lancashire | Face-to-face |
| DF8 | Dairy Farmer | Autumn Block Calving | 300 Cows | 50-60 | North Wales | Face-to-face |
| DF9 | Dairy Farmer | Spring Block Calving | 450 Cows | 20-30 | Cheshire | Face-to-face |
| DF10 | Dairy Farmer | All Year Round | 500 Cows | 20-30 | Lancashire | Face-to-face |
| DF11 | Dairy Farmer | All Year Round | 450Cows | 30-40 | Cheshire | Face-to-face |
| DF12 | Dairy Farmer | All Year Round | 300Cows | 40-50 | Lancashire | Face-to-face |
| Vet 1 | Vet in Practice | N/A | N/A | 20-30 | Shropshire | Face-to-face |
| Vet 2 | Vet in Practice | N/A | N/A | 30-40 | Cheshire | Face-to-face |
| Vet 3 | Vet in Practice | N/A | N/A | 30-40 | Cheshire | Face-to-face |
| Vet 4 | Vet in Practice | N/A | N/A | 40-50 | Lancashire | Telephone |
| SQP 1 | Active R-SQP | N/A | N/A | 60-70 | Cheshire | Face-to-face |
| SQP 2 | Active R-SQP | N/A | N/A | 40-50 | Shropshire | Face-to-face |
| SQP 3 | Active R-SQP | N/A | N/A | 30-40 | Cheshire | Face-to-face |
| SQP 4 | Active R-SQP | N/A | N/A | 20-30 | Cheshire | Face-to-face |
| OS 1 | Vet, working in VI centres and laboratories | N/A | N/A | 60-70 | Shropshire | Face-to-face |
| OS 2 | Vet, working in VI centres and laboratories | N/A | N/A | 50-60 | Scotland | Telephone |

(a) Unique code

(b) years of age (category)

(c) Number of milking cows (not including dairy youngstock)

**4.0 Research Results and Analysis**

The results demonstrated a variety of attitudes towards lungworm and mixed understanding of effective sustainable control in all ages of dairy cattle. A thematic map to visualize themes and subthemes to show their connection is demonstrated in figure 3.

**Figure 3** see next page (Page 21)

**Theme 1: Stakeholders perceptions and understanding of *Dictyocaulus viviparus***

Resources

Education

Knowledge

**Subtheme 1.3:**

**Farmer observation & awareness**

**Subtheme 1.2:**

 **How dairy farmers perceive the risk**

**Subtheme 1.1 :**

**Passion for Parasitology**

**Theme 2: Outbreaks of lungworm and professional Involvement on dairy farms**

Health Planning

Social Engagement

**Subtheme 2.2:**

**Farmers driven by Growth rates and financial gain**

**Subtheme 2.3:**

**Long term damage and Impact on the business**

**Subtheme 2.1:**

**Outbreaks, age of animals and Immunity**

SSSJJJJ

Motivation

Irreversible Lung damage

Bio security &

Quarantine

**Theme 3: Barriers to Vaccination, restrictions to implementation**

**Subtheme 3.3 Farmer Motivation Around Treatment**

**Subtheme 3.1**

**Anthelmintics**

**t.2 Grazing management & Climate Chan Subtheme 3.2 Grazing management & Climate Change**

**ge**

**ubtheme 3.2 Grazing Subtheme 3.2 Grazing management & Climate Change**

**ent & Climate Change**

**Subtheme 3.2**

**Grazing management & Climate Change**

Ease of Application and Handling Facilities

Cost

Efficacy

Environment and Public Perception

Anthelmintic

Resistance

Housing

Turnout

Immunity Gap

Dung Beetles

**Figure 3**. Thematic map displays the connection between the three themes, subthemes emerged throughout thematic analysis of the 22 Interviews.

**4.1 Theme 1: Stakeholders Perceptions and Understanding of *Dictyocaulus viviparus* (Lungworm)**

Current knowledge of most stakeholders was substandard. This included Vets in practice, SQP’s and UK dairy farmers:

In general, a high percentage of stakeholders were lacking in knowledge and understanding as expressed in the following direct statements:

‘*’Lungworm is not understood as much as it should be as it’s a serious disease’’* DF1

*‘’ Lungworm is poorly understood, we need more education’’* DF8

‘*’My knowledge of the lungworm parasite is pretty poor’’* Vet 3

Farmers don’t see lungworm as an important disease:

‘*’I don’t think we have a full understanding of lungworm; this may be because it’s not a headline disease like Johnes’’* DF6

However, some are saying there is a better understanding, but some room for improvement:

*‘’I think issues of lungworm are understood a lot more now than it once was, as the impact lungworm causes is serious and we have had to listen and change our ways, for the last 20 years we have just blanket treated with wormers, the vets just telling us to worm, worm, worm.* DF7

And this improvement is driven by a need to understand, once a dairy farmer has seen an outbreak, they suddenly see lungworm differently:

‘*’Lungworm has been a big problem for us on this farm in recent years, particularly in our adult milking cows, so we now understand lungworm well, however, I don’t think it’s understood well within the farming community’*’ DF9

Although there was a lot of negativity vets that worked in veterinary investigation centres had an excellent understanding:

*‘’I personally have an excellent knowledge of the lungworm parasite and very good product knowledge on anthelmintics that control lungworm’’* OS1

*‘’My knowledge of the lungworm parasite is very good, and my knowledge on anthelmintics to control lungworm is excellent’’* OS2

There is an absence of vet involvement on some farms, should the SQP and Vet channels be more joined up? And should vets get more education on lungworm and parasitology in general, when training to become a vet:

‘*’I don’t believe that lungworm is understood particularly well within the farming community, my own involvement on farm with lungworm is poor, I don’t feel farmers understand the lifecycle and worming strategies enough, I don’t think worms in general are understood very well by vets and dairy farmers. Vets are not involved with lungworm on farm enough’’* Vet2

Plus, a number of the advisors (SQPs and Vets alike) felt their product knowledge of the anthelmintics that control lungworm was poor:

‘’ *I don’t believe farmers, vets or SQP’s are the best at perceiving the risk of lungworm, my knowledge as a vet is very poor on lungworm, it would be 50/50 as to whether I get involved in lungworm control on my client’s farms’’* Vet2

‘’My product knowledge on products to control lungworm is poor’’ SQP 4

Several farms vets’ knowledge of the lungworm parasite is poor along with poor product knowledge:

‘*’My knowledge as a vet is very poor on lungworm’’* Vet2

‘*’My knowledge of the lungworm parasite is pretty poor, plus my product knowledge on anthelmintics to control lungworm is pretty poo*r’’ Vet3

It’s not only vets but also lots of SQP’s need a lot more lungworm training, both need to take a lot more interest in parasitology:

*‘’I don’t feel SQP’s see lungworm as that serious, my knowledge of the lungworm parasite is below average, plus my product knowledge on wormers that treat lungworm is not great’’* SQP1

‘’My knowledge of the lungworm parasite is quite poor’’ SQP3

**4.1.1 Subtheme: Passion for Parasitology**

However, those professionals and paraprofessionals that did take a real interest in parasitology expressed their current knowledge of the parasite and the products to control it and fully understand the real issues that lungworm pose:

When vets don’t see any commercial advantage in POM-VPS anthelmintic products, they don’t sell/prescribe them, therefore their product knowledge wanes. They may then avoid engaging with the farmer and leave it to the local SQP to deal with:

‘*’I feel lungworm is understood pretty well, the parasite is discussed annually between vet and farmer (at the herd health planning), I feel vets and the SQP’s I know perceive lungworm as a big risk, my knowledge of the lungworm parasite such as the epidemiology and lifecycle are very good, however my knowledge on anthelmintics to control lungworm is very poor as we don’t sell any wormers, however I talk to a very good SQP’’* Vet1

Specific farm vets that are interested in parasitology get involved with lungworm strongly on farm, resulting in the vet taking extra steps on farm:

‘*’I don’t feel the issues of lungworm is brilliantly understood within the farming community, I feel that vets and SQP’s perceive the risk as variable, my personal knowledge of the lungworm parasite is reasonably good, as is my knowledge on anthelmintics that control lungworm, I would get involved in lungworm on 100% of my dairy client farms*’’ Vet4

As with specific vets, certain SQP’s show a real passion and want to understand about the lungworm parasite, and would even take the next step and get involved with parasite control on farm:

‘*’I feel lungworm is very variable with how it’s understood within the farming community, some dairy farmers, SQP’s and Vets get the disease, however, some don’t get it at all, I have a pretty good knowledge of the anthelmintics that control lungworm and my knowledge of the lungworm parasite is fairly good, as I would get involved in lungworm control on farm’’* SQP2

It’s important to understand that dairy farmers are time poor and want simple solutions on lungworm control, but presently the quality of advice they are receiving is very variable from both the farmers vet and SQP:

‘*’I feel farmers are aware of lungworm and they understand it, however, they are very busy and don’t prioritize worm control, such as preventative strategies, farmers just want simple solutions’’* OS2

*I feel SQP’s are very variable in their knowledge and vets don’t get involved enough, some practices are very active others not, there is a massive range in the quality of advice given to the farmer. New graduate vets should have a basic understanding of the life cycle and a good knowledge of vaccines and products’’* OS2

There is a strong feeling that lungworm is not covered enough within the farms herd health plan. Some of this might be due to the lack of interest from vets on parasitology, whilst also there may be a lack of communication from SQP’s to Vets, when advice is being given to a farmer. The importance of good biosecurity is paramount, as purchased animals may be bringing the disease on the farm, furthermore, these fresh animals may be naïve and have never been exposed to lungworm. These animals would not have built up any immunity, then can easily succumb to lungworm when exposed to a heavy challenge on their new farm:

*‘’Personally, I don’t think lungworm is understood very well at all within the farming community, It should definitely come up in health planning and I don’t think it always does, lungworm should come up in both parasite control and respiratory disease, Vets think about bacteria and viruses causing respiratory disease and forget about lungworm in my experience. Vets should understand lungworm. Every farmer is different, farmers that have had a problem in the past tend to understand the disease, however others won’t. Most farmers don’t understand immunity and they definitely don’t understand biosecurity. Some SQP’s are good and understand lungworm disease, however not many’’* OS1

**4.1.2 Subtheme: How Dairy Farmers Perceive the Risk**

The majority of the dairy farmers in all 4 counties perceived the risk of lungworm as serious on their farm.

On specific farms lungworm is seen in adult dairy cows regularly:

‘*’Yes, I feel I’m at a very high risk, as I see lungworm ever year on this farm, particularly in my adult milking herd, especially in cows I buy in, just last September I had about 20% of my adult milking cows coughing’’* DF4

Cattle on rented land always need to be considered differently to that of animals closer to home. It’s completely different pasture:

‘*’Lungworm has always been a high risk on this farm, and particular on land that’s rented away from the farm where some of the youngstock go to graze, we always lose one or two animals a year there’’* DF7

Having a post-mortem (PM) done on farm is an extremely valuable diagnostic tool for lungworm. It will throw significant light on the severity of risk to a currently affected group and help prevent further groups being infested.

‘*’The risk of lungworm on this farm is very high, I’ve had it confirmed by postmortems in adult dairy cows over the last two years’’* DF6

Just because lungworm has not been a problem before, that doesn’t mean it won’t be in the future, our climate is changing, farmers grazing strategies are changing all the time, there is more and more housed cattle nowadays, plus any bought-on animals need to be considered a risk:

‘*’Lungworm is bad, it’s very serious, it wasn’t a problem, however it is now’’* DF11

Lungworm is a serious risk on dairy farms, however vaccinating with Huskvac can reduce the chances of an outbreak occurring, whilst also it allows new roundworm strategies to be introduced such as monitoring roundworms with faecal egg counts:

‘*’Yes, I perceive the risk of lungworm to be very high, so, I vaccinate my youngstock every year. Huskvac is my insurance policy. By vaccinating it also allows me to monitor for gut worm with faecal egg counts, I don’t have to use a lot of preventative wormers. I bought in just a couple of adult cows last year and they both went down with lungworm’*’DF5

**4.1.3 Subtheme: Farmer Observation & Awareness**

The majority of dairy farmers and staff felt they could identify the clinical signs of lungworm, such as coughing, laboured breathing, milk yield reduction and associated loss of condition. Others admitted they may not respond quickly enough to prevent death.

