A report investigating how to reduce the impact of gastrointestinal nematodes and their resistance to anthelmintic treatments in sheep production

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Research compiled in New Zealand

Hybu Cig Cymru
Meat Promotion Wales

Contents

This report focuses on my scholarship study tour of New Zealand which investigated how to reduce the impact of gastrointestinal nematodes and their resistance to anthelmintic treatments in sheep production. The scholarship was funded by Hybu Cig Cymru (HCC) who annually supports scholars to travel abroad and study a topic of interest to them and of relevance to the red meat industry in Wales.

About me

I am a fourth generation farmer from Pontypridd, a small historic market town at the gateway to the South Wales Valleys. The farm consists of approximately 100ha and runs both sheep and beef enterprises with great emphasis placed on quality. The sheep enterprise consists of 500 Suffolk X Glamorgan Welsh ewes put to Charollais X Texel rams. The aim of the enterprise is to produce a quality lamb carcase of R or above with efficiency measured on a days to slaughter basis. The beef enterprise is Charolais X steers overwintered and sold as outlying stores in the spring.

After completing my A Levels I studied a HND in Agriculture whilst working on the farm. I then progressed to Aberystwyth University gaining a Bsc Hons in Agriculture with Business studies 2:1. After completing my studies I returned home to the farm to put theory into practice.

Introduction

The ability of worms to resist treatment is one of the most serious problems confronting sheep production around the world. Resistance is a genetic trait that allows worms to survive treatment and form the basis for future generations to become resistant. Resistance becomes a problem on farms when genes build up in a worm population to a level that treatment is no longer effective.

Resistance has been found in most countries especially those with a large national sheep flock. The problem is widespread in New Zealand (NZ) and poses a significant threat to the productivity and sustainability of its sheep industry. Internal parasites are still the most important animal health problem in the NZ industry. The industry has been reliant on drenches for the last 35 years.

New Zealand farmers have adopted strategic worming strategies and techniques to delay the development and transmission of resistant worms. Two of the main strategies for slowing the development of resistance are the use of drenches that contain a combination of more than one active ingredient and the practice of retaining worms in refugia (susceptible to treatment). Once the parasite population on a farm becomes resistant then this resistance is permanent.

The incidence of anthelmintic resistance is increasing in Wales. Fortunately, the situation is less serious. Gastrointestinal nematode infections alone cost the UK sheep industry £65 million per annum.

New Zealand Agriculture

Agriculture is very important economically to New Zealand. The New Zealand red meat sector is worth NZ$8 billion in export earnings, with over 90% of sheep meat exported. New Zealand is the largest lamb exporter in the World. The largest market is the European Union, which imports 51% of New Zealand's sheep-meat.

The domestic sheep population has halved over the last 20 years to 32 million in 2012 with breeding ewe numbers at 20.61 million and hoggets at 10.26 million. Declining sheep numbers has not impacted on lamb production which remains relatively constant.

The farms I visited had between 4,000 and 38,000 ewes. Romneys and their crosses are the dominant breed because of their maternal and easy care characteristics.

Other breeds include Perendale, Corriedale, Coopworth, Highlander, Primera, Merino, Lincoln, Southdown, Suffolk, Texel and Cheviots.

Romney X Texel Ram hoggets

Roundworms (Nematodes)

Roundworms (nematodes) are the most economically important internal parasites of sheep in New Zealand and the major animal health problem on NZ farms, the most important species being Nematodirus, Trichostrongylus, Haemonchus, Ostertagia and Cooperia. Internal parasites cost the sheep industry approximately NZ$300m annually in lost production and drench use. Parasite resistance to drenches costs an estimated additional NZ$20m per year and this is predicted to rise to NZ$60m per year by 2022. FEC (faecal egg counts) are the most commonly used diagnostic aid to measure parasite status of animals.

Important gastro-intestinal roundworms of sheep in New Zealand and their common location

Abomasum	Haemonchus contortus Ostertagia circumcinta (telodorsagia circumcinta) Ostertagia trifurcata Trichostrongylus axei
Small intestine	Trichostrongylus vitrinus Trichostrongylus colubriformis Cooperia curticei Nematodirus spathiger* Nematodirus filicollis*

*mainly in lambs

There are 5 major groups of chemicals.

