wormwise

national worm management strategy

HANDBOOK JULY 2019

Resource book 22

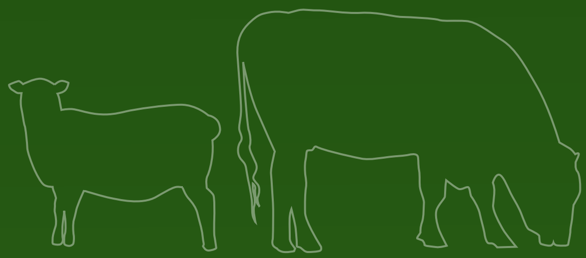
wormwise national worm management strategy

beef+lamb new zealand

Ministry for Primary Industries
Manatū Ahu Matua

AGCARM

NZVA
New Zealand Veterinary Association



What is Wormwise?

Farmers have identified the sustainable management of worms as one of the biggest challenges they currently face.

They have asked for a consistent message from those advising them on testing, drench selection, grazing management and genetic solutions to worm problems.

In May 2005, Beef + Lamb New Zealand (formerly Meat and Wool New Zealand) and MPI (formerly MAF) Sustainable Farming Fund initiated the development of a national worm management strategy, named Wormwise, involving all stakeholders. The strategy was completed and agreed by all stakeholders in December 2005.

In 2012 a new strategic plan was devised outlining the activities and actions for Wormwise to continue addressing.

In September 2014, Wormwise established a new website—wormwise.co.nz—to be the central repository of information pertaining to internal parasites.

As representatives of the Wormwise Implementation Group, Agcarm, New Zealand Veterinary Association, Ministry of Primary Industries and Beef + Lamb New Zealand Ltd have agreed to lead and resource the implementation of this strategy.

A series of workshops for farmers is part of the strategic plan, aiming to help farmers with the practical application of the information in this handbook.

For more information see www.wormwise.co.nz

CONTENTS

Authors
Wormwise Technical Advisory Group

Editors
Robin McAnulty and Trevor Cook

First published 2007
Republished 2019

Disclaimer
While the authors have made every effort to ensure the information and advice presented in this handbook is accurate and up to date, they do not accept liability for consequences that may result from the use of any information contained or advice given herein.

Sustainable worm management for livestock farmers

This handbook for New Zealand farmers is part of the Wormwise initiative that identified the need for an independent and central source of information about the principles and strategies for sustainable worm management.

The principles themselves are quite straightforward; it is their practical application that is more complicated. Farming systems vary tremendously and what works for one may not be practical for another. For this reason it is impossible to develop a set of “rules”. Instead farmers should seek to understand the principles and then make their own decisions on how they might be applied to their farm. This book is designed to help develop that understanding.

A successful worm management plan should be designed in close cooperation with your animal health adviser.

Why sustainable worm management?

Being able to farm efficiently and sustainably in the years ahead requires examining if what we do now will make sense in the future. The accelerating development of drench resistance means many current worm control practices are not sustainable.

No drench or drenching programme can offer total freedom from the effects of worms, so having other ways to minimise those effects will improve production and profitability. Added to this are the costs of drenching, both in time and money. Without a sound drenching strategy, which is part of an overall worm management plan, much of this expense and effort can be wasted.

Drench resistance is also a cost to production. Drench failure begins to cost the moment drench effectiveness begins to decline. The point at which this decline in efficacy becomes economically significant occurs long before there is visible evidence of drench failure.

To appreciate the benefits of adopting sustainable worm management principles it is first necessary to have an understanding of how worms affect production. This is the subject of the first chapter, and should stimulate interest in learning more about worms and their management as covered in the subsequent chapters.

CHAPTER ONE

Effects of worms and how they limit production

CHAPTER OVERVIEW

After reading this chapter you will have an understanding of how worms impact animal production. There are worm management approaches aimed at maximising profitability.

- Larval challenge occurs whenever animals graze on pasture contaminated with infective L3 larvae. Infection causes appetite suppression and changed grazing behaviour, as well as demanding an immune response, which is a cost to production.
- All animals grazing pasture in New Zealand will be exposed to larval challenge.
- Production loss due to worms is of greatest importance in young stock.
- Physical signs represent the end stage of a complex and progressive disease process. Their appearance represents failure of your worm management strategies.
- Young stock are a fertile breeding ground for the multiplication of worm populations and can become a major source of pasture contamination.
- No drench can completely eliminate the effects of larval challenge.
- Successful worm management strategies should aim to minimise larval challenge at critical points in your farming operation.

As livestock farmers know, worms are one of the main threats to stock health and production, impacting the viability of their farming operations. After reading this chapter you will have an understanding of the ways in which worms exert their effects on animal production and how this affects different stock classes throughout the year. You will also appreciate how this understanding can assist in your farm management profitability.

Two popular concepts of how worms affect livestock are they compete for nutrition with the animals they infect, and cause damage to the gut leading to inefficient feed utilisation and scouring.

Both of these are true, although for the most part even large numbers of worms do not "rob" animals of nutrition. The exceptions to this are the blood sucking parasites such as the *Haemonchus* species (barber's pole worm).

The impact of worms on animal production begins as soon as animals are exposed to worm larvae on pasture. These effects may be viewed as a continuum from no exposure to worms, and therefore no impact, to the presence of heavy burdens of worms in animals leading to disease and even death.

The point, at which these effects become visible, either through stock weight or body condition loss, or through physical symptoms such as scouring, is called clinical parasitism. Before this point is reached the unseen but important effects, from a productivity point of view, are called subclinical parasitism. In today's modern livestock farming operations minimising these subclinical effects can mean the difference between profit and loss.

This diagram illustrates that long before clinical (visible) signs of worm infection occurs, there can be significant production loss.

Subclinical effects

It is safe to say all grazing animals in New Zealand will be exposed to worms on pasture, and as long as there are larvae in pasture animals are grazing, these effects will continue. The level of impact will depend on the amount of pasture contamination, but it is the constant nature of the exposure that results in accumulated productivity loss.

The process begins with animals picking up infective L3 worm larvae when grazing contaminated pasture. This is known as larval challenge. These larvae are foreign to the animal in a similar way to bacteria or viruses and have two major effects.

The first is appetite suppression and changed grazing behaviour. This occurs even at very low levels of larval challenge resulting in reduced food intake. The second effect is the generation of an immune response to the incoming larvae. The immune response requires energy and protein. Both of these needs are met at a cost to production whether it is through loss of body weight, wool growth or milk production.

There are numerous studies that demonstrate these effects. These are summarised below: one in lambs and a series of trials in cattle.

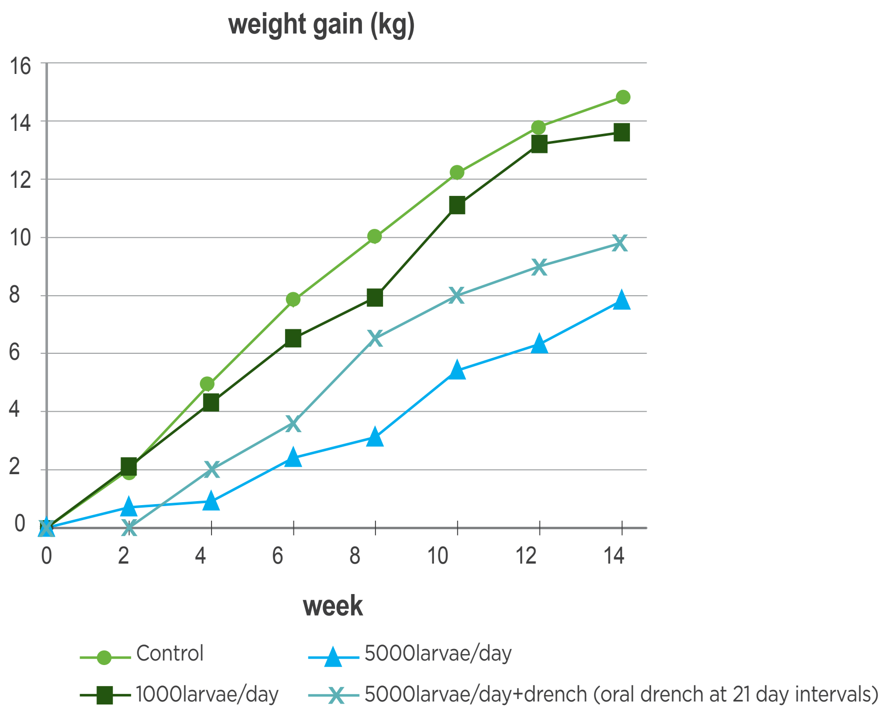
The graph below shows the growth rates of previously worm-free lambs dosed with different levels of infective L3 (larval challenge). The control animals received no larvae. The animals were housed and fed a dry ration. Growth rates and feed intake were monitored.