However, they may not have an understanding of subclinical lungworm; it may be present and impacting productivity but might not be obvious. Most employed staff on the farm would spot the signs but some international workers may have never come across the parasite before:

‘*’Coughing, weight loss, poor breathing and at times a lack of energy and dirty tails including scour I feel from previous experience are all signs of lungworm, I personally would be able to spot them, although sometimes not quick enough’’* DF6

Coughing, weight loss and milk loss can be easy signs to spot, everybody should always have lungworm in the back of their minds when animals start to cough:

‘’ *Coughing, weight loss and a drop in milk yield are sure signs of lungworm, everybody on this farm will spot these signs’’* DF11

Over the last two decades, there has been a lot of Eastern European agricultural workers placed on UK dairy farms, who might not have seen lungworm previously and need some education:

*‘’Signs include coughing and poor condition, the farm manger would spot these signs that’s myself, however I don’t think our staff would, especially some of the workers from eastern Europe’’* DF5

After seeing an outbreak of lungworm, farm owners and staff are always on the lookout for any signs of coughing, as they know it can lead to serious disease:

‘’ *Coughing and severe weight loss are signs I’ve seen when we have had an outbreak of lungworm, both myself and our staff could spot these early’’ ’*DF12

Educating farm staff is vitally important in controlling lungworm on farm:

‘’ *Yes, we all pretty good at spotting signs of lungworm, it’s the importance of having good experienced staff, however, we have to prevent it’’* DF2

**4.2 Theme 2: Outbreaks of Lungworm and Professional Involvement on Dairy farms Including Herd Health Planning**

Lungworm outbreaks have risen over the last three decades, particularly in adult dairy cows. Control techniques and climate change have played major roles alongside the variable involvement of professionals or paraprofessionals.

Lack of involvement: expressed by Vet 2

‘*’My involvement on farm with lungworm is poor’’* Vet 2

‘*’Vets are not involved with lungworm on farm enough therefore my knowledge as a vet is very poor on lungworm’’* Vet 2

‘*’It would be 50/50 as to whether I get involved in the lungworm control on my client’s farms’’* Vet 2

‘*’I would especially get involved with lungworm when herd health planning; however, my knowledge of the lungworm parasite is pretty poor, and my knowledge of the products to control lungworm is poor, so my involvement on farm is poor’’* Vet 3

However, it emerged there would be some involvement on farm by vets and SQP’s:

‘*’Yes, I would get involved in lungworm control on my dairy client’s farm especially in the herd health plan, however, my involvement on farm is generally poor, a lot of the time when we see it it’s just clinical cases which is about 10% of our clients it’s the tip of the iceberg, almost too late’’* Vet 3

‘*’Yes, I would get involved in lungworm on farm, and talk to a vets’’* SQP 2

‘*’Lungworm is always discussed in the herd health plan, but probably not as much as it should be as we don’t sell any anthelmintics’’* Vet 1

‘*’Yes, lungworm control is covered on 100% of my farms in the herd health plan, and I would have a discussion with my clients over appropriate use of anthelmintics’’* Vet 4

Prevention is better than cure, so its important vets get involved:

‘*’Vets must make sure lungworm is part of the herd health plan, I get involved with lungworm investigations when it has not been thought about enough, then farmers get caught out, prevention is better than cure, get the cattle immune, build up immunity when they are young’’* OS1

Both vets and SQP’s are involved with controlling lungworm on farm, therefore, would a Vet have any contact with SQP’s about lungworm on one of their clients’ farms? There appears to be little contact between Vets and SQP’s. However, on farms where there is a joined-up advisor approach, significant success can follow:

‘*’No, I don’t have contact with SQP’s when a treatment to control lungworm is prescribed’’* Vet 2

‘’No, I don’t have any contact with SQP’s when a treatment to control lungworm is prescribed by an SQP’’ Vet 4

‘*’I wouldn’t have confidence to talk to a vet about lungworm’’* SQP 3

*’Yes, I do have some contact with SQP’s when a treatment to control lungworm is prescribed, however, this is only one SQP, who has an excellent knowledge of lungworm and the products to control it*’’ Vet 3

‘*’There needs to be more parasite planning done by vets and SQP’s especially a joined-up approach, this is complicated but a lot more needs to be done’’* OS2

Poor knowledge of both the lungworm parasite and product knowledge from both Vets and SQP’s emerged. This can only reduce involvement and appropriate advice on farm:

‘*’My product knowledge on anthelmintics to control lungworm is poor’’* Vet 3

‘*’There is some vet and farmer engagement about lungworm in the herd health plan’’* Vet 3

‘’I have very poor product knowledge’’ Vet 1

‘*’My product knowledge is not great, so I don’t like getting involved when a farmer explains he has lungworm’’* SQP 1

It’s important to understand how stakeholder advice particularly Veterinary and or SQP influences the key decision pathways of dairy farmers, and where they get majority of the advice from.

Qualitative data from the research responses demonstrates that its apparent that dairy farmers get the majority of their advice from SQP’s (69%) and there is much less involvement from their Vet (31%), except when the clients herd health plan is due. At this point lungworm may still get overlooked.

Data from the interviews suggested that dairy farmers are receiving majority of their advice on lungworm control from the SQP compared to the vet:

‘*’I listen a lot to both my SQP and vet, but regarding lungworm it would be 90% SQP and 10% vet’*’ DF9

‘*’I would get 100% of my advice on lungworm from my SQP’’* DF5

**4.2.1 Subtheme: Outbreaks of Lungworm and the Age of Animals that it’s Being Seen in, plus Immunity and Naïve Animals**

Climatic factors such as warm and wet summers or milder winters need consideration as outbreaks now occur in all ages of dairy cattle.

Significantly, there has been an increase in cases seen in adult dairy cows.

Of all 12 dairy farmers interviewed, 11 of them had seen lungworm in adult cows in the last two years and this was mainly from non-vaccinated herds.

There was lungworm seen in vaccinated herds, but this was in cows that had been bought in from different counties within the UK and from other European countries:

Expressed by DF 6 ‘*’We had a significant outbreak of lungworm in the past two years 2020 and 2021, this was in young first grazing animals of six months of age in July, but we have also had serious cases of lungworm confirmed by a post-mortem over the last two years in adult dairy cows up to seven years old and two-year-old heifers, in fact we had 6 die in total’’* DF6

‘*’A lot of the dairy cows that had bad lungworm and some died were in cows bought in from Denmark’*’ DF 6

‘*’Other milking animals it’s been seen in on this farm are animals from Norfolk’’* DF 6

‘*’Lungworm has certainly been seen on this farm, particularly in cows bought in, from various parts of the country, not so much in my own replacements’’* DF 4

‘*’We never really had an issue until we started buying cattle in’’* DF 4

‘’ *During the last two years we have seen lungworm not only in my first-year grazing animals, but also in my adult cows, normally around the end of July*’’ DF8

Diagnostic cases of lungworm seen in adult dairy cows has also risen in recent years at Veterinary laboratories and Veterinary investigation centres:

‘*’The reasons I believe outbreaks of lungworm in dairy cattle is becoming more common in recent years is due to the following, not enough immunity, an immunity gap and a lack of vaccine use, cattle are being housed more nowadays, so housing issues, cattle are grazed les*s, *plus Movement of animals around the country, purchased adult replacements that don’t have enough immunity, immunity gap’’* OS2

‘*’There is an over reliance of anthelmintics, particularly long-acting anthelmintics, then these cattle are not prepared when they go into the milking herd,* *personally, I believe it’s switched from being a youngstock disease into a disease that affects all ages of dairy cattle’’* OS2

‘*’I personally believe the reasons we are seeing lungworm in adult dairy cows a lot more now than years ago is there are not enough farmers vaccinating, this is possibly down to cost, or the farmers feel they can manage with Ivermectin wormers, although, ivermectin will impact the environment, soil, killing off dung beetles. Adult cattle not being immune, is either they have not had enough exposure as they have been over wormed, or they have been purchased from a herd that hasn’t had any exposure to lungworm, or the farmers biosecurity is poor when they are buying in* OS1

Vets in practice are also seeing more cases of lungworm in adult dairy cows, and express these thoughts and reasons:

‘*’ Lack of grazing is a major issue, dairy farmers house their cattle more nowadays, then farmers will suddenly decide to put the cattle out especially the milking cows, lungworm is not on their radar, grazing isn’t on their radar’’* Vet 4

Furthermore, from participant data we are now seeing an emergence of outbreaks in second year grazing heifers and freshly first calved heifers.

This could be from a lack of exposure when the animals are young, resulting in a lack of acquired immunity. Enhanced involvement by Vets and SQP’s on farm, giving advice on grazing management, immunity (including vaccination) and advice on anthelmintics (including resistance) can only help.

‘*’We saw a major outbreak in September 2021 in our in-calf and first calved heifers in milk that were all around 2 to 2.5 years of age, this was serious as two animals died, plus there was a lot of animals ill, and lot had to be treated twice with Eprinex [Eprinomectin] pour-on*’’ DF11

‘’*Lungworm has been a problem in both our adult cows and our freshly calved heifers around 2 years of age, we in fact had two heifers die last year’’* DF9

**4.2.2 Subtheme: Farmers Driven by Growth Rates and Financial Gain**

Hitting growth rate targets in youngstock is vital on all dairy farms but especially with those on a block calving system (Spring or Autumn) where a target calving age of 2 years old is crucial. Animals falling out of calving blocks in subsequent years are a costly loss.

Several dairy farmers interviewed agreed that they may over-use anthelmintics from the 3-ML group as they can’t afford for heifers not to grow:

‘*’I’ve always relied on pour-on Ivomec [Ivermectin] or Dectomax [Doramectin] wormers to control lungworm in my youngstock as I’m driven by good growth rates, they have to make serving and calving weights’’* DF 1

‘*’I worm with an ivermectin pour-on wormer through the grazing season, this is all driven by me wanting good growth rates in my heifers, although I’m also definitely going to vaccinate for lungworm this year’’* D3

**4.2.3 Subtheme: Long Term Damage and Impact on the Business**

A small number of cattle die from post-patent parasitic bronchitis but happily most animals will gradually recover albeit an absolute return to normality can often take months.

The interviews revealed that approximately one or two animals died per outbreak but particularly if treatment was delayed. There was serious farmer concern that even once the animals recovered severe lung damage would impact on youngstock growth rates or quality and quality of milk yield in adult milking animals. Affected youngstock might be less likely to be retained past their second lactation as lungworm contracted earlier in life, had affected fertility and performance.

‘*’Lungworm not only impacts my heifer’s growth, but it also impacts the milk yield later in life, and I feel the cows don’t produce the quantity and quality of milk later when they reach the milking herd, this impacts the business considerably’’* DF10

‘*’One or two heifers that had lungworm bad last year are still very thin, these must have significant lung damage and will be more susceptible to other diseases later in life, we might even have to cull them, this impacts the business. Our milk yield was low when we had an outbreak last year, and to be honest it’s never really recovered and we are now 8 months later, and some have been treated twice adding further cost’’* DF11

‘*’Even after our dairy heifers have recovered from lungworm the growth rates are significantly impacted, very often they won’t make bulling weight, so then these animals won’t calve around 24 months when we want them too. We lost one animal at around 7 months of age and that would have been worth £500.00 at that age then there was treatment costs and loss in growth so this would possibly add up to £1000.00 for that group of heifers’’* DF12

‘*’I’ve decided to vaccinate, because lungworm impacts me bigtime, I like my heifers to calve at 23 months of age, we spend so much money on rearing these heifers they have to grow’’* DF 2

**4.3 Theme 3: Barriers to Vaccination, Restrictions to Implementation**

Interview data suggest that there are thematic barriers restricting dairy farmers from incorporating the lungworm vaccine, Bovilis Huskvac (£10/head) into the farm’s parasite control plan.

Vaccine awareness was high in all interviewees. A high percentage of stakeholders recognised the issue of overuse of anthelmintics, and some worried stakeholders were starting to make changes.

Supermarket milk contracts, focus on sustainability and the environment. They have driven change and best practice, however, there are still barriers to the use of an excellent proven vaccine.

Out of the 12 participant dairy farmers only 3 vaccinated annually and these farms only started following an outbreak. In general, they have been very pleased with the results from vaccination, although, 2 of these farms had still seen an outbreak in bought-in adult dairy cows.

Perhaps more Vet and SQP input on farm about these new farm arrivals could have prevented these occurrences.