- Benzimidazoles and probenzimidazoles (BZ - white)
- Levamisole (LV - yellow)
- Macrocyclic Lactones (ML - clear)
- Monepantel (AD - orange)
- Derquantel (SI - purple)

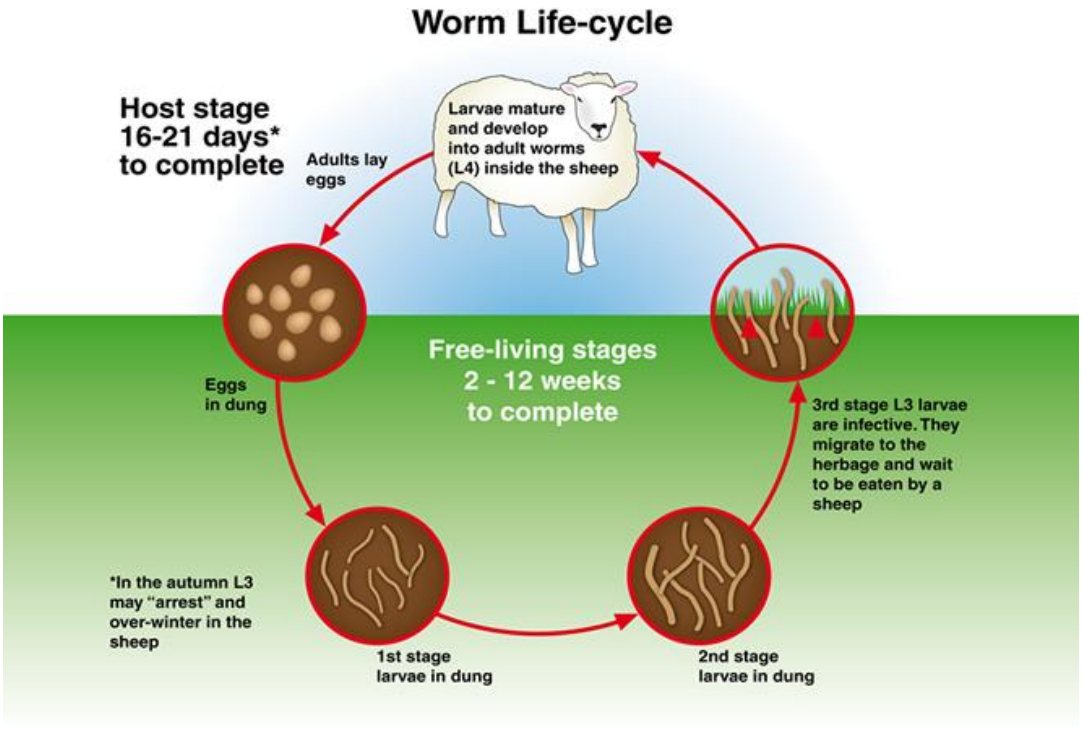
Nematodirus

Nematodirus affects young lambs so therefore has great economic importance to Welsh farmers. It has a different life-cycle (14 days) to other worms and under certain climatic conditions, can strike very quickly.

The main difference in the life cycle compared with other parasitic worms, is that development takes place within the egg and infection passes from one lamb crop to the next year’s crop. Before they can hatch, the eggs have to undergo a period of cold weather followed by warmer temperatures of 10 degrees or more. If these conditions occur over a short period of time, triggering a mass hatch, and it coincides

with the time when lambs are starting to take in significant amounts of grass, the result can be devastating.

Current advice is to treat with a BZ group 1 white drench, regardless of the resistance status of your farm to this group. However in 2011, Nematodirus resistance has been reported in the UK, in New Zealand a BZ is not suitable or widely used for treatment due to Nematodirus being very fecundate and being able to mutate quickly. It is also misunderstood in the UK that BZ's are the only group effective against Nematodirus. In addition, a FEC count should be used 7-10days after the lambs were treated to check that the treatment has been fully effective.



Worms can produce either a clinical or sub-clinical (no obvious symptoms) disease in lambs. Loss of production can vary in both cases and if the challenge is severe enough, death is inevitable. Even low numbers of larvae on pastures (<200 larvae/kg of fresh herbage) can result in reductions in live weight gain. The effects include a reduced appetite, changes in mineral metabolism, reduced muscle mass and diarrhoea. Frequent drenching is needed every 3 - 4 weeks to prevent the establishment of mature adult worm populations and suppresses egg production for 19-21 days. Current oral anthelmintics have little if any residual effect after a few days. The lamb is therefore open to challenge from infective pasture very early on after treatment. However, treatment does not remove previous damage caused by

the parasite larvae between drenching. Considerable damage can be done to the host by the immature larvae during development stages within the animal. Frequent drenching also accelerates parasite resistance especially when the same chemical group is routinely used. Improving worm control must understand the importance of the level of larval challenge, its effect on the efficiency of anthelmintic treatment and on subsequent production. It is also well documented that adult ewes relax their immunity around lambing, allowing an increase in the number of parasitic eggs returned to pasture.