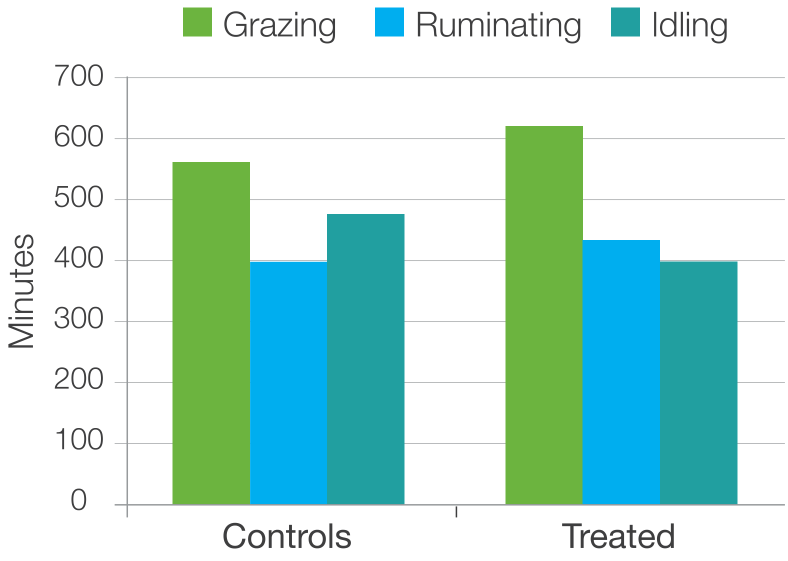
It can be seen that the challenge of L3-reduced growth rates occurs immediately. The effect increased with increasing challenge.

The depression of feed intake of both drenched and undrenched groups receiving 5,000 larvae per day was the same. At slaughter, the drenched group had no resident worms, from which we can deduce that establishing worms were removed at each drench. None of the animals in this trial showed clinical signs of parasitism.

This trial demonstrates the subclinical effects of larval challenge. Regular drenching to remove any established worms has minimal impact. In other words drench on its own cannot eliminate the effects of worms.

Effect of daily intake of *Ostertagia* larvae and anthelmintic on growth of young lambs (adapted from Coop *et al* 1982)





Adapted from Forbes *et al* Vet. Parasitol 2004

Past work has looked at the effects of grazing behaviour in both young and adult cattle using sensors attached to the animals' jaws. Animals were either treated with long-acting drenches, both to remove resident worms and negate the effects of larval challenge, or allowed to become naturally infected by grazing contaminated pasture. Observations were made over a 28 day period. The trials showed exposure to worms reduced productive grazing behaviour. Consequently, there were reductions in weight gain in young cattle and in milk production in adult dairy cows. The graph shows the differences in behaviour between two groups of adult cows in one of these trials.

Cows exposed to worms spent less time grazing and ruminating and more time in non-productive behaviour (idling).

None of the animals in either of these trials showed clinical signs at any stage. The trials demonstrate the subclinical effects of worm exposure and their impact on productivity. It appears that the suppression in appetite is involved in the immune response to challenge. Other trials involving animals whose immune system has been artificially suppressed have found nil or minimal effects in terms of productivity when these animals are challenged with worm larvae.

Clinical effects

The clinical effects of worms on animals are a progression from the subclinical effects, as worms become established in the body. The distinction between clinical and subclinical is an arbitrary one and may depend on how hard you are looking. Generally speaking, at the clinical stage there are visible signs in the animal. The major physical signs are weight loss, scouring and dehydration. Whilst worms cause varying amounts of direct damage to host tissues by their activities of feeding on the gut lining or sucking blood, most effects leading to clinical disease are due to the host reaction to the presence of the worms. The inflammation resulting from physical damage can lead to secondary bacterial infection and ulcers. Worm larvae invade glands in the gut lining and, whilst some adult worms burrow into the lining, many simply reside in the surface mucous layer. The host's defensive inflammatory response causes changes in the structure and physiology of the gut, leading to disturbances in normal gut function. The gut lining may thicken or nodules may form. Abnormal acid or hormone production may occur and the gut becomes "leaky", possibly resulting in loss of fluid and protein. Feed conversion efficiency suffers resulting in weight loss, and diarrhoea (scouring) may occur. If these changes are sufficiently severe, death usually results. In the case of Haemonchus, death can also result from blood loss.

At the point where the physical symptoms of worm infection, such as weight loss and diarrhoea are apparent, the end stage of a complex and progressive disease process has occurred. It could be said that the appearance of these signs represents failure of your worm management strategies.

Age effects and immunity

Young animals first encounter worms when they start grazing and at this point they have no specific immunity to them. This means it is easy for worms to establish themselves and become "residents", reproducing relatively freely. The result is that young stock are a fertile breeding ground for the multiplication of worm populations and can become a major source of pasture contamination.

Because young animals are using large amounts of energy and protein to grow, they are highly susceptible to the effects of parasites. Production loss due to worms is therefore of greatest importance in young stock. Both cattle and sheep generally develop full immunity to worms by 18–20 months of age. Continual exposure to worms is thought to be important for the development of good immunity, and it is extremely likely there are sufficient worm numbers on New Zealand pasture for animals to develop such immunity.

A successful worm management programme should aim to minimise exposure of young stock to worms. The immune system is energy and protein hungry and depressed by the physiological response to stress, so good nutrition and minimising stress are important management considerations.

Healthy adult animals generally cope much better with worm challenge as their immunity is fully developed and they are not growing, but the comments above regarding nutrition and stress still apply. Remembering the demand for an immune response is responsible for subclinical production loss, there are times when the impact of worms on the productivity of older animals will be important. Around lambing and calving, animals are under stress and there can be a decrease in immunity.

This can lead to higher burdens of worms and higher faecal egg outputs as the decreased immunity allows worms to reproduce more freely.

Ewes and cows in lactation have a high energy and protein demand, so the effects of worm challenge will have a higher impact on productivity. Your worm management strategy should aim to minimise exposure of these animals to a worm challenge.

Rams and bulls at mating time are another example of when attention to these principles is important.

This chapter should have convinced you the subclinical effects of worms can have a major impact on profitability. It has attempted to show you how, by giving some thought to when each stock class is likely to suffer productivity losses from worm challenge, these losses can be minimised. Successful worm management strategies should aim to minimise exposure at these critical points in your farming operation. The rest of this book is aimed at providing the knowledge required to develop these strategies and put them into action.

Remember the whole area of worm management is extremely complex, far from being fully understood and unexpected things will happen. Forming a partnership with your animal health adviser will greatly increase your chances of success.

Take away messages

If you are seeing clinical signs, your worm management strategy is not working and you may be losing money.

By minimising worm exposure at critical times, production may be increased.

Bibliography

B+LNZ Fact sheet 70: Worm management

B+LNZ Fact sheet 151: Worms in refugia

Podcast from Dave Leathwick, AgResearch, on internal parasites and drenching: https://beeflambnz.podbean.com/e/dave-leathwick-animal-health-internal-parasites/

Sustainable control of internal parasites in ruminants. Animal industries workshop 1997 G K Barrell, Lincoln University Press

The Sheep: Health, Disease and Production. 2nd Edition 2002. Bruere, West and Ridler Veterinary Continuing Education, Palmerston North

Coop R L et al. 1982. *The effects of three levels of intake of Ostertagia circumcinta larvae on growth rate, food intake and body composition of growing lambs.* Journal of Agricultural Science (Cambridge), 98, 255

Forbes et al. 2004. *Impact of eprinomectin on grazing behaviour and performance in dairy cattle with subclinical gastrointestinal nematode infections under continuous stocking management.* Veterinary Parasitology 125, 364

CHAPTER TWO

Worm biology

CHAPTER OVERVIEW

This chapter is devoted to important aspects of worm biology as they impact on worm management. After reading this you will understand the reasons behind some of the principles as well as some of the difficulties. It should also help you see why there is no one single solution.

- Sheep and cattle in New Zealand are infected by a variety of different worm types. Worm eggs pass out onto pasture in animal dung. The larvae develop in the deposited dung and become infective (L3) to animals grazing on pasture.
- The number of larvae on pasture is affected by weather. Warm moist conditions speed up larval development, resulting in greater numbers of eggs developing to become infective larvae.
- It takes around 21-28 days from when an animal eats a worm larva to when worm eggs appear in dung samples.
- The whole life cycle may be completed in four weeks; even less in special cases.
- The number of eggs and larvae present on pasture is much higher than the number of worms inside animals. Therefore, effective worm management requires more than simply killing worms in the animal. It should minimise exposure of animals to worms at crucial times.
- Most larvae are found in the first 2cm of pasture height or in the first 1cm of soil.
- Intensive grazing exposes animals to a higher level of larval intake compared to animals lightly grazing the same pasture.

What should you know about the important worms in New Zealand sheep and cattle?

Several different types of worms live inside sheep and cattle. This handbook focuses on roundworms (also called nematodes) that live in the gut and will be referred to as “worms”. Flukes and tapeworms are commonly found and are discussed briefly.

The worms of most importance in New Zealand livestock live in the animal’s gut (stomach and intestine). Although this book refers to worms as if they are all the same, there are actually several different types. These may vary in size, where they live in the animal, and in their life cycles.

Individual worm species that infect cattle do not usually infect sheep and vice versa, even though they might have the same genus name. Some worms live only in the stomach (abomasum), others only in the small intestine, and *Trichostrongylus* species can be found in both.