Whilst a couple dairy farmers prioritised the vaccine on their farm:

‘*’Following outbreaks of lungworm a few years ago, I would never not vaccinate now, I feel the only barrier is cost, however, I feel its money well spent*’’ DF2

‘*’There would be a considerable economic impact on this farm if we had an outbreak of lungworm, that’s why I personally vaccinate, I would always vaccinate. As I believe it would affect growth rates in my heifers, conception rates and milk yield in my milking herd’’* DF3

Financial considerations were evident, and it was suggested that anthelmintics are far too cheap compared to the vaccine when cost per dose was considered. This was a significant discovery:

‘*’The barriers to vaccination are for sure the cost, £10.00 for two doses is a lot of money, when I can worm with pour-on wormers all season for a quarter of the price’’* DF1

‘*’Cost is big barrier, if it was a one-shot vaccine I would do it, there is too much agro to doing two doses and Ivermectin wormers are so cheap, there is a big difference between the cost of wormer and the vaccine’’* DF8

‘*’It’s an expensive vaccine, so there is an initial cost especially in large herds, plus wormers are so cheap’’* DF12

‘*’The biggest barrier to using the vaccine is cost, it’s a cash flow problem’’* DF4

Two dairy farmers have stopped vaccination due to monetary reasons. They are now having a problem with lungworm and so should really start using it again:

‘*’I really should be using the vaccine as I had a case of lungworm last year in a young calf. Following a bad year with lungworm when I lost 2 animals I started vaccinating, but then stopped because of various barriers mainly due to the cost of the vaccine and housing more cattle’*’ DF9

‘*’I used to use Huskvac, but it’s another job and plus it’s an expense, it’s very costly compared to the price of Ivermectin wormer’’* DF10

Supermarket milk contracts pressure to reduce anthelmintic usage on farm, aid the environment and enhance sustainability, has meant that some dairy farmers such as these two farms will be vaccinating for the first time in 2022:

‘*’I’ve never vaccinated, although lungworm has always been a problem on our rented land, the cost of the vaccine has always stopped me from using it, however, I am this year in 2022, mainly down to my milk contract driving me to do this’’* DF7

‘*’I’ve contacted my SQP and Vet to tell them I’m going to use the vaccine this year, as the vet for my Arla Morrisons contract is wanting me to use it, to reduce the amount of wormer applications I’m currently giving’’* DF1

Recent changes in supermarket milk contracts are driving best practice and changing the views of dairy farmers, vets and SQP’s:

*Supermarket milk contracts are asking for us to change our ways, as now are the vets and SQP’s that I currently work with’’* DF7

Once a farmer has had a significant number of animals die from lungworm, then vaccination looks a good saving, as one farmer explained:

‘*’The barriers to lungworm vaccination are definitely financial, but I will defiantly use the vaccine going forward as it’s a lot cheaper than losing animals’’* DF6

In addition to vaccine price, mention was made of increased labour costs with the burden of dosing stock with two oral doses of vaccine. There were also restraints on turn-out times to allow for adequate uptake of the vaccine pre turnout.

‘*’It look’s a ball ache [sic] to do, plus their extra labour, and two doses to be given, and you can’t turn out until two weeks after receiving the second dose, this means some of my spring born calves staying in too long, way into the summer. If you’re going to use Huskvac you have to have a parasite plan in place, my vet from my milk contract has asked for this to be done, more expense’’* DF1

*‘’If it was a one-shot vaccine I would do it, there is to much agro to doing two doses’’* DF8

‘*Time is a big barrier, and also you need a good handling system as it’s not easy to give’’* DF11

‘*’Two doses for me is major barrier as it affects turn-out times, its not easy to drench huskvac, it would be a lot easier in injection form’’* DF9

Although it’s their belief that vaccinating with Huskvac is the gold standard, it emerged from interview data that only between 25% and 30% are currently vaccinating. Several non-farmer stakeholders believed there to be lot of barriers to lungworm vaccination:

‘*’Cost is the biggest barrier I find when I’m talking to my dairy farmers about the use of Huskvac’’* Vet1

‘*’It’s an expensive vaccine compared to other vaccinations, so there is an initial cost, and farmers don’t perceive there is a problem on their farm because they are worming, plus wormers are too cheap compared to the vaccine there is far too much of a difference in cost compared to the cost of a wormer and the vaccination’’* Vet4

‘*’Production of the vaccine is poor, we can’t produce enough vaccine early enough in the year, this leads to in-proper use. Furthermore, handling is also a problem, it’s difficult to use its not farmer friendly, with it being in glass bottles. There is too much difference in the price of the vaccine and some wormers especially the active ingredient Ivermectin. We could also do with knowing how much heifers grow in the months of July, August and September with the vaccine compared to heifers not receiving the vaccine’’* Vet2

‘*’The cost differential between the vaccine and most anthelmintics is ridiculous, the price of some wormers is pennies compared to the cost of the vaccine, this has to change, i feel we need research and development into a new vaccine, Huskvac has been around for a long time now and it works so well. I believe every breeding dairy female animal should be vaccinated’’* OS2

**4.3.1 Subtheme: Anthelmintics**

It’s important to understand the rationale of differing vaccine and anthelmintic strategies for control of *D. Viviparus.*

Interview data suggests that the quantity of anthelmintics used on farm is overwhelming compared to vaccination.

The low prices of the Ivermectin based (ML group) Pour-On wormers are attractive to cost conscious clients. They consider the cost first and often ignore the longer-term cost benefit to their stock and enterprise.

As mentioned, supermarkets are leading the change here.

‘*’I control lungworm on my farm with strategic use of Ivomec Classic [Ivermectin] Pour-On wormer on my youngstock, at 3, 8 and 13 weeks after turnout and then again at housing, this is a simple and cheap’’* DF10

‘*’Financial gain is what drives my anthelmintic practice on farm, this is why I use an Ivermectin Pour-On wormer on my dairy heifers, Ivermectin is penny’s here in North Wales, but I totally understand this is bad for the environment, and I could run into trouble with anthelmintic resistance, so I’m looking at using a first grazer bolus in 2022, these will be used next month on this farm’’* DF8

‘*’I continue to use Enovex Pour-On [Ivermectin] on my R2’s, second season heifers at grass, as its cheap, and these heifers should have a bit of immunity, however, I use Dectomax [Doramectin] Pour-On on my R1’s first season grazers as it lasts longer, but I am going to use lass wormer hopefully in 2022 as I’m going to vaccinate for the first time, along with undertaking regular faecal egg counts for roundworm’’* DF1

Doramectin Pour-On is also still used significantly, due to dairy farmers being advised to use this active ingredient at turn-out on their youngstock and then again 8 weeks later, this has been convenient and easy to use:

‘*’Dectomax [Doramectin] Pour-On is used at turn-out and then around two months later on my R1’s, but it’s going to be used this year alongside the lungworm vaccination, plus ill only worm with Dectomax after a high faecal egg count result, or if my heifers are not growing’’* DF1

‘*’Dectomax [Doramectin] Pour-On has been used a lot on all my three farms, because we have been able to use it at turn-out and the 8 weeks later, making it easy to use, this year though in 2022 I’m looking at vaccinating for lungworm, whilst also my SQP is going to be undertaking faecal egg counts for roundworm’’* DF7

Levamisole oral drench has often been the product of choice for anthelmintic treatment of coughing youngstock with lungworm, although a re-treatment may be required as it only kills adult lungworm. It can’t be used on animals producing milk for human consumption:

‘*’Levacide [Levamisole drench] has also worked well, especially when treating lungworm, the other products we use such as Dectomax [Doramectin] and Ivomec [Ivermectin] are ok at preventing lungworm, but if the animals need treating because they are coughing bad then I would always get my staff to treat with Levacide [Levamisole]*’’ DF7

‘*’I now vaccinate for lungworm and we faecal egg count teat for roundworms, and when needed we will often use a levamisole drench, this I used to treat for lungworm before we started to vaccinate’’* DF12

Oxfendazole boluses have also been used on farm with considerable success in first season growing heifers, particularly alongside Huskvac.

‘*’My dad likes using Ivomec [Ivermectin] pour-on because it’s so cheap, but we now use oxfendazole first grazer boluses on my youngstock, and these have worked really well, especially alongside the lungworm vaccination Huskvac, but they are both expensive, so I don’t think we are going to let our youngstock out to grass this year’’* DF9

‘*’We have used Autoworm first grazer boluses containing oxfendazole and these are brilliant on my youngstock, although when we bring animals in, these don’t always get treated’’ We are going to vaccinate with Huskvac this yea*r’’ DF6

Participating data shows that long acting moxidectin is also being used on dairy heifers, particularly on first season grazers away from home. These heifers have achieved some excellent growth rates and this strategy can work out significantly cheaper than a bolus.

‘*’We have used Cydectin moxidectin 10% LA Injection for a few years now on our heifers, but we house early, so our heifers are only out from May until the end of August, the time that the persistency of the wormer lasts*. DF11

11 out of the 12 farmers were having to treat with an eprinomectin pour-on wormer at least once a year for a lungworm outbreak and some will have to retreat for reinfection. A significant quantity of medication involved:

‘*’Eprinex [Eprinomectin] pour-on is used on the milking cows at first signs of coughing’’* DF4

‘*’We are using more wormer such as Eprinex [Eprinomectin] pour-on, on our dairy cows than we used to, this is because we have to’’* DF6

‘*’Yes, farmers especially us are using more wormer because of an outbreak of lungworm, particularly on adult dairy cows and often having to retreat’’* DF11

**4.3.2 Subtheme Grazing Management & Climate Change**

Perception of the influences of the above were significant.

Whilst many farmers continue to graze heifers in traditional ways, especially block calving herds, some have nearly abandoned pasture exposure. Intensive milking herds with advanced housing facilities, often manage their cattle inside all year round apart from a small window of grazing for dry cows or older heifers aged 15-24 months. This practice really limits lungworm exposure and diminishes natural immunity.

Conversely some farms are so densely stocked that the grazing becomes dangerously contaminated and acquires “elevated risk” status. Clean ground is at a premium.

Expressed by several dairy farmers:

‘*’We don’t turn-out as many of our dairy replacement heifers now until they pd in-calf, at around 15 months of age, because I want them to grow, and I’ve found their daily live weight gain hasn’t been great out at grass, I want growth rates, and they don’t grow as well outside, and our youngstock that do go out will not go out until we have clean grazing such as silage aftermath’’’’* DF9

‘*’We have changed the amount of time our stock are out at grass in recent years, possibly a lot less grazing, especially the high yielders (adult milking cows) these won’t go out much at all, and the low yielders will only go out for a small amount of time. This is because we want more performance milk yield, also our heifers won’t go out much either as we want them to grow more, and we feel they will put more weight on inside, although they will go out for a few months of the year’’* DF11

‘*’We haven’t changed our grazing system really, all our youngstock go out to high-risk pasture, although we are going to try to avoid it this year’’* DF6

A change in the epidemiology:

‘*’Over the last three decades the epidemiology of lungworm in the UK has changed, I believe we are seeing a lot more lungworm outbreaks due to a lack of herd/animal immunity, there are not enough dairy cattle being vaccinated, not enough up-take of the vaccine. We are seeing a lot mare management practices being changed, such as heifers don’t get turned out to grass until they are in-calf. High yielders don’t go out at all (don’t graze) and a lot more dairy cattle in the UK are housed permently, then some of these animals may be sold and moved to a different location. Years ago, cattle might have been slightly exposed and gain a little bit of immunity before they faced a challenge. Nowadays, these cattle have not had any exposure and then take a big hit, then you see a lot more severe clinical disease. Plus, housing dates have changed over recent years, some come in early now, however some stay out late into the autumn and winter, and there very often isn’t a plan in place for these cattle that are staying out at grass longer’’* OS2

The UK seems to be changing and we are seeing a lot more wet, warm summers and mild winters. In 2020 and 2021 we experienced a long dry spell early in the summer followed by episodes of wet weather, resulting in the release of masses of infective larvae onto pastures, creating a serious threat to all ages of cattle:

Expressed by OS2 *Climate change has also played a significant change to the epidemiology of lungworm, the last two years have been very challenging, particularly when we have had a very dry start to the summer, then heavy summer rain’’* OS2

‘*’We will only see the tip of the iceberg though in PM data’’* OS2

*‘’Traditionally, lungworm was often diagnosed in the South West and the midlands, however now it’s not as specific as this, it has changed, you can see it at any time any place of the UK, however, there is still a west and east split, the west gets a lot more rainfall and still sees the most outbreaks’’* OS2

‘*’Lungworm cases have seen a steady increase particular over the last two years, September 2021 we sore a lot of cases, however, like vets we only see the tip of the iceberg, as I suspect a lot of dead animals won’t get a post-mortem. These cases in September come about after we have had a very dry spell followed by a significant amount of heavy rainfall’’* OS1

**4.3.3 Subtheme Farmer Motivation Around Treatment**

The three “P” s of productivity, performance and profit always ride high in attitudes compared with sustainability and the environment. Pleasingly, a substantial number of DF interviewees were concerned about anthelmintic resistance as they need their wormers to remain efficacious, whilst the environment was a lower concern:

Anthelmintic resistance:

‘*’Yes, I am worried about anthelmintic resistance, I need the wormers to work’’* DF1

‘*’I’m not personally concerned about anthelmintic resistance, however, my heifers need to grow, so the wormer has to work’’* DF2

‘*’I am concerned about anthelmintic resistance, and I listen to both my SQP and Vet on this subject’’* DF3

‘*’Yes, I’m concerned about anthelmintic resistance, as I need money’’* DF10

‘*’Yes, I am concerned about anthelmintic resistance’’* DF8

‘*’I think anthelmintic resistance in cattle is an important emerging problem, you can make a difference by doing a parasite plan with your SQP or Vet, my vet that works for my milk buyer is asking me to do this’’* DF12