For the last 25 years we have had only three available classes of broad-spectrum drenches – the Benzimidazoles, the Levamisoles and the Macrocyclic Lactones. Since all members of each action-family kill worms by attacking the same target site, when resistance develops to one active within a class this places resistance to all other members of that group. By the time you see a drench resistance problem it will have placed a high cost on productivity. Resistance can be expected to increase rapidly with significant ill-thrift and deaths appearing as if from no-where, thus regular testing for drench resistance is an important part of the management process.

Full and partial drench resistance is now confirmed in NZ to all three of the older drench families individually and also to all three families simultaneously. Combinations of the above drench families are widely available and used routinely. These combination products are not licenced for use in the UK, thus are not available. While there have only been a minority cases of multiple resistance to drenches recorded in New Zealand, it is widely accepted that the use of a combination product can delay the onset of resistance.

Alternative methods of parasite control should, where possible, be incorporated into control programmes. The less reliance there is on anthelmintic treatments as the sole method of worm control, the longer these drugs will be available for use by the sheep industry. Sustainable methods are the key to longevity. Non-chemical control strategies including the use of vaccines, naturally resistant animals and other biological controls are currently being investigated.

There maybe some quite large differences in effectiveness against some parasites between members within each of the three families, especially within the MLs, but modes of action will remain the same. This is important to know, particularly when assessing the effectiveness of drenches.

In April 2009, New Zealand experienced the global launch of a new (fourth) family of anthelmintic drenches with the release of Monepantel (Zolvix). The fifth family of anthelmintic Derquantel (Startect) has come onto the market recently in New Zealand as a combination.

Quarantine treatment

Drenching all sheep coming onto your farm with a quarantine treatment is the single most important part of any flock health plan, treating with a chemical that has no known resistance and is 99.9% effective such as Monepantel (Zolvix) or Derquantel (Startect). This stops the possibility of importing drench resistant worms on to your farm which could otherwise have a detrimental impact on efficacy of other chemical groups. Ideally all livestock should be isolated and treated prior to arrival at the destination including stock returning from external grazing, however if this is not possible should then be isolated on concrete and treated. Livestock should then be held for a short period and placed in a holding area for at least 7-10 days. Resistance can be introduced by stray stock, maintaining boundary fences and gates in order to keep strays out is also vital in ensuring that resistance is not introduced.

Faecal egg counting (FEC)

Faecal egg counts (FEC) are widely used throughout New Zealand as a diagnostic tool, however the technology does have its limitations and can sometimes be inaccurate. There is a need for a more reliable predictive tool. FEC Samples from groups of animals in the same flock can vary from 0 to 1000 eggs per gram (epg), therefore caution should be taken when interpreting results. FEC, in spite of its limitations, can be used as a guide and management aid to support decision making with other information to help establish the need or not for treatment, as parasites do not fit the calendar especially with changing weather patterns. This test does provide some valuable information; it has the ability to show that lambs with a high epg have already been compromised with lower growth rates – “Damage is done, when they are over the tongue”. It is useful in identifying groups of high egg shedding animals thus modifying grazing management to avoid vulnerable animals on highly contaminated fields. The FECPAK system is going back towards a semi protective rather than a preventive approach.

Drench resistance testing

It is vital to know whether the worms in a farm's sheep flock are resistant to any of the available drench groups and also to decide which chemicals are likely to be the most effective. If resistance is present but unrecognised there is a risk that drenching will be less than fully effective.

Monitoring drench efficacy by undertaking a drench resistance test can be undertaken by competent individuals who have experience of FEC or a veterinary surgeon. Faecal samples are taken 10-14 days after drenching and checked for parasite eggs. If the drench is effective there should be no eggs (or very few) present until 19-21 days after treatment depending on the type of worm and its life cycle.

Immunity

As a sheep ages its natural immunity develops as a result of exposure to parasites. A lamb can develop a valuable immunity as a result of constant and very small doses of larvae from pasture. It is difficult to try and regulate levels of larval intake in the field without adversely affecting production. Some lambs have the ability to maintain good growth rates and have minimal dags when exposed to roundworm challenge, despite reduced use of drenches. Breeding sheep that can resist infection is one way that sheep farmers can limit their use of drenches. Such sheep develop a high level of immunity to nematode infection and therefore have low faecal worm egg counts (FEC). Another breeding strategy may be to select for sheep that maintain adequate productivity under worm challenge, despite reduced drenching frequency. This trait is called resilience. Some resilient lambs are also resistant to infection with worms, but not all are. Those that are resilient but have high FEC are said to be tolerant of worm infection. Research has indicated that lambs with low FEC do not always perform better than lambs with high FEC and lambs which perform well when left undrenched do not always have low FEC.