The correct name for what we have traditionally called *Ostertagia* in sheep is now *Teladorsagia*. However, in this book we continue to use the name *Ostertagia* as this is more familiar to most people.

The worm families/types listed are those that cause the most problems in sheep and cattle. There are others that are less common or cause little problem: *Strongyloides, Bunostomum, Oesophagostomum, Chabertia* and *Trichuris.*

Although worms are often referred to by their scientific name, some also have common names, e.g. *Haemonchus* is also called Barber’s Pole.

Lungworm is another type of roundworm that lives in the lungs. They are less important for animal health than those in the gut, but can be a problem in young stock, particularly cattle.

	Sheep	Cattle
Stomach	*Haemonchus contortus* *Ostertagia (Teladorsagia) circumcinta* *Trichostrongylus axei*	*Ostertagia osteragi* *Trichostrongylus axei*
Small intestine	*Trichostrongylus colubriformis* *Trichostrongylus vitrinus* *Nematodirus filicolllis* *Nematodirus spathiger*	*Cooperia oncophora* *Trichostrongylus vitrinus* *Trichostrongylus colubriformis* *Cooperia puncata*

Geographic variations

Most of the worms listed occur and cause problems in all areas of New Zealand. However, two—*Haemonchus* and *Cooperia*—are more of a problem in the warmer areas of the north because they require a higher temperature range for development. *Nematodirus* causes more problems in the colder south as it is adapted to cool, short summers and its larvae survive cold winters on pasture. *Ostertagia* and *Trichostrongylus* occur in all areas.

The life cycle of roundworms

The common roundworm of sheep and cattle has three phases or forms in its life cycle: egg, larva and adult. The adult stage is the worm that lives in the gut of the animal; they may be seen when the stomach (abomasum), small intestine or lungs of a sheep are cut open.

Adult worms shed eggs, which pass out of the animal in the dung. The immature worm hatches out from an egg within the dung pat. At hatching it is called a larva and in most worm species will go through four larval stages. The first three stages of development take place within the dung pat; the first two stages of which (L1 and L2) are free living.

The third larval stage (often referred to as L3) is the infective stage. Infective larvae migrate out of the dung onto soil, or onto the grass, where they can be eaten by a grazing animal.

Under ideal environmental conditions, development from egg to L3 takes around seven days, but can be as long as five to ten weeks depending on warmth and moisture. Heavy dew and rain release the L3 from the dung pellet onto the pasture. L3 larvae increase their chance of being eaten by responding to light and temperature. As the pasture is warmed by sunlight, and in the presence of moisture (dew/rain), the L3 migrate up the grass blades where they are most likely to be eaten. When the L3 are eaten by an animal they undergo another moult to become an immature worm (L4 larva), which moults once more and matures into an adult worm.

The female worm mates inside the host animal and produces eggs in about 21 days. The eggs pass out in the dung and the life cycle begins again.

Female worms produce large numbers of eggs over their lifetime and the population of eggs and larvae on pasture is considerable.

Nematodirus has a slightly different life cycle from the other common worms. The larvae develop inside the egg in the dung pat and it is the infective third stage larva that hatches from the egg. Because the larvae are protected inside the egg, they can survive over winter to hatch in the warmer spring or summer weather. From then on they behave like other types of roundworm.

Eggs of *Haemonchus* (Barber's Pole) are different from other worm eggs in that they require a relatively high temperature to complete their development. This is why *Haemonchus* is more of a problem in the warmer north and eastern parts of the country.

Lungworm

Of the three species of lungworms that can infect ruminants in New Zealand, the most common is *Dictyocaulus*. In the mature form, *Dictyocaulus* lives in the airways of the lungs, where it causes irritation and inflammation. Animals severely affected with lungworm may cough and have difficulty breathing. They often have a mucus discharge from the nose.

Survival of eggs and larvae

The development of worms from an egg through the larval stages requires a moist environment and occurs at a different rate at different temperatures. At low temperatures development is slow, whereas in warmer temperatures it is faster. A temperatures of 20-25°C is optimal for larvae, as they die at higher temperatures due to desiccation (loss of moisture or dehydration).

Most developing eggs and larvae are killed by hot, dry weather, and most eggs on pasture die during cold weather (average air temperature less than 10°C). Some larvae survive through winter, also known as "overwintering", and together with new eggs shed by animals in early spring, this initiates the build-up in worm numbers.

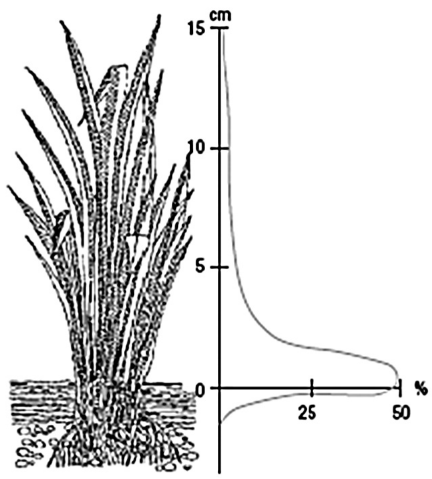
Infective larvae (L3) are relatively hardy. Once the larva has reached the infective third stage (L3), temperature and moisture will determine how long it survives.

Infective larvae on pasture eventually die as they cannot feed and have to survive on stored energy. In cooler temperatures larvae can survive for up to eight months and in some cases for more than a year. In warmer temperatures larvae may survive only two or three months. Naturally, the longer pasture is left or spelled without grazing animals, the fewer infective larvae it will contain. The length of time this takes will vary, as it depends on climatic factors.

The type of pasture can also affect the rate at which dung pats dry out and eggs and larvae die. Some open sward pasture species provide a less suitable environment for larval survival than those with a dense thatch.

Most larvae are found in the first 2cm of pasture height or in the first 1cm of soil. When animals graze pasture with longer grass they are likely to be taking in fewer worm larvae than when they graze pasture with shorter cover.

Intensive grazing exposes animals to a higher level of larval intake than animals lightly grazing the same pasture. Amounts and patterns of dung deposition, and therefore numbers and distribution of parasites on pasture, will vary with the type of grazing management.



The vertical distribution of infective larvae on grass.

Inhibited larvae

At some points in a worm's life cycle, development can become arrested or inhibited. Development resumes later, presumably after a favourable stimulus has been received. The most obvious example of this is the infective third larval stage. This stage will not advance to the next, the L4; it will not grow, or even feed, unless it is eaten by a suitable host animal.

Another example of arrest occurs in the parasitic phase of the life cycle of many parasites of temperate climates. Recently acquired larval stages may become temporarily inhibited during development inside the host. This kind of arrest commonly affects the L4 stage. Not all larvae may undergo arrest and the length of time they spend in this state varies.

Environmental factors are thought to play some role in encouraging larvae to become arrested. Exposure of the infective L3 to cooling pasture temperatures in the autumn is thought to encourage them to become arrested once they have entered the host. They typically resume development after a few months, towards spring, when their progeny will find conditions outside the animal more favourable for development. Arrested development also tends to occur in areas with regular dry seasons.

Host factors, principally the immune status of the host, may also encourage arrest, whilst exposure of animals to stress may contribute to larvae 'waking up'.

In most cases, the resumption of larval development has no real consequences for the host animal. One exception to this is seen in cattle, in which the synchronous resumption of development of previously inhibited *Ostertagia ostertagi* larvae can cause a lot of damage to gut tissues, resulting in the syndrome of Type II ostertagiosis (see page 12). This syndrome is uncommon in New Zealand, due to larvae resuming development sequentially rather than en masse.

The prepatent period

Typically it takes around 21 days from when a sheep ingests a worm larva to when worm eggs appear in dung samples. In a few species, it takes slightly longer. This is called the prepatent period.

It is important for two reasons:

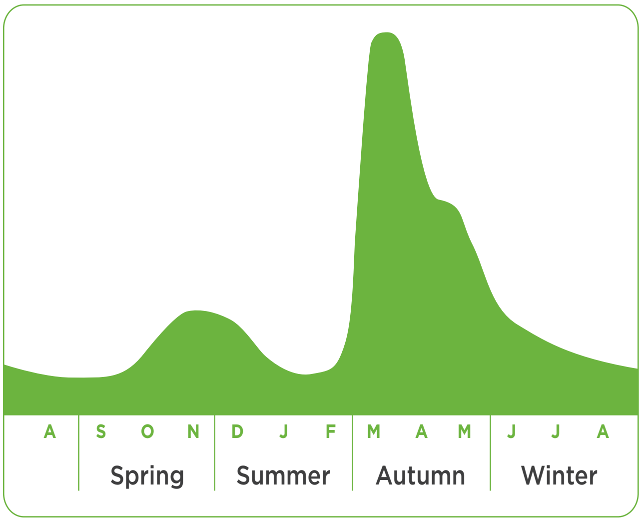
- The commonly recommended interval of 28 days between drenches in young stock is aimed at minimising pasture contamination with worm eggs.
- Worm egg counts provide, at best, a 'picture' of the levels of larval challenge on pasture, three weeks prior to measurement. You may therefore think sheep are free from worms but, under the right conditions, they could have picked up a considerable burden. Obviously, if a sustained action drench was used, the period from drench to eggs appearing in the dung is longer, i.e. the length of action plus the 21 day prepatent period.