Environment:

‘*’No, I’m not worried about the impact wormers have on the environment, I’m more concerned that I don’t have any coughing animals’’* DF2

‘*’No, I’m definitely not worried about the impact wormers have on the environme*nt’’ DF3

‘*’No, I am not really worried about the impact some anthelmintics have on the environment, there are a lot worse things going into the environment, I’m certainly not worried about dung beetles, however, my milk buyer is trying to make me understand’’* DF1

‘*’No, I’m not concerned about the impact wormers like Ivermectin have on the environment, there are bigger issues’’* DF10

‘*’No, I’m not concerned about the impact wormers have on the environment, there are a lot more things that I need to be concerned of’’* DF4

Some of the farms were looking to change their grazing management and their current use of the 3-ML group anthelmintics. Uptake of education by these farmers meant they could see the benefits of the dung beetle aiding reduction of parasitic nematodes and the improvement of land productivity,

Crucially their milk contract requirements push them to look at their anthelmintic usage, whilst also rotating the wormer groups, and think about the environment:

‘*’We need to look after our wormers, we need to be more sustainable’’*DF5

‘*’I’m not personally worried about the environment, however, I do want to abide by my milk contract and only treat with anthelmintics when needed, this why I’m conducting Faecal egg counts for roundworms during the grazing season and why I’m also vaccinating with Huskvac for lungworm’’* DF5

‘*’I’m going to vaccinate for lungworm for the first time in 2022, because my milk contract with Arla Morrisons is wanting me to vaccinate, whilst also undertaking faecal egg counts before treating for roundworms, alongside me monitoring my weights of my youngstock. I don’t really want to do this but it looks like I’m going to have to do it’’* DF1

‘*’Yes, I’m also concerned about the impact wormers have on the environment, we should be concerned about the impact Ivermectin’s have on dung beetles, dung beetles do a good job, so, I’m looking at vaccinating and using Autoworm first grazer boluses or the white drench Endospec on my youngstock this year in 2022’’* DF8

‘*’Yes, I am worried about the impact some anthelmintics have on the environment, Ivermectin’s are out’’* DF12

1. **Discussion**

This qualitive study explored the attitudes of stakeholders towards lungworm and understanding of effective sustainable control in dairy cattle. It is obvious that dairy farmers attitudes to lungworm control are influenced by performance, productivity, and financial gain, however, there appears to be a drive for farmers to seek alternative options and change their management. This may be milk contract driven (Arla, 2018)

The future is clear – all stakeholders must work together to counteract the upward surge of outbreaks in all ages of cattle, but particularly adult dairy cows.

There is often a lack of communication and engagement between farmer, Vet and SQP on parasitology in general but especially on lungworm. There is a need for extra education for both Vets and SQP’s so they can relay this back to the dairy farmer (Dobbs, 2022) (Pyatt et al 2020).

**5.1 Stakeholder’s Perceptions and Understanding of Lungworm**

In this report, some dairy farmers perceived lungworm to be a serious disease, however, their understanding of the parasite was inadequate, as was that of some of the Vets working in practice plus prescribing SQP’s. A high percentage of stakeholders don’t prioritise lungworm as much as other headline diseases such as Johnes or BVD (Paton, 2015).

Recent milk contracts have mandated dairy farmers to review their anthelmintic usage and substantiate why they are worming animals. An in-depth parasite plan including vaccination for lungworm is required. They want their farmers to think about sustainability, anthelmintic resistance, and the environment (Arla, 2018). This requires vets and SQP’s who are giving parasite control advice to put develop a bespoke parasite plan for these clients, preferably as a joined-up approach working together (Pyatt et al., 2020).

**5.2 Education and Resources**

For these plans to be put in place and more importantly, succeed (Tremetsberger et al., 2015), the advisors such as Vets and SQP’s must have sound knowledge of the subject matter (MSD, 2021).

In this study its perceived that a vast number of both Vets and SQP’s not only have a poor knowledge of anthelmintics controlling lungworm, but worryingly have little understanding of the parasite in general. More education is needed to upgrade quality of advice (Vaarst et al., 2007), this will hopefully lead to more vet involvement on farm (Van der Leek, 2015).

Vets often felt they had precious little training on parasitology in the saturated timetable at Vet school and lacked understanding of the distribution channels and medicine classification POM-V versus POM VPS (Noah Compendium, 2022).

Equally, several participating SQP’s felt they didn’t have the knowledge to give good advice on lungworm. Substandard initial training and variable ongoing CPD did not build confidence or interest in the topic. Some dairy farmers also perceived some Vets to be disinterested in providing proactive advice on lungworm.

Enhanced CPD training for both Vets and SQP’s is lacking. Use could be made of peer-to-peer interaction by Vets or SQP’s and even some dairy farmers that have a good understanding and knowledge of the parasite and products to control it. Focused groups of passionate and knowledgeable people exchanging knowledge (peer learning) has been shown to work extremely well, particularly in the reduction of antibiotics on farm (Vaarst et al., 2007)

Further education could come from AHDB or pharmaceutical companies. Parasitology, particularly lungworm needs additional focus both in Vet school and the AMTRA training that SQP’s receive. Unfortunately, a lack of interest in lungworm from the majority of Vets and SQP’s in the UK, may feedback to the dairy farmer who compounds the problem by displaying little interest until a severe outbreak occurs (McLeonard and Dijk, 2017).

**5.3 Passion for Parasitology**

Where specific Vets and SQP’s show a real passion and keen interest in parasite control, they can educate their clients with a bespoke parasite control plan, review immunity, grazing management, biosecurity, vaccination and the anthelmintics that control lungworm (MSD, 2021).

However, there are hurdles as SQP’s cannot prescribe the POM V lungworm vaccination (Noah Compendium, 2022). Vets generally don’t prescribe many anthelmintics as they feel they cannot compete commercially on these products. This is where a joined-up approach between Vets and SQP’s certainly would work. It requires an openness with each other and shared passion for the subject (Vaarst et al., 2007). Dairy farmers want simple time efficient solutions with aligned advice from Vet and SQP and no mixed messages (Atkinson, 2010)

This study also finds that biosecurity and quarantine is poorly undertaken by dairy farmers who would benefit from extra education from both SQP’s and Vets (Enticott et al., 2011),

Naïve heifers and adult milking cows are being frequently bought-in and interviewees suggest this is a major problem. Transmission between cows is most troublesome if animals of different immunity levels are mixed (McLeonard and Dijk, 2017).

Over two thirds of the dairy farmers interviewed receive their advice from their local SQP (working in trade stores and animal health businesses), some farmers perceived Vets to lack specialist lungworm experience above their own and the SQP’s understanding of the subject. This has also been previously identified as a hurdle to farmer-advisor engagement (VDS, 2021).

Happily, there are some practicing Vets with a good understanding. They are aided by the Veterinarians working in diagnostic laboratories and investigation centres, who boast excellent knowledge of the lungworm parasite, the anthelmintics and vaccine. These allied Vets offer an excellent service and going forward could educate both practising Vets, SQP’s and dairy farmers on poorly understood immunity and biosecurity (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC).

**5.4 How Dairy Farmers Perceive the Risk**

All participant dairy farmers perceived their risk to be very high on their farms, including four neighbouring counties on the north-west side of the UK, particularly in adult dairy cows, as 11 of the 12 interviewees all had lungworm outbreaks during the past two years, consistent with past studies (Holzhauer et al., 2011).

Some farmers seek a diagnosis while others do not. Although, this percentage shows that outbreaks have continued to rise annually, the past two grazing seasons 2020 and 2021 have been an extremely high risk, due to wet and warm summers and mild winters. The last two summers have seen a hot spell followed by high rainfall for a considerable number of weeks, this has led to a high number of outbreaks (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC). The winters have been extremely mild, and may have allowed larvae to overwinter on pasture facilitating transmission from year to year affecting animals put out to pasture in the Spring (Crawshaw and Smith, 2003).

Outbreaks of lungworm in bought-in heifers and adult cows (from UK and European herds) are significant, and formed common theme from the interviewees, (Henriksen and Anderson, 1979) (Schunn et al, 2013) and even heifers away on rented land or contract reared heifers. Farmers explained they are not considering the lungworm history of the farms that the animals are coming from, with no conversation from farmer to farmer, and very little involvement by the farmers vet when these animals are arriving (Howarth and Van Winden, 2021). Introducing naïve purchased cattle may interfere with balance of the herds immunity (McLeonard and Dijk, 2017) biosecurity may get touched on within the herd health plan, however, its very often not followed up. The health plan stays in the drawer in the office! (MSD, 2021).

Quarantine and vaccination are rarely considered by farmers, introducing naïve replacement stock may interfere with the balance of the herds immunity (McLeonard and Dijk, 2017). It’s vital that rigorous quarantine protocols are followed through, not only for bought in animals but also for youngstock that are away from the farm on rented land, or where heifers are contract reared, as even low levels of current challenge may cause an outbreak (Forbes, 2018).

**5.5 Observation and Awareness**

Farmers and stockmen seem confident to recognise clinical lungworm but can sometimes be slow to react (Elsheikha, 2017). Foreign workers are problematic (Szelewa and Poalkowski, 2022).

There is often a high turnover of staff on UK farms (Szelewa and Poalkowski, 2022) and this highlights the importance of having skilled, well-educated staff on farm, while also having consistency when rearing dairy youngstock (Boulton et al., 2017).

**5.6 Outbreaks of Lungworm and Professional and Para-Professional Involvement on Dairy Farms Including Herd Health Planning**

As highlighted in past studies, outbreaks of lungworm have continued to rise over the last thirty years and particularly in the past two grazing seasons, affecting both adult dairy cows and milking heifers. Bought-in cattle, unvaccinated animals and those with limited pasture larval exposure lack immunity and are vulnerable. Gaining some immunity to lungworm in early rearing, either by vaccination (gold standard) or by allowing a trickle of exposure whilst using anthelmintics only when needed (Forbes, 2018) is critical.

Forbes would advocate undertaking faecal egg counts for roundworm and treating stock with egg counts exceeding 200 eggs per gram, monitoring weight gain and looking out for clinical signs such as scouring. However, for this to happen there needs to be some social engagement from all stakeholders, especially vets and SQP’s (Dobbs, 2022).

Lungworm is rarely diagnosed by a Vet in practice or diagnostic laboratory investigation centre (Van Der Burgt, 2022. Pers Comm. Mrs. G Van Der Burgt is the Veterinary Investigation Officer of APHA).

However, in recent years as farm planning has become more of a requirement (Red Tractor, 2020), it’s vital that parasite control is not overlooked, and not just a ‘tick box exercise. By engaging, over lungworm, vets, SQP’s and dairy farmers can all take a major step forward in controlling the parasite so the farmers are not caught out, prevention is better than cure (AHDB, 2022).

**5.7 Outbreaks of Lungworm and the Age of Animals that its Being Seen In and Immunity**

Traditionally lungworm was predominantly thought to affect youngstock and cattle in the south-west of England and the midlands, however, it is now well-established right across the UK (McLeonard, and Dijk, 2017), but remains more common in the west. Even though the overall prevalence of disease has increased, it has become a disease of adult cattle especially adult milking cows differing to the historical presentation of ‘coughing in young cattle in their first season at grass (McCarthy, 2020). Hypotheses for the changes include:

* Lack of quarantine protocols and biosecurity in replacement bought-in adult cows and milking heifers from various parts of Europe,
* A reduction in vaccine uptake
* Over-reliance on anthelmintics for roundworm control
* Changes in grazing management (Forbes, 2018) resulting in an immunity gap, with a substantial proportion of animals immunologically naïve, particularly adult replacements (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC).
* A considerable number of outbreaks in second year grazing heifers and freshly calved heifers probably from lack of exposure while young. Potentially through overuse of preventative anthelmintics, a poor uptake of the vaccine or that young dairy heifers are being housed a lot more than historically (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC).
* Animals are not gaining enough immunity (Van Der Burgt, 2022. Pers Comm. Mrs. G Van Der Burgt is the Veterinary Investigation Officer of APHA). The parasite is thriving more despite a large quantity of anthelmintic’s including long-acting being used through-out the grazing season. It’s now impacting growth rates of calves in their first grazing season and having a major impact on milk yield (Timothy, 2020).

**5.8 Farmers Driven by Growth Rates and Financial Gain**

Dairy heifers have to grow to the right weight at 14 to 15 months ready for serving, for farmers to calve them at 23 to 24 months of age (Boulton et al., 2017).

Just like with mastitis in dairy cows nearly all dairy farmers are motivated by growth rates and financial gain (Valeeva et al., 2007) (Boulton et al., 2017). This is even more important on farms with a block calving system as these farms cannot afford for animals to fall out of the block.