Breeding animals that are less reliant on anthelmintic treatments for maintaining health and productivity is one option to manage the growing anthelmintic resistance problem in NZ, and to meet consumer demands for less drug usage in livestock.

Achieving low levels of infective larvae on pastures by relying almost exclusively on anthelmintic treatment of stock can result in high selection pressure for resistance. The issue is complicated by the fact that when numbers of larvae on pasture are low, anthelmintic treatment of animals results in higher selection pressures than when levels of pasture contamination are high. Serious consideration of breeding for such factors in NZ only became clear after recognition that heavy reliance on anthelmintic use for worm control in livestock could not be sustained much longer, due to the growing anthelmintic-resistance problem and consumer demands to reduce chemical residues in meat.

Breeding for resistance - an alternative method to control roundworms

One option to combat production losses caused by roundworms is to improve the genetics of the flock, through selecting animals that show natural host resistance. Host resistance is the ability of a sheep to successfully resist the establishment of roundworm infection and interrupt the life cycle. Resistance is estimated using faecal egg counts (FEC) with lower values indicating greater resistance. Some animals and breeds have a greater natural resistance to disease challenge. Breed selection based on these animals should decrease disease severity and incidence, though progress is very much dependent on the trait's heritability. The immune response through breeding sheep for their own resistance has a negative impact on growth rates and productivity due to their low threshold for immune response. There is a slight benefit in breeding for resistance with slightly greater fertility.

At present parasite resistance selection is based mainly on differences in faecal egg count over time. However, if a genetic marker can be found, this could speed up the selection process considerably; however this method isn't one that would be adopted at grass roots level due to the current inability to identify a gene or genes that affect resistance and its cost implications. FEC testing and blood testing to identify animals with natural resistance are available.

Resistant sheep deposit fewer eggs onto the pasture reducing pasture contamination. This has long term financial and production benefits to all the animals in the flock, not just those depositing fewer eggs. It is estimated that eggs shed onto pasture will decrease by 4% per year under a selection programme for both production and resistance traits. However, trends suggest selecting for increased resistance causes lower production. Both resistance and production can be improved at the same time by using a selection index.

Since 1994, selection on the basis of both resistance and production traits has been available to commercial ram breeders through the WormFEC™ service. Currently, about 15,000 sheep are evaluated annually through WormFEC™.

Breeding for Resilience

Resilience is only moderately heritable (approximately 30%), nevertheless there may be long term benefits for farmers if they select for resilience.

New Zealand farmers have moved from breeding for resistant ewes to breeding for resilience. The main reason for this is that resistant ewes/lambs often put a considerable amount of their energy into an immune response, resulting in reduced growth and poorer performance. Therefore the approach they now take is to extend the timing between when they would normally treat and not keep the last lambs for breeding. Lambs are drenched at weaning (12 weeks of age) and placed in groups of light, medium and heavy weights, this offers the ability to administer the right amount of treatment more accurately in a tighter weight range. Poor condition lambs (10-20%) are separated and drenched every 3 weeks. Every time they take a cull, they weigh and look at figures per sire to see if they want to use that sire next year. Undrenched lambs for breeding have been found to have 80% of the growth of drenched lambs with the aim of indirectly selecting for both resistance and resilience traits. Lambs that are unable to maintain growth under this regime are culled.

Resilient ram lambs perform better under limited drenching; the progeny of those rams selected for resilience need fewer drench treatments than their non-resilient counterparts. Lambs from resilient rams have significantly less dags and higher weight gains under challenge compared with the lambs from the resistant or susceptible rams. Resilience however, does not necessarily reduce FEC levels.

Resilient sheep have higher dry matter intakes and higher growth rates while resistant sheep keep away from dung and have reduced dry matter intakes.

I visited Robert Peacock a South Canterbury sheep and beef farmer who individually worm tested all ram hoggets for resistance to worms while also selecting for resilience following the SIL (Sheep Improvement Ltd) protocol, the only stud of any breed in the South Island to be doing this. The ewes (including 2ths) have not been drenched for 20 years, either at mating time or even pre or post lambing to reduce pressure on drench resistance developing.