Seasonal patterns of larvae on pasture

Larval numbers on pasture are generally highest in late spring and autumn. This is because worms complete their life cycle fastest in warm, wet conditions. Many developing eggs and larvae are killed by hot, dry summer weather and fewer eggs develop in the colder temperatures of the winter months. The mild, moist conditions of spring and early summer are ideal for larvae, so their numbers on pasture increase. Numbers build up through summer and early autumn but drop off if hot, dry weather occurs.

Danger periods extend from spring to early winter; extreme danger occurs from March to July. This will vary across the country according to the climatic conditions.

The number of eggs and larvae present on pasture is much higher than the number of worms inside animals. Generally, when conditions are favourable, 85–95% of the worm population will be found in the soil or on pasture and the remaining 15% are elsewhere (animals, faecal pats). It is very important to remember this when planning worm management. Simply killing worms in the animal is only a part of the overall strategy to minimise exposure of animals to worms at crucial times.



Generalised seasonal pattern of infective larvae on the pasture arising from untreated sheep.

Seasonal pattern of worm burdens in sheep

The seasonal pattern of worm burdens in sheep reflects the levels of pasture larvae they are eating. The number of worm eggs in faeces is measured by faecal egg counts, and these typically reach the highest levels in autumn.

Numbers of larvae on pasture are related to the numbers of eggs passed out by the grazing animals. In general, young infected animals will pass much larger numbers of eggs than older animals. As animals mature they develop immunity to worms, so carry fewer numbers and pass fewer eggs onto the pasture.

However, during late pregnancy and in early lactation, most ewes have a temporary drop in immunity and consequently pass more worm eggs in their faeces. This is the cause of the peripartum rise in egg counts (PPR) that occurs around mid-lactation. By the time of weaning, the ewe's immune response should have recovered and egg counts returned to normal.

Different types of worms have different yearly patterns of prevalence. The most common worm in ewes during the PPR is *Ostertagia* yet this is much less common by the autumn. The PPR is greater for ewes with multiple lambs and young ewes having their first lamb.

The peripartum rise in eggs produced results in a corresponding increase in larvae numbers on pasture, so that when lambs start grazing there is a new generation of larvae on the pasture ready to infect them.

Seasonal pattern in cattle

The seasonal pattern in cattle is similar to that of sheep. However, the main peak is late autumn/early winter.

Calves born in spring become infected as soon as they start nibbling pasture. Larvae on the pasture at this time of year have survived over winter. These mature inside the calf and produce eggs which contaminate the pasture in spring and early summer. Therefore, by early summer larval numbers on pasture have built up and calves become re-infected, resulting in an even heavier burden. The eggs from these worms cause a peak of larvae on pasture in May/June.

As calves mature they start to develop some resistance to worms and faecal egg counts start to fall. With the lower egg counts and cooler weather, the larval numbers on pasture are lower in winter. The growth of grass in spring means the larvae are spread over more pasture and are thus diluted.

Calves have their greatest burden of *Ostertagia* and *Cooperia* in their first winter. By the time they are a year old they have normally developed resistance to *Cooperia* and levels of *Ostertagia*. However, peak numbers of *Trichostrongylus axei* (both as larvae on pasture and worms in the abomasum) occur later, in about October, and drop off soon after. So it is not until cattle are about 18-20 months of age that they have significant levels of resistance to all three major species found in cattle.

Calves in their first year are the main source of pasture contamination. Climatic variations in different parts of the country have some effect on the patterns. Larval development on pasture is more rapid and continues for longer throughout the year in warmer areas.

Infective larvae can survive for long periods in undisturbed dung pats.

Important worm types

Haemonchus contortus

- Primarily a parasite of sheep and goats, can establish in small numbers in cattle and deer
- Called barber's pole worm because of its appearance
- Blood-sucking
- Lives in abomasum (4th stomach)
- Quite large (20–30mm)
- Female barber's pole worms are prodigious egg layers and can lay up to 10,000 eggs per day
- The danger period for *Haemonchus* is in late summer and autumn. The numbers of *Haemonchus* can build up rapidly, leading to sudden and severe illness in lambs. Being a blood-sucking worm, it can cause lamb deaths from anaemia and blood loss. It can affect two tooth ewes, but less commonly causes serious illness in older sheep.

Ostertagia/Teladorsagia circumcincta

- Called brown stomach worms
- Female worm lays 50–100 eggs per day
- Lives in abomasum (4th stomach)
- Quite small (~10mm)
- The L3 larvae of *Ostertagia* are resilient and able to survive freezing on the pasture and dry conditions
- *Ostertagia* has a characteristic not shared by other worm types; the larvae can embed themselves in the wall of the abomasum in small nodules and remain dormant there for several months without maturing. When ready, they emerge from the wall of the abomasum as adult worms and lay eggs.

Ostertagia osertagi

- *Ostertagia* is the most significant worm for New Zealand cattle. The disease ostertagiasis causes can occur in two forms: Type I and Type II
- Type I ostertagiasis is the typical scouring and weight loss associated with other worm infestations in calves. The larvae mature normally and the effect of them and adult worms in the stomach causes loss of appetite, poor feed conversion and weight loss. Type I ostertagiasis is of most importance in summer and autumn
- Type II ostertagiasis results when the inhibited larvae in the stomach wall mature and break out of the mucosa, causing damage to the stomach lining. In some situations large numbers emerge at the same time and can cause sudden and severe illness, and even sudden death. This mass emergence usually occurs in the spring in animals of 9–12 months or older. Their presence will not be detected by faecal egg counts (FEC) because it is the maturing larvae that cause the damage, not the adult worms. Type II disease is relatively rare in New Zealand.

Trichostrongylus

- There are three common species of *Trichostrongylus*. Adult *Trichostrongylus axei* worms (also called stomach hair worm) live in the abomasum of sheep and cattle (and other species such as horses and pigs). *Trichostrongylus colubriformis* (black scour worm) and *T. Vitrinus* live in the small intestine of sheep; both cause damage to the lining of the gut
- Adult female worms lay 100–200 eggs per day
- *T. longispicularis* is a fairly minor parasite of the small intestine of cattle. The effects of *Trichostrongylus* in cattle are intermediate between *Ostertagia* and *Cooperia*. However, *Trichostrongylus* worms can be very damaging in sheep. The main danger period for *Trichostrongylus* is in winter, as the infective larvae are very resistant to cold and desiccation and their numbers can reach high levels in the cooler months.

Nematodirus

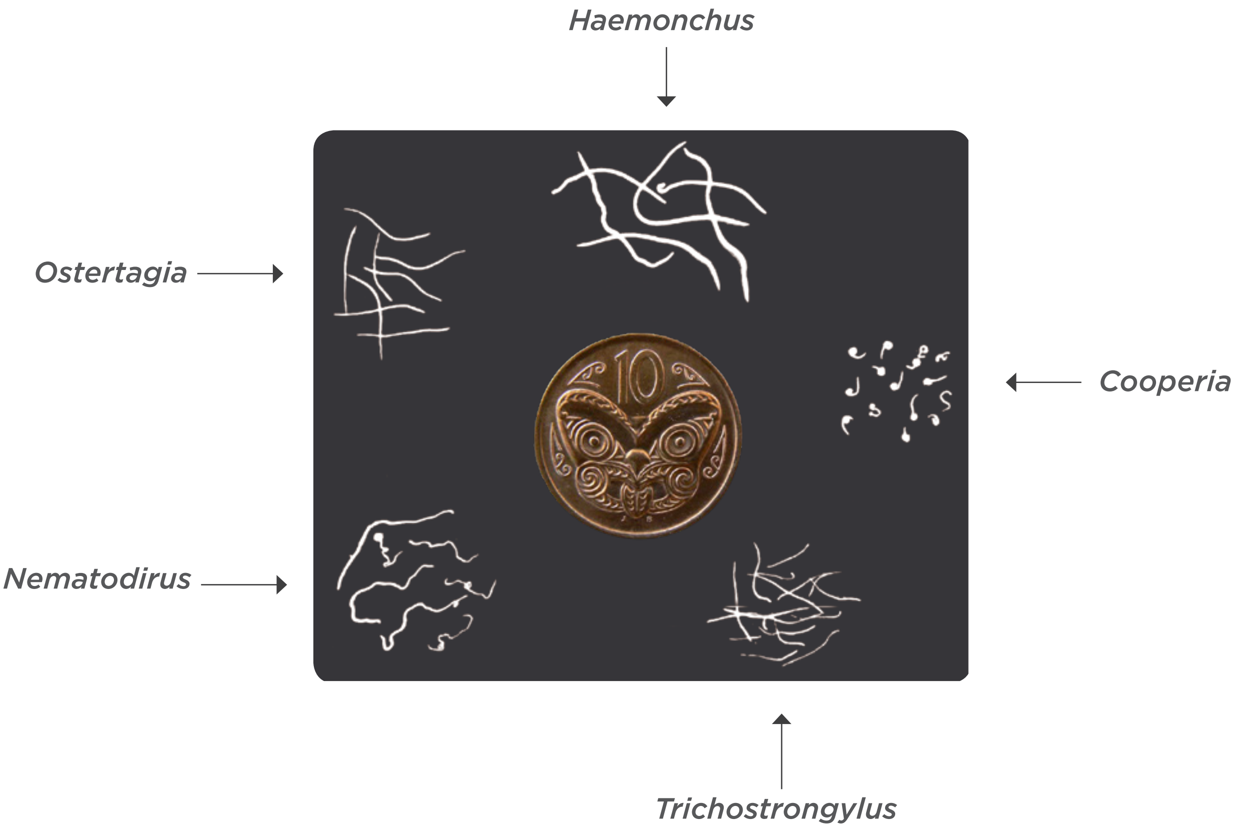
- Called the thin-necked intestinal worm
- The female worm lays 25–30 eggs per day in the small intestine. These pass out into the dung
- The larvae develop to 3rd stage (L3) in the egg shell over a period of two or more months. The combination of egg shell and L3 sheath make it able to survive desiccation and cold, and it survives winter in large numbers. This overwintering means the pattern of infection for *Nematodirus* can differ from other worms, in that transmission can occur directly (via pasture) from one season's lambs to the next. Sudden outbreaks of clinical disease can occur in lambs before weaning. *Nematodirus* is of most importance in early spring and throughout the summer.