Anthelmintics are probably being overused as many farmers rely on wormers containing Ivermectin, Doramectin and Moxidectin to control both roundworms and lungworm (COWS, 2020).

Extra education and prescriber involvement will be needed to convince dairy farmers to vaccinate and undertake faecal egg counts for roundworm (and treat only when needed) but also to review their grazing management and use of anthelmintics at housing (Forbes, 2018).

**5.9 Long Term Damage and the Impact on the Business**

Dairy farmers are motivated by growth rates of their dairy youngstock, however, some of this is down to their drive for financial gain and their business model to succeed (Charlier et al., 2020).

A small number of cattle will die from post-patent bronchitis, and this will have immediate business impact with carcass disposal, labour costs and loss of a valuable replacement heifer. There are also treatment (and re-treatment) costs. The cost of a replacement heifer ranges from approximately £500 for a young animal around 6 months of age through to a milking heifer/cow at around £2,000 (Bland, 2022. Pers Comm. Mrs E. Bland is a Farm Vet of Lanes Vets).

In addition, there can be major chronic damage to numerous heifers, and it can take months for animals to return to normality. Furthermore, participating dairy farmers feel that some heifers never recover and even six months later remain thin, are susceptible to other diseases (potentially immunosuppressed), and may have to be culled (McCarthy 2020).

It costs approximately £1500 to rear the animal to the age of 24 months (AHDB, 2022) so replacement cost is significant. Fertility will also be impacted and very often repeat services are required to get heifers and cows back in-calf (Boulton et al, 2017). There is also a belief from dairy farmers that milk quality and quantity from an animal following lungworm infection is poorer later in life, resulting in impaired fertility and longevity (Devries and Marcondes, 2020).

**5.10 Barriers to Vaccination, Restrictions to Implementation**

All stakeholders recognised that routine vaccination in their youngstock would help prevent lungworm, but when asked if they would be willing to use the vaccine there were common barriers. Barriers included six common themes,

1. The cost of the vaccine, vs the cost of wormers,
2. The disadvantage of it being a 2-dose vaccine compared to a BVD vaccine like Bovela that’s single shot (Noah Compendium, 2022),
3. Dose timing impacts turn out time
4. The lungworm vaccination is administered orally, this also poses handling system requirements (Grandin, 1997), especially as the vaccine is in glass bottles,
5. Extra labour is needed.
6. Production challenges impacting time of administration

***Cost*** The cost of the two-dose primary course of the vaccine varies from £10 to £12 depending on practices and location (Howe, 2022. Pers Comm. Mr R. Howe is a Vet of LLM). Most farmers feel that the initial cost of Huskvac is expensive compared to other vaccines, however those currently vaccinating felt it was money well spent.

***Difference*** Every stakeholder opined on the low price of wormers like Ivermectin pour-ons compared to the cost of the vaccine. This frustrates most Vets, who feel this must change otherwise it will always be a struggle to implement the lungworm vaccine on farm.

Whilst participating dairy farmers all agreed that wormers were ridiculously cheap some even mention ‘’pennies’’ and as a result often dismissed the vaccine because of this aspect.

However, as anthelmintic resistance has become a major problem in the sheep sector in recent years (SCOPS, 2022) there is concern that this will also become a problem in cattle in future years (COWS, 2020). Consequently, emphasis must shift towards cost effective growth rates from grass and the opportunity for development of trickle immunity via exposure to larvae on pasture (University of Glasgow, 2018).

Presently many farmers feel they can blanket treat youngstock all season with anthelmintics for less than a quarter of the price than the vaccine cost. Pleasingly, the industry is starting to change, and industry groups such as COWS are pushing for both SQP’s and Vets to advise farmers to implement regular faecal worm egg counts for roundworms throughout the grazing season.

Supermarket milk contracts are also driving best practice and influencing farmers to act, reduce their anthelmintic usage and consider vaccinating their youngstock for lungworm. Vaccination education will be needed as vaccinal oral immunisation is the only real insurance policy available (Cresswell et al., 2013).

Supermarket milk contracts will continue to strongly advocate vaccinating youngstock. (Atkinson, 2022. Pers Comm. Mr O. Atkinson is a Dairy Consulting Vet of Dairy Veterinary Consulting LTD).

***Two-doses and Turn-out:***

Farmers perceive two doses as a barrier to vaccination with increased time and labour cost. However, the real issue is the restriction on turn-out times in Spring. Vaccination fits well for autumn block calving herds, as these calves are old enough to have the vaccine for example in January and February and then be turned out depending on the weather in March (Forbes, 2018). However, this also depends on whether the vaccine is produced on time, as interview data suggests it is not always available in January, due to manufacturing challenges related to the live contents, production timescale and short shelf life (Baxter-Smith, 2022. Pers Comm. Dr K. Baxter-Smith is the Veterinary Advisor of MSD Animal Health).

In Spring block calving herds, the animals are often less than 8 weeks old by May and farmers will want to turn them out soonest as stocking rates are now generally high on most dairy farms, and this can lead to other pressure and diseases particularly when housed (Fujiwara et al., 2020)

These calves are often not given the vaccine because they are out at grass before they are old enough for vaccination. The second dose is especially problematic as roundworm treatments overlap. Generally, vaccinating herds will often vaccinate these-spring born animals before their second-year grazing season (Rickard Ballweber, 2022).

**5.11 Administration and Handling**

All felt that orally drenching cattle is challenging work and time consuming particularly in older animals (Grandin 1997). This probably explains why bought-in naïve adult cows and milking heifers are not even being considered for vaccination (Hayes et al., 2021). Some farms do not have a crush with a head yoke for drenching cattle easily (COWS, 2020) Huskvac presents in glass bottles, which are easily broken or can injure an animal or operator (One health).

Vets, feel there may be some benefit in pharmaceutical companies bringing out another rival lungworm vaccine after extra research and development (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC).

A common theme is apparent, that a lot of dairy heifers are not being vaccinated, with many being housed until they are confirmed pregnant at around 16 months of age when vaccination is no longer a viable option (Ridler et al., 2009).

**5.12 Anthelmintic Treatment**

Treatment options for lungworm are mainly based on anthelmintics, however supportive treatment by non-steroidal anti-inflammatory and antibiotics may be advised by a Vet (APHA, 2021).

As the vast amount of anthelmintics are purchased from an SQP not linked with a Vet practice, there is a benefit for any SQP to contact the dairy farmers Vet when advising and prescribing an anthelmintic for an outbreak just in case an anti-inflammatory and or an antibiotic is needed (APHA, 2021).

It is crucial to understand what anthelmintic practices are employed in relation to lungworm on dairy farms, and what drives these actions (Clay et al., 2019).

Principally, all the groups of anthelmintics are licenced against adult lungworm, so a myriad of choices exist with numerous brand names clouding the issue. Further complexity centres on the route of administration, whether it be by injection, pour-on, oral bolus or drench formulation. Only certain products will treat the L4 stage of lungworm. Furthermore, there are products that have a persistent duration of activity against infection or re-infection of *D. viviparus,* such as Dectomax Pour-On containing doramectin (Noah Compendium, 2022).

Interview data suggests that either Ivermectin Pour-On’s or Doramectin Pour-On’s are the usual choices within two months of calving. The injectable formulations of these active ingredients are also widely used.

Farmers favour inexpensive but effective Ivermectin or long acting moxidectin injection. Oxfendazole oral boluses are also being used on farm to control lungworm, particularly on land away from the farm, which is often rented with poor handling facilities. Poor handling facilities along with other psychological barriers that include one health such as personal injury can also influence dairy farmers decisions (Brennan et al., 2016).

However, it also emerged that Levamisole oral drench has worked well for many years now and is quite commonly used when treating a group of young animals that are showing clinical signs (Matthews, 2008).

It is highly desirable that advisors such as Vets and SQP’s have a good understanding of all the products available to them for the control of lungworm and just as important is tailoring their advice to the individual farm (Forbes, 2018).

Eprinomectin is commonly used when there is an outbreak of lungworm in a milking herd, because of its zero milk-withhold. The topical pour-on solutions are most popular; however, an injectable formulation is available which used to be POM-VPS. However, reclassification as a POM-V offers Vets the chance to become involved. It has a significantly longer meat withdrawal (63 days) compared to the eprinomectin pour-on’s which range from 10 to 15 days, and the persistent activity is also lower than the pour-on’s, all this must be taken into account (Noah Compendium, 2022).

**5.13 Grazing Management and Climate Change and Diagnosis**

All parties agreed, as previously discussed, that climate and seasonal changes were playing a role in the evolution of lungworm epidemiology. Both practicing Vets and allied Vets working in Veterinary investigation centres and laboratories, acknowledged that they were only seeing the worst cases. Inevitably many cases go unreported, and farmers will employ multiple treatments to save their stock (Mason, 2022. Pers Comm. Mr C. Mason is the Veterinary Centre Manger of SRUC).

In the past with traditional grazing patterns, most young animals would have experienced some sort of exposure to lungworm but these days many are denied that opportunity (Shortall, 2022). Today those that remain naïve risk facing a massive challenge at some point, and this will result in serious clinical disease (McLeonard and Dijk, 2017).

Modern farming practices evolved to be more profitable for other good commercial reasons invite the downside of reduced larval exposure and alternative commercial losses (Hawkins et al., 2020).

**5.14 Farmer Motivation - Supermarket Milk Contracts Drive for Change Including Sustainability, Environment and Dung Beetles**

Dairy farmers interviewed felt that there are more principal factors to think about than the environment, and although most want to be sustainable, the environment comes down the list. Practicing and allied Vets took more of a concerned approach. However, dairy farmers may be open to change regarding anthelmintic resistance and can see the benefit in knowing their wormers are working (Forbes, 2018).

Following recent education by engaged Vets and SQP’s and the ever-increasing milk contract pressures on necessary usage and rotation of chemical groups used, vaccinating for lungworm remains the route of choice (Arla, 2018).

Dairy farmers fundamentally understand the need for change and an increasing percentage can now see the unforeseen consequences of mass preventative use of the macrocylic lactone (3-ML) group on critical tunnelling dung beetles (Sands and Wall, 2016). Past studies show Ivermectin treated dung reduces ryegrass growth by 18% (Sands and Wall, 2016), so dairy farmers must begin to understand the real benefits that the dung beetle offers.

Gold standard is heading towards using the lungworm vaccine plus the oxfendazole bolus on youngstock or undertaking regular faecal egg counts which then inform treatment when needed (Baxter-Smith, 2021).

**6.0 Conclusion**

There is an increasing concern that lungworm disease is rising in prevalence with management becoming more challenging.

The industry is seeing farm more outbreaks of lungworm in adult dairy cows and two-year-old dairy heifers once they have joined the milking herd. Immunity and lack of exposure plays an important role. It is that youngstock are exposed to a trickle of lungworm from an early age, so that immunity can start to develop when animals are young.

Dairy farmers financial motivation and a need for their youngstock to grow without any parasitic check, has led to an overuse of anthelmintics to control both roundworm and lungworm. However effective knowledge transfer and advice from increasingly well-educated advisors, has meant that more farmers understand the basis of lungworm disease and its prevention and control. This process must continue, especially regarding the implementation of herd health plans. Therefore, vets and SQP’s may well need extra education to familiarise themselves with the parasite and the products available to control lungworm.

In the Research Hypothesis, the researcher felt that vets and paraprofessionals might consider that lungworm is underdiscussed. This can be more apparent with vets due to their potential lack of involvement on farm. Dairy farmers often say that they are adequately educated on Lungworm. The author was surprised about this, as many of them remark that, with the increased importance of lungworm, more information would be beneficial. Unfortunately, the farmers vets were often reluctant to discuss the issue in depth.

Vaccination programmes are an important element in a comprehensive well-planned herd health control strategy and lungworm is entirely preventable by proper use of the Bovilis Huskvac vaccination regime. Vaccination will also potentially reduce the need to use as much precious anthelmintic. Alongside faecal egg counting for roundworm and regular stock weighing, all these measures should reduce the development of further anthelmintic resistance in helminth populations.

During the last three decades the epidemiology of lungworm in the UK would appear to have changed. Increased prevalence is an emerging scenario, possibly due to a lack of herd/animal immunity. Vaccination sales have stayed relatively stable over recent years, so there is probably a lower than optimal uptake of the lungworm vaccine. Management practices, including grazing and housing have also changed significantly, with youngstock being housed a lot more than they once were. It is more usual for them to graze at pasture for only a few months of the year, with the same trend seen in the milking portion of the herd. Some herds in the UK are now housing permanently or zero graze. Hence the now common usage of the term ‘’immunity gap.’’ Heifers are often ill prepared immunologically upon entering the main herd. So, with cattle having less parasitic exposure, when they do come under heavy challenge, there can be widespread morbidity and significant mortality.