Selecting for both resilience and resistance

FEC levels, and the resulting pasture contamination levels, won't necessarily decrease in a flock when it is selected for resilience. On the flipside, if lambs are selected purely for resistance (i.e. low FEC), some will be poor performers in terms of productivity but this might be counteracted to some extent by a reduction in pasture contamination. Therefore selecting for both resilience and resistance is practiced. A susceptible sire line may shed 1000epg/day verses a resistant sire line at 250epg in the same environment. That may translate to 2 million eggs (susceptible) verses 500,000 eggs produced from the resistant sire line.

What does this mean for farmers?

A reduction of up to one drench per lamb per 4-5 sheep generations can be achieved through breeding for resilience using traditional methods, The strategy used most widely involves selecting lambs for high productivity and low FEC when left undrenched for limited periods. This approach can be applied with the use of technology that is already available in Wales, using EID technology. Breeding for resilience is not enough to manage the drench resistance problem in the short term. Heritability for resilience is low from one generation to the next and depends on how severe the worm challenge was, the more severe, the higher heritability. Date of birth; age of dam and birth rank all significantly affect resilience, largely because of their influence on weaning weight. Selecting for individual lambs which do well when left undrenched may cause a bias towards lambs that are simply well grown at weaning. This in turn would work against twins and late born lambs which tend to be lighter at weaning, regardless of their genetic merit.

Murray Rohloff, Ram Breeder, Southland

When Murray first included FEC in the breeding index, in the space of two years he successfully introduced internal parasite resistance into his flock and in the later years reduced FEC in adult ewes by 60%. He maintains that others could also do this just as rapidly. FEC is now about 20% of the index. He culls severely against dags and scouring and does not believe inclusion of FEC in the index compromises production in any way, so is probably selecting for both parasite resistance and

resilience. He has found that his drench usage has declined over the years and now uses only 3 drenches in the lifetime of the sheep, and has done so for several years now. Murray feels there is huge potential in the sheep industry to use this approach much more widely than it is currently being used. Additional benefits over and above the productivity gains are lower use of chemicals and implied residue problems.

Problems Associated With Assessing Resilience

The method to assess resilience, i.e. measurement of growth rate in lambs while subjected to roundworm challenge, relative to their growth rate while not subjected to challenge, is generally considered to be impractical to implement under field conditions. An indication of resilience could be determined by exposing lambs to severe roundworm challenge for prolonged periods and identifying those least affected, but in practice, this option is unacceptable on animal welfare and economic grounds in commercial flocks. Reducing the duration and/or severity of worm challenge is likely to introduce another problem between an animal's genetic potential for growth and its ability to withstand worm challenge.

In an attempt to overcome these problems, NZ studies on the genetics for resilience, used a "drench-on-demand" procedure, administering anthelmintic to selected individuals only as deemed necessary on the basis of body weight change or visual assessment of body condition. This approach allowed the most resilient lambs to be subjected to prolonged periods of moderate to high challenge without treatment, but avoided seriously jeopardizing the health of the least resilient lambs. The resilience trait(s) can be expressed in terms of drench requirements under challenge, which are considered useful in view of the ultimate breeding objective of reducing anthelmintic usage.

The characteristics of sire offspring indicate improved resilience were by a greater average age at first drench; fewer lambs drenched within a defined period and; lower average number of drench treatments administered by the end of the season. However, this selective drenching approach also has some major drawbacks from a practical point of view; frequent flock inspections are required to avoid the risk of serious infection in some animals and the fact that some animals receive more drench treatments than others can lead to difficulties in ranking animals for other production and/or parasite objectives.

Hybrid vigour

Hybrid vigour describes the superiority in performance of crossbred animals compared to their parents. Offspring have the ability to increase their resilience to roundworms as they are more able to maintain growth rates in sight of a worm challenge.

Nutrition

Optimal levels of nutrition are essential in combating parasitism and achieving good levels of production. When sheep receive a high plane of nutrition containing high amounts of protein in the various forms (DUP CP), this allows the animals to tolerate internal parasite infection, developing a good immune response. Nutrition greatly reduces production losses and mortality rates, since the establishment rate and egg output of the roundworms are reduced.

Good levels of feeding of pregnant and early lactating ewes, in particular multiple bearing ewes and poor conditioned ewes will help prevent the temporary breakdown in their immunity and the periparturient rise in faecal egg counts. This will result in lower levels of pasture contamination than otherwise would have been the case.