Cooperia

- Called small intestinal worm
- Small intestinal worm 10–15mm long and found coiled close to the wall of the small intestine
- *Cooperia* is most common in autumn but is rarely important
- In cattle the parasitic effects of *Cooperia* are significantly less than those of *Ostertagia* but as they can lay large numbers of eggs large populations can develop, making *Cooperia* a significant worm problem in intensive cattle farming systems.

Lungworms

- The major lungworm in New Zealand is *Dictyocaulus* (*D. filaria* in sheep, *D. vivparous* in cattle and *D. eckerti* in deer). *Dictyocaulus* worms are white, long (several centimetres) and thin, with few identifying features. They are commonly found in frothy material in the airways of the lung.
- The life cycle of *Dictyocaulus* is similar to that of intestinal worms. Adult females lay eggs containing larvae. After hatching, the larvae wriggle into the animal's throat, are swallowed, and then passed out into the faeces. They develop on pasture and are eaten by the animals. Larvae travel from the gut through the tissues to the lungs.
- Lungworms are generally less important than the gastrointestinal nematode species in sheep and cattle, but *D. eckerti* is a very significant parasite of farmed red deer.



Liver fluke

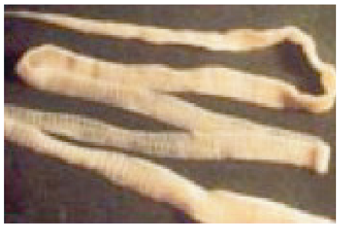
The adult liver fluke (*Fasciola hepatica*) is a flat leaf-shaped parasite (about 20mm x 10mm) that lives in the bile ducts of sheep, cattle and other animals.

The life cycle of the liver fluke involves a small freshwater snail. For animals to become infected, they must graze damp areas where the snail is living.

Eggs from the adult fluke pass out onto pasture in the faeces where they can be eaten by the snail host. After going through several developmental stages inside the snail and on the pasture, the infective stage (called metacercariae) is ready to infect a grazing animal. Inside the animal, the young fluke finds its way to the bile ducts of the liver where it matures and produces eggs, completing the life cycle.

The numbers of metacercariae on the pasture build up from late spring until late autumn when temperatures drop.

The signs of fluke infestation in an animal can vary from sudden death (which is rare) to reduced growth rate and production.

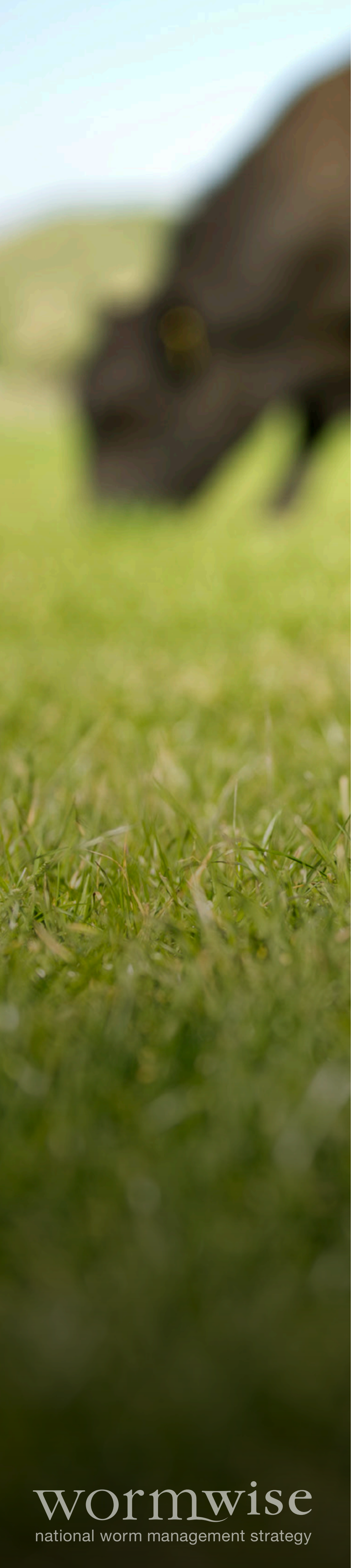


Tapeworm

The tapeworm (*Monieza expansa*) is the largest internal parasite of sheep in New Zealand. Tapeworms are common in young animals, and the tapeworm segments can often be seen in their faeces. By about eight months of age animals usually spontaneously lose their tapeworm burden.

The tapeworm segments passed in the faeces contain eggs, which develop inside a small pasture mite. The animal becomes infected when it eats the mite on the pasture it is grazing.

There is little evidence that tapeworms have a significant detrimental effect on lamb growth rate. Tapeworms are rare in cattle and little is known about their effects.



CHAPTER THREE

Principles of worm management

CHAPTER OVERVIEW

After reading this chapter you will understand how to apply the knowledge gained from chapters 1 and 2. The principles of worm management are derived from this understanding, as well as from many research studies and the experience of researchers, vets and farmers.

When implementing the principles outlined in this chapter the issue of drench resistance must be kept in mind. This is discussed separately in chapters 3 and 4, which presents ways of reducing the risks of drench resistance development. At times this will involve compromise, so the two chapters should be read in combination.

- The purpose of any worm management programme is to maintain or enhance profitability by:
  - Minimising contamination of pasture with infective worm larvae
  - Minimising uptake of infective larvae by susceptible stock
  - Monitoring the success of worm management strategies.
- The main focus should be to reduce exposure, especially of young animals, to worms, by limiting the number of infective larvae on pasture.
- Many tools are available but the mix will vary from farm to farm. Every farmer should carefully consider all the available options for worm management and how best to integrate them on their property.
- A key factor in implementing any strategy is knowing what is happening with worms on the farm. The tools to determine this are faecal egg counts (FEC) and the identification of worms present using faecal larval cultures. Monitoring production measures such as weight gain gives information about the effects of worms on stock.
- Worm management strategies may include:
  - Manipulation of pasture and stock management plans to reduce exposure of animals to worms at key times
  - Ensuring animals are well fed and have adequate mineral status
  - Minimising stress and attending to disease prevention
  - Breeding resistant/resilient animals
  - Appropriate drenching strategies.

The basis of a successful worm management strategy is to prevent their negative effects on animal health and production by:

- Restricting the exposure of susceptible stock to infective larvae
- Reducing the contamination of pasture with worm eggs shed by infected stock.

Many tools are available but those used will vary from farm to farm, depending on what is most appropriate. The situation on any farm is not static and strategies need to be reviewed frequently to take advantage of changes in farm conditions and new control technologies. Farmers should consult their veterinarian or other animal health adviser.

A key factor in implementing a strategy is knowing what is happening with worms on your farm. Currently, the key tools to determine the situation are faecal egg counts (FEC) and faecal larval cultures to identify the species present. Monitoring production such as weight gain and body condition score (BCS) are also important tools to gauge the effects on your stock, but there may be other causes of reduced production.

Every farmer needs to consider the options available for worm management and how they can best be integrated on the farm. Key tools are discussed below. The benefits from some may be small but the overall benefit is the sum of all the parts. New developments will continue to appear and should be incorporated into the management strategy. Some possible future developments are discussed at the end of this section.

It is advisable to develop a worm management strategy in consultation with your animal health adviser.

A worm management strategy requires planning but should result in a more efficient, cost-effective and productive farm. It becomes easier with experience, and a strategy can be fine-tuned with changing conditions.

Key factors for a worm management strategy

Worm location

At any one time the vast majority of the worm population is on the pasture, rather than inside the gut of the host animal. Therefore, effective controls should minimise pasture contamination and minimise the exposure of susceptible stock to contaminated pasture. Keeping the worm challenge low by keeping low larval levels on pasture results in healthier, more productive stock.