Moreover, there is the effect of an ever-increasing movement of replacement animals to consider. This is a national and European trend and only serves to increase the introduction of potentially naïve milking dairy heifers and adult cows into UK herds, with the obvious implications for the balance of herd immunity.

Quarantine and biosecurity protocols, as outlined in Red Tractor and herd health plans may lack full implementation. Consequently, even low levels of existing challenge can cause an outbreak. Vaccination is often not practiced when incoming stock join the existing herd.

Lungworm vaccination uptake continues to face certain barriers. The scarcity and quality of on-farm labour for cattle handling, two-dose regime and price continue to feature. The commercial sensitivity is key, as frequent reference is made to the cost differential between anthelmintics and the vaccine. These attitudes can result in the perfect storm of low immunity, high challenge, over-used anthelmintics and resultant serious losses.

Increased pressure from supermarket milk contracts for environmental and resistance reasons may eventually reduce anthelmintic usage in favour of more considered management and vaccine usage.

**Recommendations**

The study shows that the quality of advice varies from practice to practice and even within each practice. Whilst farmers might talk to the SQP more, is the advice given good enough by these SQP’s? This study shows this is questionable.

The researcher would recommend extra education on parasitology for both qualified and unqualified Vets and SQP’s. More CPD on lungworm and the role of immunity to be added in the future to avoid “Husk” becoming a headline disease like BVD.

A joined-up parasitological approach by both Vets and SQP’s in the herd health plan is key.

Currently there is substantial evidence of lungworm advice falling in the gap between vets and SQP’s. Both channels could be encouraged to engage a lot more.

Regarding quarantine and biosecurity, our dairy farmers need to pay rigid attention to where they source their cattle. This applies to all potential disease ingress, not just lungworm.

An influx of milking cows/heifers from any source is a signal to follow strict biosecurity guidelines but especially when buying from naïve herds in the UK or especially other European countries. The researcher would recommend more engagement between, vets and dairy farmers when replacement stock are brought onto farm.

More farmer awareness on sustainability.

The human populations perception of farming is changing, people want to know how the food that they are eating, or drinking is produced.

Mass prophylactic treatment of groups of animals with long acting anthelmintics must change. This is often the main driver of resistance in parasitic worm populations. Continuing such practices will ultimately create long term welfare problems in the future.

I would recommend that pharmaceutical companies and stakeholders such as Vets and SQP’s alongside groups such as BVA and AHDA consider how to manage the retail price of some very affordable pour-on and injectable anthelmintics, particularly ones with the active ingredient, Ivermectin.

References

Aiello, S. and Mays, A. 2010. *The Merck veterinary manual*. In:Whitehouse Station, N.J. Merck & Co. in cooperation with Merial Limited. pp.1309

Agriculture and Horticulture Development Board. 2022. *Calf to calving*. [online]. AHDB. Available from: https://ahdb.org.uk/knowledge-library/calf-to-calving [Accessed 1 July 2022].

Agriculture and Horticulture Development Board. 2022. *Medicine use in livestock: Health planning*. [online]. AHDB. Available from: https://ahdb.org.uk/knowledge-library/medicine-livestock-health-planning [Accessed 18 July 2022].

Agriculture and Horticulture Development Board. 2022. *UK and EU cow numbers.* [online]. AHDB. Available from: https://ahdb.org.uk/dairy/uk-and-eu-cow-numbers [Accessed 1 July 2022].

APHA (Animal and Plant Health Agency). 2021.*Disease Surveillance Monthly Reports*. [online]. UK Government. Available from: http://apha.defra.gov.uk/documents/surveillance/diseases/Lungworm%20information%20note.pdf [Accessed 19 June 2022].

Archer, S. 2021. *An observational study of growth rate and body weight variance partition for United Kingdom dairy calves from birth to 20 weeks of age*. *JDS Communications*. 2(5), pp.248-252.

Arla. 2018. *New farming standards model to bring sustainable change to dairy farming*. [online]. Arla Foods UK. Available from: https://www.arlafoods.co.uk/overview/news--press/2018/pressrelease/arla-foods-uk-unveils-new-farming-standards-model-to-bring-sustainable-change-to-dairy-farming-2764879/ [Accessed 1 July 2022].

Atkinson, O. 2010. *The role of the vet in knowledge transfer in the dairy industry*. [online]. Nuffield Farming Scholarships Trusts. Available from: https://www.nuffieldscholar.org/sites/default/files/reports/2009\_UK\_Owen-Atkinson\_The-Role-Of-The-Vet-In-Knowledge-Transfer-In-The-Dairy-Industry.pdf [Accessed 18 July 2022].

Bard, A. Main, D. Roe, E. Haase, A. Whay, H. and Reyher, K. 2019. *To change or not to change? Veterinarian and farmer perceptions of relational factors influencing the enactment of veterinary advice on dairy farms in the United Kingdom.* Journal of Dairy Science, 102(11), pp.10379-10394.

Barkema, H. von Keyserlingk, M. Kastelic, J. Lam, T. Luby, C. Roy, J. LeBlanc, S. Keefe, G. and Kelton, D. 2015. *Invited review: Changes in the dairy industry affecting dairy cattle health and welfare*. Journal of Dairy Science, 98(11), pp.7426-7445.

Baxter-Smith, K. and Simpson, R. 2020. *Insights into UK farmers' attitudes towards cattle youngstock rearing and disease. Livestock.* MAG Online Library*.*25(6), pp.274-281.

Baxter-smith, K. 2021. *Act now to prevent lungworm ahead of turnout, vet says.* [online]. Farmers Guide. Available from: https://www.farmersguide.co.uk/act-now-to-prevent-lungworm-ahead-of-turnout-vet-says/ [Accessed 15 June 2022].

Bennett, R. and IJpelaar, J. 2005. *Updated Estimates of the Costs Associated with Thirty-Four Endemic Livestock Diseases in Great Britain*. Journal of Agricultural Economics, 56(1), pp.135-144.

Best, C. Pyatt, A. Roden, J. Behnke, M. and Phillips, K. 2021. *Sheep farmers’ attitudes towards lameness control: Qualitative exploration of factors affecting adoption of the lameness Five-Point Plan. PLOS ONE*. 16(2), pp.0246798.

Beynon, S. Wainwright, W. and Christie, M. 2015. *The application of an ecosystem services framework to estimate the economic value of dung beetles to the U.K.* cattle industry. Ecological Entomology. 40, pp.124-135.

Borsberry, S. 2012. *Impact of Lungworm on Cattle Health and Future Production*. [online]. Vet Times. Available from: https://www.vettimes.co.uk/article/impact-of-lungworm-on-cattle-health-and-future-production/ [Accessed 17 June 2022].

Boulton, A. Rushton, J. and Wathes, D. 2017. *An empirical analysis of the cost of rearing dairy heifers from birth to first calving and the time taken to repay these costs*. Cambridge University Press. 11(8), pp.1372-1380.

Braun, V. and Clarke, V. 2006. *Using thematic analysis in psychology*. Qualitative Research in Psychology, 3(2), pp.77-101.

Brennan, M. Wright, N. Wapenaar, W. Jarratt, S. Hobson-West, P. Richens, I. Kaler, J. Buchanan, H. Huxley, J. and O’Connor, H. 2016. *Exploring Attitudes and Beliefs towards Implementing Cattle Disease Prevention and Control Measures: A Qualitative Study with Dairy Farmers in Great Britain. Animals,* 6(10), pp.61.

British Cattle Veterinary Association. 2022. *Parasiticides*. [online]. BCVA. Available from: https://www.bcva.org.uk/system/files/basic\_page\_files/220428%20BCVA%20Policy%20Parasiticides%20Updated%20April%202022%20FINAL%20APPROVED%20SW.pdf [Accessed 1 July 2022].

Charlier, J. De Waele, V. Ducheyne, E. van der Voort, M. Vande Velde, F. and Claerebout, E. 2015. *Decision making on helminths in cattle: diagnostics, economics and human behavior.* Irish Veterinary Journal. 69(1).

Charlier, J. Rinaldi, L. Musella, V. Ploeger, H. Chartier, C. Vineer, H. Hinney, B. von Samson-Himmelstjerna, G. Băcescu, B. Mickiewicz, M. Mateus, T. Martinez-Valladares, M. Quealy, S. Azaizeh, H. Sekovska, B. Akkari, H, Petkevicius, S. Hektoen, L. Höglund, J. Morgan, E. Bartley, D. and Claerebout, E. 2020. *Initial assessment of the economic burden of major parasitic helminth infections to the ruminant livestock industry in Europe*. Preventive Veterinary Medicine. 182, pp.105103.

Crawshaw, W. and Smith, J. 2003. *Dictyocaulosis in housed five- to eight-month-old dairy-bred calves*. Veterinary Record. 153(5), pp.149-150.

Cresswell, L. Richens, I. Archer, S. Breen, J. Huxley, J. Randall, L. Remnant, J. Wapenaar, W. Biggs, A. Kerby, M. and Statham, J. 2013. *Veterinary vaccination advice and perceived farmer compliance on UK dairy farms*. Livestock. 18(5), pp.166-174.

COWS, 2020. *Integrated parasite control on cattleman’s farms*. [online]. Cattleparasites. Available from: https://www.cattleparasites.org.uk/app/uploads/2018/04/Integrated-parasite-control-on-cattle-farms.pdf [Accessed 1 July 2022].

Clay, N. Garnett, T. and Lorimer, J. 2019. *Dairy intensification: Drivers, impacts and alternatives*. Ambio. 49(1), pp.35-48.

Damory, 2021. *Farm*. [online]. Damory Vets. Available From: https://www.damoryvets.co.uk/Damory\_Farm.html [Accessed 1 July 2022].

De Vries, A. and Marcondes, M. 2020. Review: *Overview of factors affecting productive lifespan of dairy cows.* National Center for Biotechnology Information .14, pp. s155-s164.

Dobbs, M. 2022. *The changing role of vets on farm*. [online]. MSD Animal Health. Available From: https://www.msd-animal-health-hub.co.uk/dairy-vets [Accessed 19 June 2022].

Dorso, L. Rouault, M. Barbotin, C. Chartier, C. and Assié, S. 2021. *Infectious Bovine Respiratory Diseases in Adult Cattle*: An Extensive Necropsic and Etiological Study. National Centre for Biotechnology Information. 11(8), pp.2280.

Down, P. Bradley, A. Breen, J. Hudson, C. and Green, M. 2016. *Current management practices and interventions prioritised as part of a nationwide mastitis control plan*. Veterinary Record. 178(18), pp.449-449.

Elsheikha, H. 2017. *Endoparasites in cattle: studies and diagnostics*. [online]. Vet Times. Available From: https://www.vettimes.co.uk/article/endoparasites-in-cattle-studies-and-diagnostics/ [Accessed 1 July 2022].

Enticott, G. Donaldson, A. Lowe, P. Power, M. Proctor, A. and Wilkinson, K. 2011*. The changing role of veterinary expertise in the food chain*. Philosophical Transactions of the Royal Society B: Biological Sciences. 366(1573), pp.1955-1965.

Etikan, I. Musa, S. and Alkassim, R. 2016. *Comparison of Convenience Sampling and Purposive Sampling*. American Journal of Theoretical and Applied Statistics, 5(1), pp.1.

Eysker, M. Claessens, E. Lam, T. Moons, M. and Pijpers, A. 1994. *The prevalence of patent lungworm infections in herd of dairy cows in the Netherlands.* Veterinary Parasitology. 53(3-4), pp.263-267.

Forbes, A. 2018. *Lungworm in cattle: epidemiology, pathology and immunobiolo*gy. UK Vet Livestock. 23(2), pp.59-66.

Forbes, A. 2018. *Lungworm in cattle: treatment and control*. UK Vet Livestock. 23(3), pp.102-106.

Fujiwara, M. Haskell, M. Macrae, A. and Rutherford, K. 2020. *Impact of Maternal High Stocking Density during the Dry Period on Dairy Calf Health, Behaviour, and Welfare*., National Centre for Biotechnology Information .10(6), p.922.

Grandin, T. 1997. *The design and construction of facilities for handling cattle*. Livestock Production Science. 49(2), pp.103-119.

Hayes, C. McAloon, C. Kelly, E. Carty, C. Ryan, E. Mee, J. and O'Grady, L. 2021. *The effect of dairy heifer pre-breeding growth rate on first lactation milk yield in spring-calving, pasture-based herds.* National Centre for Biotechnology Information. 15(3), p.100169.

Hawkins, A, Burdine, K. Amaral-Phillips, D. and Costa, J. 2020. *Effects of Housing System on Dairy Heifer Replacement Cost From Birth to Calving: Evaluating Costs of Confinement, Dry-Lot, and Pasture-Based Systems and Their Impact on Total Rearing Investment*.

Farm Health. 2018.  *Animal Health and Welfare Knowledge Hub Dictyocaulus viviparus*. [online]. Farm Health Online. Available From: https://www.farmhealthonline.com/US/disease-management/cattle-diseases/dictyocaulus-viviparus/ [Accessed 1 July 2022].