Many plant species, chicory, plantain and lotus, have been associated with reducing the impact of roundworms. This could be as a result of unfavourable larval environment or because of plant components such as tannins. However there is not a wide uptake due to their lower growth rates and shorter growing season in comparison to grass with slow spring growth, which could put pressure on available grass throughout the summer for lactating ewes and finishing lambs. They are practically useful when sown in mix with grass and clover mixtures; however sheep need time to adjust. These should be rotationally grazed allowing a period of about four weeks to allow recovery and regrowth, over-grazing should be avoided or the chicory crowns will become damaged in sward. New Zealand thistle control becomes a problem when using these alternative species, the only spray on the market currently targets both; therefore the uptake of these alternative species is greatly reduced.

Trace elements are essential in boosting appetite and the immune system in the presence of a worm challenge. A deficiency can cause growth to decline and immunity to decrease.

Integrated Grazing Management

One of the best ways to reduce stock exposure to worms, minimise their effect of stock health and reduce drench usage is by the integrated grazing of different stock classes. Sheep and cattle in general, are hosts to different parasite species and it is thought that they cannot establish in each other. Grazing cattle and sheep over the same pastures will reduce the worm challenge to both classes of stock.

This can be achieved by:

- Integrating different stock/age classes

The worst option for both worm control and drench resistance is to run lambs as a block with lots of drenching to keep them alive. This is highly selective for drench resistance.

- Create low-contamination pastures for lambs

Most of the worm population on any farm is located on the pasture in the form of eggs and larvae. There are significant production advantages from reducing the exposure of all stock to worm larvae and this can be done by utilizing low-contamination pasture. These can be created by management practices which allow for periods of nil grazing (so that worm larvae die off over time). For example,

• Cutting silage or hay

• Growing a break crop (swedes, turnips, barley)

• A long hot dry spell

• Grazing with an alternative class of stock for more than two months

Unfortunately on many farms there are limited opportunities for creating low-contamination pasture.

- Keeping drenching to the minimum required

For the last 25 years New Zealand farmers have tended to use drenching as almost their only worm control practice, this has resulted in widespread drench resistance.

Young stock are the most susceptible to worms and so routine drenching is necessary. Older stock drenching is generally not required unless poor body condition and a very high FEC is observed. Ewes that are being fed adequately and are in good condition are unlikely to show a production response to a drench. Drenching ewes at lambing and weaning can increase the risk of drench resistance. Therefore to increase production and reduce the risk of drench resistance limit treatment to only ewes with a low condition score. In contrast to this situation with

lambs, healthy adult sheep are generally able to handle a parasite challenge and should not require drenching. Lambing hoggets and 2-tooths fall somewhere in the middle – they are much more able to suppress worms than lambs but are less able than older ewes.

Minimising the drenching of adult sheep has two advantages;

Drenching adult sheep is more selective for drench resistance than drenching of lambs. If adult sheep can remain undrenched they can be used as a valuable source of susceptible parasites (worms in refugia). Avoiding the drenching of adult sheep may not always be possible; however adult sheep should only be drenched where there is a risk to their health and condition. The immunity of the ewe is compromised only around lambing time, so worms are able to establish and develop over this period. However immunity returns soon after lambing and the ewe is able to eject most of the established worms, to achieve this a readily available supply of quality feed is needed.

The drench input should be tailored to the level of pressure that the animals are under - for example lighter condition twinning ewe hoggets are far more likely to give a production response to a long acting product. Whereas an oral drench may be more cost effective and suitable for a single bearing ewe hogget in good condition - and also reduce the likelihood of drench resistance. Not treating all lambing hoggets in the group aids sustainability. Running some undrenched dry hoggets with the treated lambing ones is becoming a common practice in New Zealand.

In general it should not be necessary to drench lambs prior to weaning without checking the level of worm burden. Worm burdens acquired prior to early weaning are not normally significant enough to affect productivity. However in years of very bad weather over lactation, or when feed for the ewe is very short, lambs may be forced to eat more pasture at a younger age, so this can change. This will be detectable using FEC. Drenches to lambs, in particular, administered early after lambing are generally a waste of money and effort.

Young lambs are highly susceptible to infection and it takes about 9 months for them to develop the ability to resist infection. In general this means that lambs have the highest levels of infection, the highest egg counts and are the major contributors of pasture contamination.

It is important to realise that the routine drenching of young lambs in summer months is not necessarily about treating animals that need a drench, but is rather about preventing a worm problem from developing in the autumn. There has been a tendency on many New Zealand farms to try and space out the early lamb drenches (say to 5-6 weeks) when the farm is having a good year. However, this has in some cases resulted in serious worm challenge in the autumn/winter and so is not always a good idea – there are of course always exceptions, such as when lambs are grazing with cattle. Unless lambs are grazing over pastures with large numbers of alternative stock classes (e.g. cattle, mature ewes), the routine drenching of lambs at 28-30 day intervals should be strictly adhered to over the summer period. Lambs that are retained for breeding should be placed on a different treatment regime as this can lead to low immune ewes.