Worm numbers

Worm numbers in pastures vary throughout the year, with peaks in spring and autumn, when the climate favours worm development and young stock are present.

Larval removal

It is difficult to remove larvae without removing the affected herbage, e.g. by cutting for hay or grazing with non-susceptible animals.

Spelling period

Spelling pasture for short periods (less than three months) will not reduce numbers of infective larvae sufficiently. Larvae can survive for many months, even years, on pasture. Cold weather slows their development but does not kill them. Exposure to direct sunlight will dry out and kill some eggs and larvae, but worms can survive and develop in the moisture of a cow pat even in drought conditions.

Immunity

Sheep and cattle develop a level of age immunity to worms. They begin to develop some immunity from around six months, which is fully developed by 18 months of age. Therefore, it is important to avoid exposing young stock with under-developed immunity to high levels of infective larvae.

Nutrition

Animals under stress are less able to counter the effects of a parasite challenge. It is vital to maintain good levels of nutrition to meet the seasonal needs of the animal. Remember, adult stock under stress, animals suffering a mineral deficiency and stock that have recently calved or lambed, may also release more worm eggs onto the pasture.

Scouring

Although worms can cause animals to scour, there are also other causes of scouring unrelated to worms.

Tools for worm management

The main focus of any worm management strategy is to reduce animals' exposure, by limiting the number of infective larvae on pasture.

To achieve this, investigate all available options, do not be afraid to seek advice and watch out for new developments.

Keeping stock healthy is important to reduce the effects of worms. Minimising stress and paying attention to disease prevention will mean stock are better able to deal with worm infestations, and will deposit fewer eggs on pasture. If young animals do become wormy, use drenches to kill the worms.

The tools available for you to use in any control programme include: farmer knowledge, pasture management, stock management, on-farm diversification, drenching and the use of genetics.

Farmer knowledge

Here are some of the things you need to know:

- Which worms are prevalent in your area?
- How do they affect sheep and cattle? What are their life cycles?
- When are they important?
- Which factors favour larval challenge?

Pasture management

- Pasture length: keep covers long—most worm larvae are in the bottom 2cm of pasture
- Pasture species: tannin-rich pasture species may decrease the rate of larval establishment
- Hay and silage aftermaths (preferably closed up for three months or longer): most worm eggs and larvae will not survive
- Fodder crops and new pasture should contain low levels of worm eggs and larvae
- Spelling pasture (preferably for three months or longer) will reduce the level of eggs and larvae
- Use of rotation or set stocking will depend on individual circumstances.

Stock management

- Stocking rate: the size of the worm problem largely depends on grazing animal density. The higher the stocking rate for a particular stock class, the higher the potential for worm problems
- Graze young animals ahead of older stock
- Alternation of grazing species: grazing interchange systems, incorporating cattle, deer and adult, non-lactating sheep, will reduce larval pickup in young stock. Pasture can be pre-grazed with resistant stock (for example cattle can be used to prepare pasture for lambs). It may take 4–16+ weeks, depending on initial contamination levels of grazing, to make a pasture safe for the next stock class. Improved growth rates have been recorded where areas of a farm are grazed by one species for a period of time and animals are swapped between blocks. As goats share the same worm species as sheep, they cannot be used to prepare safe pasture for sheep. Any age class of cattle can prepare safer pasture for lambs. Any age class of sheep can prepare safer pasture for cattle
- Use immune stock, e.g. older animals that have developed age resistance to worms, to prepare pasture for young stock. Below are some general guidelines based on pasture and stock management principles. These are examples of worm management strategies but is not an exhaustive list or designed to apply to all farms.

Sheep

- Shift lambs off weaning areas for autumn
- Avoid or minimise grazing lambs on lambing areas in autumn.

Cattle

- Shift weaners off spring areas for summer and off summer areas for autumn. Avoid grazing weaners in autumn on their winter pastures.

Drenching

Drenches are discussed in detail in the next chapter. Here discussion is restricted to drenching programmes.

Drenching lambs

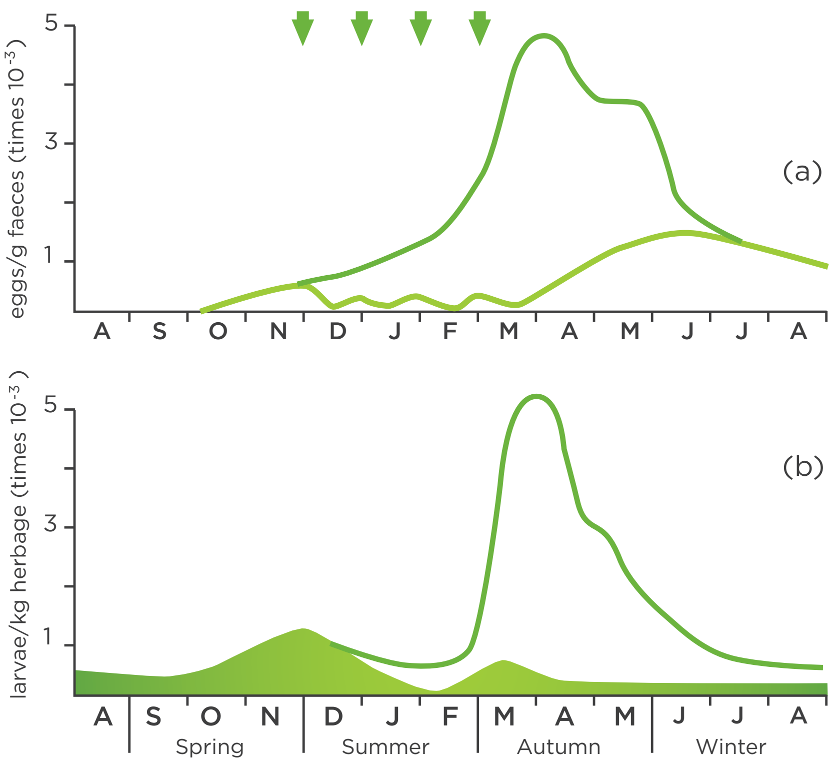
Preventative drenching is a programme of four or five drenches given to lambs at four-weekly intervals starting at weaning. An additional drench about three weeks before weaning may be needed on farms that have problems with *Nematodirus*. Additional drenches may be needed in the autumn if climatic conditions favour larval development on pasture. The effect of this preventative programme is shown in the graph opposite. Preventative drenching offers the advantage of being an easy programme to follow, but may not always be the most effective use of drench.

An alternative to preventative drenching is to monitor and treat. Use faecal eggs counts (FEC), body condition, live weight, pasture length and quality, and larval contamination of pasture to decide when to drench lambs; the higher the FEC of the grazing stock, the higher the pasture contamination with larvae. Consider past experience of worm biology, which involves more work but can be effective for some farmers. However, use of these various production indices has not always provided satisfactory levels of production.

Targeted selective treatments (TST) are partial herd treatments designed to reduce the frequency of drenching on a property by targeting only the animals which require treatment, while maintaining production. The use of productivity indicators in growing lambs, like live weight gain (LWG) over a fortnightly interval, has been shown to reduce drenching requirements by 50% with no production losses.

The effect of four x monthly drenches from weaning on (a) the faecal egg output of lambs and (b) the pattern of larval availability on pasture.

Anthelmintic treatment from (Brunsdon, 1981).



Drenching calves

Young cattle are susceptible to the production-limiting effects of worms. The need for drenching is related to the intensity of the farming operation. Calves raised intensively on pasture irrigated by centre pivot are likely to be more highly challenged by worms than calves grazed more extensively. The principles of preventative drenching outlined for sheep also apply to young cattle.

TST strategies outlined in sheep have produced similar results when applied to dairy heifers whether they are reared on farm or off farm. Using a production-based TST based on LWG over a monthly period (requiring monthly weighing) identifies the animals with poor growth rates requiring treatment. With this strategy drenching frequency was reduced by 60% with no associated production loss due to parasitism. Ideally a TST strategy would be applied from weaning until late autumn. Depending on the season, a strategic drench may be needed in late May or early June and again in the spring.

Drenching ewes

As a general rule, ewes should not need drenching, but there are circumstances when drenching ewes may bring production or animal health and welfare benefits. Blanket drenching of all ewes should be avoided. Factors which could influence the need to drench should include ewe condition, feed availability and ewes carrying multiple lambs. Two tooth ewes have been shown to be more susceptible to parasitism during lactation.

Pre-lamb drenching of ewes has produced variable production responses in published trial work. Parasitologically, the best time to treat a ewe with anthelmintic is between parturition and tailing (three weeks post parturition). However this is not always practical in most farming systems.

Factors to consider when drenching sheep or cattle

- Adult stock should not require routine drenching
- Worms are only one reason stock may be thin or scouring – make sure you know what you are treating
- Drenching intervals should seldom be less than 28 days (except in the case of *Haemonchus* outbreaks)
- Aim to keep drenching to a minimum
- Consider stock age/class, condition, feeding levels, stress
- Drenching needs to be combined with appropriate grazing management
- Drenching plays a valuable role in animal health. Its use should be part of a worm management strategy with advice from your animal health adviser.