HSE ( Health and Safety Executive). 2012.*Handling and Housing Cattle*.[online].UK Government. Available from: https://www.hse.gov.uk/pubns/ais35.pdf [Accessed 18 July 2022].

Henriksen, S. and Pilegaard-Andersen, C. 1979. *Dictyocaulus viviparus in Denmark. A survey of 15 years diagnostic examination of faeces samples*. Nord Vet Med. 11, pp.455-461.

Holzhauer, M. Van Schaik, G. Saatkamp, H. and Ploeger, H. 2011. *Journal of the British veterinary Association*. Veterinary Record, 169(19), p.P494

Holzhauer, M. van Schaik, G. Saatkamp, H. and Ploeger, H. 2011. *Lungworm outbreaks in adult dairy cows: estimating economic losses and lessons to be learned*. Veterinary Record. 169(19), pp.494-494.

Howarth, B. and van Winden, S. 2021. *Changing Veterinary Attitudes towards Delivering Biosecurity Advice to Beef Farmers.* National Centre for Biotechnology Information. 11(7), pp.1969.

Kaler, J. and Green, L. 2013. *Sheep farmer opinions on the current and future role of veterinarians in flock health management on sheep farms.* A qualitative study. Preventive Veterinary Medicine, 112(3-4), pp.370-377.

Kelleher, A. Good, B. de Waal, T. and Keane, O. 2020. *Anthelmintic resistance among gastrointestinal nematodes of cattle on dairy calf to beef farms in Ireland*. Irish Veterinary Journal, 73(1).

Klewer, A. Forbes, A. Schnieder, T. and Strube, C. 2012. *A survey on Dictyocaulus viviparus antibodies in bulk milk of dairy herds in Northern Germany*. Preventive Veterinary Medicine. 103(2-3), pp.243-245.

Lloyd, C. 2017. *Proceedings of the British Society of Animal Science*. Cambridge University Press. pp.140.

Lurier, T. Delignette-Muller, M. Rannou, B. Strube, C. Arcangioli, M. and Bourgoin, G. 2018*. Diagnosis of bovine dictyocaulosis by bronchoalveolar lavage technique: A comparative study using a Bayesian approach.* Preventive Veterinary Medicine. 154, pp.124-131.

Main, D. Leach, K. Barker, Z. Sedgwick, A. Maggs, C. Bell, N. and Whay, H. 2012. *Evaluating an intervention to reduce lameness in dairy cattle*. Journal of Dairy Science. 95(6), pp.2946-2954.

Matthews, J, 2008. *Clinical Forum: Bovine lungworm*. National Centre for Biotechnology Information. 13(6), pp.23-30.

Maunsell, F. and Donovan, G. 2008. Biosecurity and Risk Management for Dairy Replacements. *Veterinary Clinics of North America:* Food Animal Practice. 24(1), pp.155-190.

McCarthy, C. 2020. *Spatiotemporal trends in cattle lungworm disease (Dictyocaulus viviparus) in Great Britain from 1975 to 2014*. [online]. British Veterinary Association. Available From: https://bvajournals.onlinelibrary.wiley.com/doi/epdf/10.1136/vr.105509 [Accessed 12 January 2022].

McCarthy, C. Höglund, J, Christley, R. Juremalm, M. Kozlova, I. Smith, R. and van Dijk, J. 2019. *A novel pooled milk test strategy for the herd level diagnosis of* Dictyocaulus viviparus. Veterinary Parasitology. 276, pp.100008.

McLeonard, C. and Dijk, J. 2017. *Controlling lungworm disease (husk) in dairy cattle*. British Veterinary Association in Practice. 39(9), pp.408-419.

MSD. 2022. *Lungworm - MSD Animal Health Republic of Ireland*. [online]. MSD Animal Health. Available From: https://www.msd-animal-health.ie/species/cattle/lungworm/ [Accessed 15 June 2022].

MSD, 2020. *Key points for effective vaccine use*. [online]. MSD Animal Health. Available from: Http://www.msd-Animal-health-hub.co.uk/DNOMF/ProjectLANB/Tools [Accessed 24 June 2022].

MSD, 2021.*Managing Lungworm* [online]. MSD Animal Health. Available from: https://www.farmacy.co.uk/userfiles/file/managing-lungworm-during-periods-of-limited-vaccine.pdf [Accessed 19 June 2022].

MSD, 2021. *Maximising a herd health plan positively and effectively.* [online]. MSD Animal Health. Available from: https://www.msd-animal-health-hub.co.uk/dairy-herd-health-plan [Accessed 19 June 2022].

NADIS. 2022. *Lungworm in Cattle*. [online]. National Animal Disease Information Service. Available from: https://clients.nadis.org.uk/planner-articles/lungworm-in-cattle/ [Accessed 10 July 2022].

NOAH. 2022. [online]. Noahcompendium.co.uk. Available From: https://www.noahcompendium.co.uk/ [Accessed 1 July 2022].

O'Keeffe, J. Buytaert, W. Mijic, A. Brozović, N. and Sinha, R. 2016. *The use of semi-structured interviews for the characterisation of farmer irrigation practices.* Hydrology and Earth System Sciences. 20(5), pp.1911-1924.

Østerås, O. Solbu, H. Refsdal, A. Roalkvam, T. Filseth, O. and Minsaas, A. 2007. *Results and Evaluation of Thirty Years of Health Recordings in the Norwegian Dairy Cattle Population*. Journal of Dairy Science. 90(9), pp.4483-4497.

Ozols, E. 2022. *Dairy Heifer Calf Growth Rate Monitoring.* [online]. Westpoint Farm Vets. Available from: https://www.westpointfarmvets.co.uk/dairy-heifer-calf-growth-rate-monitoring/ [Accessed 19 June 2022].

Paton, N. 2015. *Controlling BVD & Johnes*. [online]. Meat promotion Wales. Available from: https://meatpromotion.wales/images/resources/Johnes\_English.pdf [Accessed 1 July 2022].

Pyatt, A. Walley, K. Wright, G. and Bleach, E. 2020. *Co-Produced Care in Veterinary Services: A Qualitative Study of UK Stakeholders’ Perspectives*. Veterinary Sciences. 7(4), pp.149.

Red Tractor. 2020. Dairy Herd Health Plan. [online]. Red Tractor Assurance. Available from: https://redtractorassurance.org.uk/wp-content/uploads/2021/07/Dairy-Herd-Health-Plan.pdf [Accessed 1 July 2022].

Rickard Ballweber, L. 2022. *Lungworm Infection in Animals - Respiratory System*. [online]. MSD Veterinary Manual. Available from: https://www.merckvetmanual.com/respiratory-system/lungworm-infection/lungworm-infection-in-animals [Accessed 17 June 2022].

Ridler, B. Broster, W. and Foot, A. 2009. *The growth rate of heifers in a dairy herd*. The Journal of Agricultural Science, 61(1), pp.1-8.

Rodriguez, J. Molnar, J. Fazio, R. Sydnor, E. and Lowe, M. 2008. *Barriers to adoption of sustainable agriculture practices: Change agent perspectives. Renewable Agriculture and Food Systems.* Cambridge University Press. 24(1), pp.60-71.

Rose, D. Keating, C. and Morris, C. 2018. *Understand how to influence farmers' decision-making behavior*. [online] Agriculture and Horticulture Development Board. Available from: https://ahdb.org.uk/knowledge-library/understand-how-to-influence-farmers-decision-making-behaviour [Accessed 23 July 2022].

Saatkamp, H. Eysker, M. and Verhoeff, J. 1994. *Study on the causes of outbreaks of lungworm disease on commercial dairy farms in the Netherlands*. Veterinary Parasitology. 53(3-4), pp.253-261.

Sands, B. and Wall, R. 2016. *Dung beetles reduce livestock gastrointestinal parasite availability on pasture*. Journal of Applied Ecology. 54(4), pp.1180-1189.

Saunders, B. Sim, J. Kingstone, T. Baker, S. Waterfield, J. Bartlam, B. Burroughs, H. and Jinks, C. 2017. *Saturation in qualitative research: exploring its conceptualization and operationalization*. Quality &amp; Quantity, 52(4), pp.1893-1907.

Schunn, A. Conraths, F. Staubach, C. Fröhlich, A. Forbes, A. Schnieder, T. and Strube, C. 2013. *Lungworm Infections in German Dairy Cattle Herds*. PLOS ONE. 8(9), pp.e74429.

SCOPS, 2022.  *Sustainable Control of Parasites in Sheep*. [online]. SCOPS. Available from: https://www.scops.org.uk/index.php [Accessed 1 July 2022].

Selman, I Wiseman, A. Breeze, R. and Pirie, H. 1977. *Differential diagnosis of pulmonary disease in adult cattle in Britian*. The Bovine Practioner. pp.63-74.

Shortall, O. 2022.Cows eat grass don’t they? Results of a social science project on the role of grass based and indoor systems ion the UK dairy sector [online]. The James Hutton Institute. Available from: https://www.hutton.ac.uk/webfm\_send/780 [Accessed 18 July 2022].

Small, R. 2022. *Vaccinate calves against lungworm before turnout*. [online]. The Cattle Site. Available from: https://thecattlesite.com/news/58083/vaccinate-calves-against-lungworm-before-turnout/ [Accessed 19 June 2022].

Scotland’s Rural University College. 2022. *Lungworm alert*. [online]. SRUC. Available from: https://www.sruc.ac.uk/veterinary-surveillance-blog/lungworm-alert/ [Accessed 24 June 2022].

Statham, J. Hewitt, S. and Armstrong, D. 2021. *Beef diseases directory*. [online]. AHDB. Available from: https://ahdb.org.uk/knowledge-library/beef-diseases-directory [Accessed 17 June 2022].

Svensson, C. Lind, N. Reyher, K. Bard, A. and Emanuelson, U. 2019. *Trust, feasibility, and priorities influence Swedish dairy farmers' adherence and nonadherence to veterinary advice*. Journal of Dairy Science. 102(11), pp.10360-10368.

Szelewa, D. and Polakowski, M. 2022. *European solidarity and “free movement of labour” during the pandemic: exposing the contradictions amid east–west migration*. Comparative European Politics. 20(2), pp.238-256.

Taylor, M. 2010. *Worms in cattle: Sustainable control plan*. [online]. ADHB. Available from: https://ahdb.org.uk/knowledge-library/worms-cattle-sustainable-control-plan [Accessed 17 June 2022].

Timothy, S. 2020. *Five tips for lungworm control*. [online]. Beat The Parasites. Available from: https://www.beattheparasites.com/blog/five-tips-for-lungworm-control [Accessed 24 June 2022].

Tong, A. Sainsbury, P. and Craig, J. 2007. *Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups*. International Journal for Quality in Health Care, 19(6), pp.349-357.

Tremetsberger, L. Leeb, C. and Winckler, C. 2015. *Animal health and welfare planning improves udder health and cleanliness but not leg health in Austrian dairy herds*. Journal of Dairy Science. 98(10), pp.6801-6811.

University Of Glasgow, 2018*.Lungworm in cattle : Treatment and Control*. [online]. University Of Glasgow. Available from: http://eprints.gla.ac.uk/162547/1/162547.pdf [Access sed 24 June 2022].

Vaarst, M. Nissen, T. Østergaard, S. Klaas, I. Bennedsgaard, T. and Christensen, J. 2007. *Danish Stable Schools for Experiential Common Learning in Groups of Organic Dairy Farmers*.

Valeeva, N. Lam, T. and Hogeveen, H. 2007. *Motivation of Dairy Farmers to Improve Mastitis Management*. Journal of Dairy Science. 90(9), pp.4466-4477.

Van Dijk, J. 2004. *The Epidemiology and Control of Dictyocaulosis in Cattle*. Cattle Practice, 12, pp.133-143.

Van der Leek, M, 2015*. Beyond traditional dairy veterinary services: ‘It’s not just about the cows!’.* Journal of the South African Veterinary Association. 86(1).

Veterinary Defence Society, 2021. *History*. [online]. The Veterinary Defence Society. Available from: https://www.thevds.co.uk/history [Accessed 19 June 2022].

Vercruysse, J. Hilderson, H. and Claerebout, E. 1995. *Effect of chemoprophylaxis with ivermectin’s on the immune response to gastrointestinal nematodes in first-season grazing calves*. Veterinary Parasitology. 58(1-2), pp.35-48.

Urquhart, C. 2013. *SAGE Research Methods - Grounded Theory for Qualitative Research*: A Practical Guide. [online]. Methods.sagepub.com. Available from: https://methods.sagepub.com/book/grounded-theory-for-qualitative-research [Accessed 23 July 2022].