Combination Treatments

The best time to use a combination drench (in the UK combination drenches are not licensed, however non mineralised products can be used separately) is when the active ingredients in the combination are both highly effective against the parasite (i.e. before a parasite becomes resistant). Therefore combinations are continually used as a routine drench, rotating the different effective Combinations on an annual basis.

NZ Sheep farmers are encouraged to use drench products which contain combinations of effective actives against parasites and to ensure that they include appropriate refugia strategies as part of their parasite management programmes.

Studies conducted in New Zealand suggest that in the first year the reduction in FEC of the lambs averaged 93% for treatment with Ivermectin and 99% for treatment with the Ivermectin-Levamisole combination. Over the duration of the study the combination drench consistently gave a greater reduction in FEC than using Ivermectin alone.

Technique

Poor administration of oral drenches (into the mouth rather than over the back of the tongue) may stimulate oesophageal groove closure which can lead to the drug bypassing the rumen and thus reduce drug uptake and efficacy. The rate of movement of digesta and drug through the gastrointestinal tract can also influence drug uptake and efficacy. If possible withhold animals from feed for 24 hours prior to treatment and for 3 hours post treatment, particularly when using drenches in the

white drench (benzimadazole) family. Position the drench gun over the tongue and do not deliver the drug forcefully - try to avoid triggering the reflex which bypasses the rumen. This can cause under dosing which will speed up the onset of resistance.

Retaining a reservoir of susceptible worms (in refugia)

In theory if an animal is drenched and put onto 100% clean pasture, the only worms to evolve on that pasture would be those totally resistant to the drench used and therefore the next intake would be resistant worms. While greatly helping productivity the practice of drench & shift has now been implicated around the world as one of the most dangerous practices for rapidly selecting for resistance. The effectiveness of drenches is improved by the in refugia strategy of leaving a proportion of lambs untreated, with greater FEC reductions for groups with 10% of lambs untreated than those with all lambs treated.

The solution is to ensure that the population of worm larvae on the pasture (ie the next intake) has a predominant mix of worms susceptible to the drench. The resistant worm larvae are thus diluted on the pasture and will reproduce with the susceptible population therefore considerably slowing down the development of fully resistant worm populations.

How do we achieve this?

There are a number of practical approaches to ensuring the on-going presence of susceptible worms.

One is to graze undrenched adult sheep with drenched lambs.

Another approach is to drench lambs (and other weaned stock) only “on demand” as indicated by faecal egg count rather than using a 5 drench preventative programme and treating every 28 days. However it must be remembered that other worm control practices such as integrated grazing of sheep with cattle, or grazing of fodder crops will probably be necessary for this to be practical. A compromise approach for lambs in particular (depending on the farm situation and options available) is to give a planned 3-4 drench preventative programme and follow with a drench on demand approach. Farms with a higher proportion of sheep and fewer options for pasture grazing management are more likely to need more drenches in order to finish lambs.

The third approach is to leave a small percentage of animals untreated at each drench – this tends to suit operations with a high proportion of young stock. If a small number of these animals in the mob were left undrenched they would shed susceptible worm eggs onto the pasture, therefore having the desired diluting effect. This can significantly delay the development of resistance to that particular drench.

A drench which is 99.9% effective means leaving 1% of animals untreated will yield about a 10-fold dilution of resistant worms surviving the drench. BUT, if the drench used is only 95% effective then a massive 34% of animals needs to be left untreated in order to achieve the same level of dilution. This is a strong argument for knowing your drench resistance status.

Selection Pressure

Treatment with long acting drenches, remove most but not all of the parasite population in the host animals. Worms remaining generally possess some genetic resistance to the anthelmintic. After treatment, it takes approximately three weeks (the pre-patent period), in lambs, for new infections to establish and develop to potency. During this time, the resistant surviving worms are the only contributors to pasture contamination, thus, they have a reproductive advantage over susceptible genotypes for the duration of the prepatent period. In this way, each treatment increases the frequency of resistant genotypes in the overall parasite population.

The use of long acting anthelmintics causes the period of reproductive advantage of resistant worms that survive the anthelmintic treatment to be longer than that following the use of short acting oral anthelmintics. The longer resistant worms are able to pass eggs onto pasture in the absence of susceptible worms, the more they will contribute to the overall pool of infective larvae and non-susceptible subsequent generations of worms. The drug acts not only on worms present at the time of initial treatment, but continues to screen the parasite population for the total period of persistent activity, allowing only resistant worms to survive and develop, which can only mate with other resistant worms during that period. Drenching adult fully immune sheep, results in greater selection pressure for resistance than drenching lambs in which immunity has not yet fully developed. It is therefore important a regular FEC monitoring programme be set up to determine when to drench. This reduces the time and costs of drenching, and minimises selection for drench resistance.