Quarantine treatment

The principle of quarantine treatment is to ensure stock coming on to your property do not bring on any resistant worms with them. All new stock, both sheep and cattle, brought onto a farm should be quarantine drenched and held off pasture for 24 hours. They should then graze contaminated pasture. A drench check by faecal egg counting is advised 10 days later. The choice of quarantine drench option for your farm may vary depending on the farming system. The following options are intended to minimise the risk of introduction of resistant worms. However, seek up-to date expert advice regarding quarantine drench treatments as recommendations may change as the drench resistance profile on NZ farms changes.

Sheep

Option 1: Drenching with a combination of no less than four unrelated drench families, with at least one of these being the drench active monepantel or derquantel.

An example of how this may be achieved is by drenching using two dual combination drenches i.e. up the race with one combination drench containing monepantel plus abamectin or derquantel plus abamectin, and then up the race again with a benzimidazole (BZ) plus levamisole combination drench. Do not mix different drench products in the same container unless the label states you can, or this is under veterinary advice, as different products may be incompatible.

This option provides the least risk for introduction of resistant worms, but requires more time, labour and cost. As possible interactions may occur between the individual drench actives when they are administered concurrently, approved meat withholding periods (WHP's) for the chosen products no longer apply. It is your responsibility to ensure that drug residues are not present at slaughter so ask your vet for advice regarding appropriate WHPs. If no information is available for the combination you have chosen, the default meat WHP of 91 days is applied.

Option 2: Drench with a registered combination drench that must contain either monepantel or derquantel. Currently there are dual combination drenches containing monepantel plus abamectin and derquantel plus abamectin available.

This option provides less protection against introduction of resistant worms; however, the risk is still minimal at this time. Time, labour and product costs are reduced. As only a single product is administered the approved meat WHPs found on the product labels will apply.

Cattle

Recently a product containing the drench active monepantel combined with abamectin has become available for use in cattle. This is suitable for use as a quarantine drench.

If use of the monepantel plus abamectin product becomes routine, concurrent use of this product with a BZ plus levamisole combination product will be recommended. Advice regarding concurrent administration of different drench products, discussed in Option 1 for sheep above, will apply.

Deer

Pending the registration of a new deer specific drench, quarantine drenching using products registered for use in cattle/sheep is recommended. Current best practice involves the concurrent administration of a macrocyclic lactone (ML), BZ and levamisole drench. As products are used off label the default 91 day withholding period applies. Veterinary advice should be sought as to which products and dose rates are to be used.

Genetics

There are differences between individual animals, and between breeds, in their susceptibility to or tolerance of worms. For example, Merinos are generally more susceptible to worms than the downland Romney or Composite breeds of sheep. These differences are inherited and can be altered through genetic selection.

Research on breeding and selection for resistant or tolerant animals has identified sires that produce progeny more resistant or tolerant to worms.

Using stock resistant to worms in the face of challenge

You may choose to buy in or breed your own stock resistant to parasites as a component of your parasite management strategy. A number of ram breeders have made significant progress with this approach (e.g. see http://www.sil.co.nz/SIL-ACE/SIL-ACE-home-page.aspx). Our advice to commercial farmers is that commercial sale rams are best described by an economic index that includes both resistance and production. Recently, the breeding values that underlie these economic indices often contain a mixture of DNA, pedigree and trait measurements. This is immaterial to the commercial farmer selecting rams who should still base their decisions on the SIL indices.

"Tail end" selection is practised by many farmers when they remove the more susceptible animals from their breeding programmes.

CARLA®

CARLA® is the acronym for Carbohydrate Larval Antigen and is promoted to sheep and goat farmers as an easy way to select animals with high levels of immunity against internal parasites (worms). The test measures antibodies against worm larvae in sheep saliva. Animals with high levels of antibodies are better at preventing worms establishing in the gut. The test provides an accurate and simple way to select animals which will suffer less from the effects of parasitic worms, and subsequently pass fewer worm eggs onto pasture.

Studies have determined while most animals eventually express a detectable salivary CARLA® response, the timing and intensity is highly variable (Shaw et al., 2012). The observation that this trait was heritable, has led to the assessment of the CARLA® Saliva Test as a means of selecting animals for breeding purposes.

It has been suggested this test represents an improvement over the current technologies for measuring protective immunity to gastrointestinal nematodes in sheep and potentially other domestic animals.

Organic production

Contemplating organic (no chemical anthelmintic) production with regard to internal parasite management in New Zealand conditions requires expert application of the principles discussed in the general sections. It is likely to require significant changes to common stocking and pasture management policies, and far greater knowledge and measurement of parasite clinical effects (e.g. bottle jaw in the case of Haemonchosis) and signs (e.g. faecal egg counts to estimate individual parasite burdens and assess future pasture contamination levels).

Organic production could involve the use of non-synthetic drenches that may assist with parasite management. Currently, no organic drenches reach the threshold for registration as veterinary medicines under the ACVM Act (clinical trial data showing greater than 95% efficacy against particular worm species). As such any potential benefits are more likely to accrue from a holistic effect of the product on the treated animal. For animal welfare reasons some organic protocols allow the use of certain chemical drench actives (e.g. Ivermectin); but the current protocol for use should always be checked with the organic certification agency prior to use.

Bibliography

Barrell GK (Ed). *Sustainable control of internal parasites in ruminants*. Animal Industries Workshop, Lincoln University, 1997. (ISBN 0-86476-099-X)

Fleming P (Ed). *Farm Technical Manual*. Farm Management Group, Lincoln University, 2003. (ISBN 0-86476-150-3)

West DM, Bruère AN, Ridler AL. *The Sheep: Health, Disease & Production*. 2nd Edition. Veterinary Continuing Education, Palmerston North, Publication No. 223, 2002. (ISSN 0112-9643)

Monitoring the success of the management strategy

There is a saying: "If you can't measure it, you can't manage it". Monitoring is an important part of any management strategy.

The specific tests used in monitoring are:

- Faecal egg counts (FEC) including Drench Check
- Faecal egg count reduction test (FECRT),
- Worm counts
- Faecal larval culture and identification

The key tools are trend information around faecal egg counts and faecal larval cultures. These diagnostic tests will measure the success level of your management strategies. Unfortunately there are no reliable methods to diagnostically measure infective larvae on pasture.

The emphasis here is on the specific diagnostic tests for worms but also important are:

- Good observational skills
- Regular weighing of stock or indicator mobs and herds.

Faecal egg counts

Faecal egg counts estimate the worm burdens of sheep or cattle. For flock examinations, faecal samples from a minimum of 10 animals are required because of the way worms are distributed in a sheep population.

However, faecal egg counting has limitations:

- Only mature adult worms lay eggs, so immature worms are not detected
- Identification of worms is limited because the eggs of several species are indistinguishable.

Collecting faecal samples

Clean, impervious containers such as plastic freezer bags or plastic pottles are ideal for collecting faecal samples, or use a faecal sampling kit.

Some points to note:

- Only one sample per container (approximately one heaped teaspoon)
- Faeces must be fresh when collected (still warm)
- At least 10 samples are needed to give a meaningful result for a mob
- Keep samples in a cool place. If they cannot be examined on the day they are collected, store them in a cool place, e.g. fridge, not freezer.

Who does faecal egg counts?

There are lots of ways of having faecal egg counts done—ask your animal health adviser or learn to do them yourself. However, as with any other technical service, the quality and value of the results is only as good as the skill and experience of the person doing the count.

Faecal larval cultures

Larval cultures involve hatching the eggs in faeces, growing the worms to the infective stage in the laboratory, and identifying them. This is the only way to identify the worms present in an animal without killing it. Although the eggs of *Nematodirus* are distinctive, the eggs of the other economically-important worms e.g. *Ostertagia*, *Trichostrongylus, Cooperia* and *Haemonchus,* are virtually identical and are reported in faecal egg counts as Strongylate eggs. Only when the identity of resistant worms and their seasonal pattern is known, can a farm-specific sustainable control programme be designed.

Surplus faecal egg count material from several animals in a mob is usually pooled for a larval culture, so this test cannot give a measure of the worm burden.

A limitation of faecal larval culture examination is that it takes about 10 days.

When to use faecal egg counts and larval cultures

Testing drench effectiveness (DrenchCheck)

Collect 10 fresh faecal samples seven to 12 days after drenching with an oral drench (preferably the lamb weaning drench).

If eggs are found by FEC, then either the drench is not being administered correctly or drench-resistant worms are present. A positive test should be followed by a FECRT.

Faecal Egg Count Reduction Test (FECRT)

Use this test:

- If eggs are present following DrenchCheck
- If drench resistance is suspected at any time
- To check the effectiveness of a particular drench
- To look at the extent of drench resistance on a property.