**Appendices**

**Appendix 1: Plain Language Statement**



**Plain Language Statement**

1. **Introduction to the Research Study**
* The research working title is **Analysing stakeholders’ perceptions of *Dictycaulus viviparus*: An exploration of attitudes towards lungworm and understanding of effective, sustainable control in dairy cattle**
* The research is being conducted by Mark Pass, a Veterinary Pharmacy MSc student at Harper Adams University.
* Mark Pass can be contacted at 05382900@live.harper.ac.uk
1. **Invitation paragraph**

Following a personal telephone call, you are being invited to take part in a research study. Before you decide it is vital for you to understand why the research is being undertaken and what it will entail. I advise you to take some time to read all the information on this sheet very carefully, and discuss with your colleagues if you feel its necessary. Please feel free to ask me if there is anything you are unsure of or if you would like more information on a specific topic. Please take your time to consider if you wish to take part.

In advance thank you for reading this.

1. **What is the purpose of the study?**

This project seeks to investigate how those who are involved in raising and keeping dairy cattle view lungworm, controlling lungworm and what effects it might have. Stakeholders include ‘’dairy farmers and their current understanding of lungworm on their farm’’ and how they perceive the risk from *D. viviparus*. Other stakeholders include vets in practice and their attitudes towards lungworm control.

The aim of the study is to also analyse the epidemiology of lungworm (history of the infection)?

Combining this information, the overall aim is to investigate why lungworm outbreaks have risen annually over the last three decades and whether there is any pattern demographically between outbreaks and factors such as stakeholders’ opinions, climate and control techniques. Furthermore, to understand why outbreaks of lungworm are becoming a lot more common in adult dairy cattle.

Your experience as a UK dairy farmer, vet in practice or a member of staff from UK Veterinary Investigation Centre or laboratories is very important to helping us address our research questions and also important for UK bovine health and welfare too.

1. **Why have I been chosen?**

You have been chosen to be part of this interview process due to your knowledge and experience while also being a contact or an acquaintance that the researcher has made within the animal health industry working as an R-SQP (animal medicines advisor) for the Willows Vet Group.

1. **Do I have to take part?**

It is your personal choice to decide if you wish to take part or not. If you should decide to participate, you are still free to withdraw at any time and without giving a reason.

If you refuse to take part or withdraw from the research after it has been started, this will not jeopardise any professional relationship you have with the researcher in any way.

1. **What will happen to me if I take part?**
* Participants will be required to be available for a face-to-face interview. However, however, if there are any Covid-19 lockdown restrictions local or national then interviews will take place virtually either by Microsoft Teams or Zoom.
* You will be asked a range of initial and follow up questions, and we are especially interested in your thoughts, opinions, knowledge and experience’s towards controlling lungworm in cattle.
* The Interview will take approximately 30 minutes.
* The Interview will be audio recorded to allow the researcher to collect data that will be used and put into transcripts and analysed. Only the transcriptor will hear the audio before it is put into writing.
* Interviews will take place during late winter and the spring of 2022.
1. **Will my taking part in this study be kept confidential?**
* All information which is obtained from yourself throughout the course of the research will be kept strictly confidential. All data collected will be anonymised such as the first dairy farmer that’s interviewed will become DF1 within the study. The first vet for example will become V1 and any other stakeholders interviewed will be identified as S1. All information will have your name and address removed so that you cannot be recognised from it and no one will hear your voice.
* Any data obtained will be analysed solely by the researcher.
* All data will be stored on a password university protected laptop, in accordance with UK data protection legislation and will only be accessible by the researcher and used when needed and then the data deleted by the researcher once the study is completed.
1. **What will happen to the results of the research study?**
* All the data obtained and the results from the research will be published as part of the MSc Veterinary Pharmacy research project and may at a later date be published in a veterinary journal.
* The MSc Veterinary Pharmacy research project is to be published in July 2022.
* Your name or address will not appear in any publication.
* All data collected from each interview will be destroyed within three years from the initial date of collection.
1. **Who has reviewed the study?**

The Harper Adams Ethics committee has reviewed the project.

1. **Please Contact for Further information**

 Mark Pass

05382900@live.harper.ac.uk

**Appendix 2: Interview Consent Form**



**Interview Consent Form**

Analysing stakeholders, perceptions of *Dictyocaulus viviparus*:

An exploration of attitudes towards lungworm and understanding of effective, sustainable control in dairy cattle

**Researcher:** Mark Pass

**Interview Participant:**

Thank you for agreeing to be interviewed as part of this research project about stakeholder’s perceptions towards lungworm control in cattle. This project seeks to explore why lungworm outbreaks have risen annually over the last three decades and whether there is any pattern demographically between outbreaks and factors such as stakeholders’ opinions, climate and control techniques. Furthermore, to understand why outbreaks of lungworm are becoming a lot more common in adult dairy cattle.

Your, knowledge and experience as a stakeholder within the animal health industry is very important to helping us address our research questions and also vital for bovine health and welfare.

This consent form is required for the research team to make sure that you understand the reason for your involvement, while also giving you the freedom to ask any questions that you feel are necessary.

Please see below specific points on the research project and regarding consent:

* The interviews will usually take approximately 30 minutes in duration.
* The interviews will hopefully be a face-to-face. However, if there are any Covid-19 lockdown restrictions local or national then interviews will take place virtually either by Microsoft Teams or Zoom.
* You will be asked a range of initial and follow up questions, and we are especially interested in your thoughts, opinions, knowledge and experience’s towards controlling lungworm in cattle.
* As a participant you will have the chance to ask any questions which you may have about the project.
* The Interview will be audio recorded to allow the researcher to collect data that will be used and put into transcripts and analysed.
* All information which is obtained from yourself throughout the course of the research will be kept strictly confidential. All data collected will be anonymised, and your name and address will not occur in any publication.
* You give consent for the researcher to use any of the anonymised quotes in the researcher’s thesis and any other research publications which come from the research.
* All data will be stored confidentially on a password university protected laptop, in accordance with UK data protection legislation and will only be accessible by the researcher and used when needed and then the data deleted by the researcher once the study is completed.
* If at any time you wish to retract your consent and data, please contact the researcher, within seven days of the interview taking place.

If you would like any more information, please don’t hesitate to contact the researcher directly.

I give my consent to participate in the above study.

Name:

Organisation:

Signature:

Date:

**Appendix 3: Interview Questions for Stakeholders**



**Questions for dairy farmers: DF**

|  |  |
| --- | --- |
| **Initial question** | **Follow up questions** |
| How are issues of *Dictyocaulus viviparus* (Lungworm) control understood and discussed within the farming community? | How do you perceive the risk from *D. viviparus* on your farm?If not, why not? |
| Did you see an outbreak of lungworm last year? | If so, what age group of animals did you see lungworm in? and at what time of year did you see it? |
| Which animals were affected? Was it first year grazing animals, pregnant dairy heifers or adult cows? | Did you have any deaths associated with lungworm?Were they confirmed by post mortem or was it suspected? |
| What clinical signs do you think lungworm causes? | Would you and your staff be able to spot the signs? |
| How are *D. viviparus* impacts, both economic and welfare, understood by key stakeholders? Such as dairy farmers, vets, SQP’s and other stakeholders like vet allied practitioners | How does lungworm impact your business? |
| What are the practices of anthelmintic employed (in relation to *D. viviparus*) on dairy farms and what drives these practices? | How do you control lungworm on your farm?What strategy do you use to control lungworm, would you usually use short acting wormers such as oral drenches, long-acting wormers, pour-on, injection or boluses? Vaccination? Combination of worming and vaccination? or nothing?What are the barriers to implementing parasite control strategies? |
| What levels of awareness do farmers and other stakeholders, have of the issues of anthelmintic over-use, stewardship and resistance? | What are your views on anthelmintic resistance?Are you worried about the impact some anthelmintics have on the environment? |
| How does stakeholder advice and understanding (particularly Veterinary and or RAMA) influence the key decision pathways of dairy farmers? | Who would you get your advice from regarding the control of lungworm? |
| Understanding farmers grazing management, have they changed this dramatically over the last few years?  | Would your animals go out to contaminated ‘high risk’ pasture or would they go out on to clean grazing? |
| What secondary health issues are you seeing in your cattle after associated lungworm disease, as the weakening of the immune system also allows secondary bacterial infections | What could the cost of a lungworm outbreak be on a farmer’s herd?Initial costs?Longer term costs?Hidden costs?After a dairy heifer as recovered from lungworm, are growth rates impacted? Would a dairy heifer still make her serving and calving dates? |
| Both anthelmintic and antibiotic resistance are hot topics of discussion presently, are farmers using more of these because of an outbreak of lungworm? | What are your thoughts on preventative anthelmintics for lungworm and their current rate of use?Are there still too many preventative anthelmintics being used to control lungworm, rather than farmers looking at their grazing patterns and the environment?Are you using a long-acting anthelmintic to control lungworm? If so, which product? |
| Are farmers vaccinating with Bovilis Huskvac? | If not why not, what are the barriers? |

**Questions for vets, and SQP’s (where applicable):**

|  |  |
| --- | --- |
| **Initial question** | **Follow up questions** |
| How are issues of *Dictyocaulus viviparus* (Lungworm) control understood and discussed within the farming community? | How do you feel that farmers and SQP’s perceive the risk of lungworm?What is your knowledge of the lungworm parasite?What would your product knowledge be like on anthelmintics that control lungworm?Would you get involved in lungworm control on your dairy client’s farms? If so what percentage of farms?Has there been too much reliance on preventative wormers? |
| How many farms under the care of your practice had an outbreak or cases of lungworm last year? | What age group of dairy animals did you see lungworm in?Was is it first year grazing animals, pregnant dairy heifers or adult cows? |
| How are *D. viviparus* impacts, both economic and welfare, understood by key stakeholders? | What economic and welfare impact does lungworm have on your farms? |
| What are the practices of anthelmintic employed (in relation to *D. viviparus*) on dairy farms and what drives these practices? | Would you get involved in controlling lungworm on farms under the care of your practice.Would you have a discussion with your clients over the appropriate use of anthelmintics? Taking into account gutworm control, incorporating vaccination and also grazing management. |
| What levels of awareness do farmers and other stakeholders, have of the issues of anthelmintic over-use, stewardship and resistance? | Would you have regular conversations with your clients about anthelmintic resistance? And the impact that some anthelmintics have on the environment?Are milk buyers contract requirements taken into account? |
| How does stakeholder advice and understanding (particularly veterinary and or RAMA) influence the key decision pathways of dairy farmers? | What is the perceived direction of travel in relation to control, treatment and prevention of *D. viviparus* among vets? |
| Would you get involved in parasite planning on your farms under your care? | What is your opinion on anthelmintic resistance?Do you have contact with RSQP’s (RAMA) when a treatment to control lungworm is prescribed? |
| How many of your dairy clients are vaccinating with Bovilis Huskvac? | What do you believe are the barriers to lungworm vaccination on farms under your care? |
| Why do you believe we are seeing cases of lungworm rising annually in the UK? | Outbreaks of lungworm in adult dairy cattle are becoming more common, what are your thoughts on this? |

**Questions for other stakeholders (Vet, working in VI centres and laboratories): OS**

|  |  |
| --- | --- |
| **Initial question** | **Follow up questions** |
| How are issues of *Dictyocaulus viviparus* (Lungworm) control understood and discussed within the farming community? | How do you feel that farmers, vets and SQP’s perceive the risk of lungworm? |
| Over the last three decades the epidemiology of lungworm in the UK has changed, why do you believe lungworm outbreaks have rapidly increased since 1990?  | How significant issue do you think it is? |
| How many cases of lungworm using postmortem data have you seen in recent years? | Have you seen an increase in cases year on year? |
| In your opinion, do you feel vets and farmers are familiar with the diagnostics that are available to them, such as the Baermann Larvae in faeces technique, ELISA, Haematology and Postmortem examination. | What patterns have you seen regards to the uptake of diagnostics in recent years? |
| Traditionally, lungworm disease was most often diagnosed in the south west and the midlands, is this still the case? | Which area’s/counties have been ‘hotspots’ for lungworm disease in recent years? |
| How are *D. viviparus* impacts, both economic and welfare, understood by key stakeholders? | What would the economic losses be in a severe lungworm outbreak in growing dairy cattle? And adult dairy cattle? |
| Outbreaks of lungworm in adult dairy cattle are becoming more common in recent years, what do believe is the reason for this? | Have you seen more outbreaks in adult dairy cattle in the last decade compared to the previous decade? |
| Would you receive cases from dairy farms that have a good level of lungworm control in place and or farms that have poorly controlled strategies? | Can you describe your typical interaction over lungworm cases with both vets and farmers? |
| Despite a good vaccine having been available for many years now, and no resistance of lungworm to any of the frequently used anthelmintics officially been reported, why does lungworm disease remain a serious threat to animal welfare? | What level of reliance has there been on preventative wormers? What changes would you recommend? |