Commercial Flocks in New Zealand

The ability of sheep to limit or tolerate the effects of roundworms, resulting in lower drench requirements, potentially involves both resistance and resilience. The main benefits derived from breeding for resistance (i.e. low FEC) in dual-purpose sheep are expected to be gained indirectly as a result of reduced pasture contamination, while the main benefits derived from breeding for resilience are likely to be gained through the improved ability of individuals to maintain health and productivity under challenge. Currently, it is generally agreed that the best breeding strategy to reduce anthelmintic usage under NZ conditions is to select for sheep that show an appropriate combination of both these traits.

While resilience appears to be a desirable trait, selective drenching is not currently recommended as a means of assessing it on commercial farms, due largely to the management complexities involved. Until genetic markers for resilience become available, the most sensible solution is for breeders to use a “selection index” which combines measures of FEC and production under limited roundworm challenge. Animals showing with low FEC but excessive dags should be avoided.

The most effective way in the future for farmers to identify sheep that are both resistant to roundworm infection and able to withstand the impact of roundworm challenge on productivity will undoubtedly be to use marker assisted selection (MAS) techniques. MAS will have several advantages over traditional selection procedures for breeding animals for low drench requirements. First, there will be no need to subject animals to prolonged roundworm challenge and so production costs associated with the test procedure will be avoided, as will costly and messy sampling procedures.

Furthermore, it will be possible to determine an animal’s genetic status at an early age. If the mode of inheritance is known, MAS will enable the problems associated with recessive or over-dominant genes under traditional selection procedures to be overcome. Unfortunately, the current costs of the technology make it likely that, at least initially, it will only be used by ram breeders selecting stud flock replacements.

The simplest and most economical way for most farmers wanting to incorporate genes for resistance and high productivity under challenge into their flocks is to buy rams from breeders who have appropriate performance recording systems in place and can demonstrate genetic improvements in these traits.

New Zealand abattoirs

I visited one abattoir in New Zealand which processed approximately 10,000 lambs a day and during peak season there were facilities to treble this output. The company being a large farmer owned co-operative, today representing more than 20,000 sheep, cattle and deer farmers throughout New Zealand. This company purchased over a million live lambs each year and placed them with finishers on a programme with a set protocol of management goals and objectives.

All animals are slaughtered to Halal specification as the Middle East makes up a large proportion of export trade. Most carcass weights are between 16kg-20kg. There is very little wastage, most of the carcass is used i.e white blood cells and pituitary gland all used for medical research. Payment at this abattoir was on weight and fat cover with no payment for conformation. However Video Image Analysis was being introduced in the near future. All carcases are labelled with the time of kill representing the batch and origin of each carcase this acts as this abattoirs traceability system. Carcases are electrically stimulated to improve eating quality and then sorted into weight and fat cover from the days kill for specific export markets. Some carcasses are exported whole these generally being the lighter carcases, however the majority are broken down into retail cuts. At the time of visit a new product was being launched in ready for retail packaging that was being trialled in Tesco UK supermarkets. As the carcasses go into the boning room an X-ray machine calculates where to divide into primals, the yield of each third is fed back to the farmer to make improvements if any. All primals and retail cuts are vacuum packed for freshness especially for export and labelled with the processors code.

Conclusion

Parasites develop resistance to drenches for a variety of reasons, but it is closely associated with prolonged and frequent use of any members of a single drench family. Resistant worms are those which remain unaffected following treatment. They continue to infect the animal, shed eggs into the environment and depress animal health and production.

It is critical that farmers take steps to delay or avoid resistance.

New drench groups on the market are extremely expensive and therefore able to be used in extreme circumstances only or for quarantine purposes. Resistance to white, yellow and clear drenches have been diagnosed both in New Zealand and Wales.

Now is the time for action. Various recommendations have been made to help delay resistance. These should be adopted by all farmers. Drench only when necessary. Use the most effective drenches, use the correct dose rates, avoid importing resistance, regularly test for drench resistance and implement other actions including grazing management and the use of in refugia population.

Remember, resistant worms do not disappear once resistance develops. There is no indication that worms become susceptible if drenching is discontinued.

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A report investigating how to reduce the impact of gastrointestinal nematodes and their resistance to anthelmintic treatments in sheep production