This test should be conducted by an appropriate adviser to ensure faulty drenching practices are not the cause of the problem. Divide animals into groups of 10-15 individually-identified animals. Check FEC test to ensure egg counts are sufficiently high to give a meaningful result. Weigh animals and drench individually at the recommended dose rate for the drench(es) being evaluated. Collect faecal samples from the rectum of each participating animal and conduct a FEC, seven to 12 days later for orally-drenched lambs, or 12 to 14 days later for calves treated with pour-on drenches.

Larval culture will tell which worms are present and therefore resistant to the drench(es) used.

Monitoring drench programme effectiveness

Use the FEC test to determine the effectiveness of a worm control programme and/or whether a drench is needed. Larval culture will identify which worms are present.

Health check

Worms can cause ill-thrift and/or scouring in stock, but these signs can also be caused by other factors. Determine the cause of the problem before spending money on drenches.

Discuss the problem with your veterinary adviser to determine the cause of the problem before spending money on drenches. A FEC may be part of the investigation.

CHAPTER FOUR

Drenches and drench resistance

CHAPTER OVERVIEW

After reading this chapter you will understand the basis of drench resistance and the concept of using refugia and other management practices to reduce the risk of drench resistance developing. You will also learn about the situations that pose the most risk for drench resistance development so you can take measures to reduce that risk. The last part of the chapter explains the different drench families and the importance of correct administration.

- Drench resistance to all drench families is increasing.
- The risk of drench resistance development can be evaluated and steps taken to minimise it.
- The concept of refugia refers to a worm population not exposed to drenching.
- Using undrenched animals to create a refugia population will ensure there are still non-resistant worms around and this can be a useful tool in delaying resistance.
- Balancing the need to reduce the risk of drench resistance and yet manage worms so production and animal welfare do not suffer involves compromise.
- Use the concepts introduced in chapter 3 to work out ways to find a balance.
- Drenching should be just one part of an overall management plan.
- Knowing the drench efficacy status on your farm is essential; poor efficacy means lost productivity. Continued use of an ineffective drench carries a high risk of accelerating drench resistance development.
- Drench resistance could result in a bigger long-term cost than short-term lower production.

What is drench resistance?

Drench resistance is present when previously susceptible worm populations in the animal survive a correctly applied, standard dose of anthelmintic or drench. The resistant worms do not die but carry on to breed. There will always be some worms with the genetic make-up to be resistant to a particular type of drench.

Over time, resistant worms will breed and pass on their resistant genes to their offspring, while non-resistant worms are killed. This means resistant worms make up an increasing proportion of the worm population on the farm.

Anecdotal evidence from veterinary practitioners indicates drench resistance continues to rise for both sheep and cattle.

Worms resistant to one drench in an action family will be resistant, to a greater or lesser extent, to all other drenches in the same action family—this is called *side resistance*. Worms may be resistant to more than one action family—this is *multiple resistance*. Drench resistance is usually permanent, so reversal to susceptibility is not a usable option.

Prevalence of drench-resistant worms in New Zealand

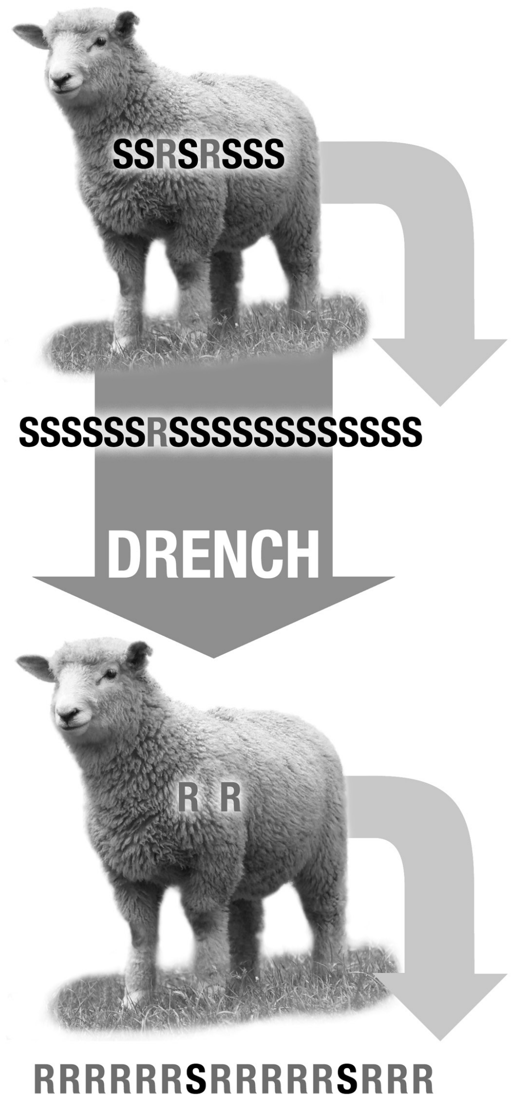
The December 2006 issue of the New Zealand Veterinary Journal presented the results of two drench resistance surveys, one for sheep and the other for beef cattle.

Sheep drench resistance survey

- Survey involved 80 randomly selected farms from North and South Islands. Drenches tested: Ivermectin (full dose), Ivermectin (half dose), Levamisole (clear)
- Albendazole (white), and Levamisole+Albendazole combination; plus untreated control group
- 36% of farms showed no evidence of drench-resistant worms
- Resistance to the half dose of Ivermectin occurred on 36% of farms, and to full dose of Ivermectin on 25%. Resistance was dominated by *Ostertagia*; although *Cooperia*, *Nematodirus* and *Trichostrongylus* were also implicated
- Resistance to Levamisole occurred on 24% of farms and involved *Nematodirus*, *Ostertagia* and *Trichostrongylus*
- Resistance to Albendazole occurred on 41% of farms and involved all the main parasitic worms
- Resistance to Levamisole+Albendazole combination occurred on 8% of farms and involved *Nematodirus, Ostertagia* and *Trichostrongylus*.

Beef cattle drench resistance survey

- Survey involved 62 randomly selected farms in the North Island. Drenches tested: Ivermectin, Levamisole (clear) and Albendazole (white) given orally, plus untreated control group
- 7% of farms showed no evidence of drench-resistant worms. Resistance to Ivermectin occurred on 92% of farms. Resistance to Albendazole occurred on 76% of farms
- Resistance to both Ivermectin and Albendazole occurred on 74% of farms
- Resistance to Levamisole occurred on 6% of farms
- The worms most prevalent in drench-resistant populations were *Cooperia* species
- On 75% of farms *Cooperia* were resistant to both Ivermectin and Albendazole. No *Cooperia* resistant to Levamisole were seen
- *Ostertagia* resistant to Ivermectin were found on four farms, to Albendazole on 15 farms, and to Levamisole on four farms.



How resistant worms become dominant

Tools to delay drench resistance

Refugia

A part of a population unexposed to treatment (anthelmintic) that may reproduce and have offspring. This can exist in an animal as susceptible adult worms or on pasture as infective larvae.

Refugia, when put into practice, involves making sure there are some drench-susceptible worms available to reproduce. The idea is to create a "refuge" for worms so non-resistant (susceptible) worms still remain in the population base. The aim is to ensure this reservoir of drench-susceptible larvae significantly outnumbers drench-resistant larvae on the pasture.

When worms breed in the animal, the gene frequency for drench resistance will be diluted.

Methods to achieve refugia

Refugia can be achieved by not drenching all the animals in a mob every time. How you select animals to remain undrenched is important, and this can be done in a number of ways. You can randomly select a proportion of the animals, e.g. the heaviest, best condition, not to treat, or target the animals to treat by FEC, milk production or LWG.

Using undrenched ewes to graze on pasture previously grazed by drenched lambs will also create refugia, as the susceptible worms shed by the ewes "dilute" the population of resistant larvae left behind by the lambs.

Returning a mob of animals to the same infective pasture, for a week or so post drenching, before or after they go onto "clean" pasture, also promotes refugia. This ensures any potential resistant worms are dilute on the existing pasture, and some unselected worms will be deposited on the next pasture.

Drench intervals should be kept to 28 days or more.

How do we know refugia practice will work?

An earlier trial funded by Beef + Lamb New Zealand showed that leaving 10 or 20% of lambs undrenched resulted in a significantly lower level of drench resistance in the worms on pasture, when compared with all animals being drenched.

This is the first research in the world to show that using refugia as a management tool can dilute resistant worms on pasture.

A major finding of this trial was an increase in the level of larvae on the pasture; some increase has to happen for refugia to work. The essence is to allow enough worms through to dilute the drench-resistant ones without significantly compromising animal productivity.

Recent work from Scotland has shown a production TST and a targeted drenching programme were both able to reduce drenching frequency and maintain levels of production, while slowing down the development of anthelmintic resistance in a farming situation. To apply these practices on your farm will require regular weighing of animals or extensive parasitological knowledge of your farm.

Putting refugia into practice

Exact recommendations on how to create refugia will vary between farms, e.g. when best to leave stock undrenched, what proportion to leave undrenched and what implications there might be for production.

The challenge is to find ways to maintain low levels of pasture infestation yet retain a useful pool of susceptible worms.

It is suggested farmers develop a plan with their animal health advisor on how refugia could be used. This could be based on: the drench resistance status of the worms on the farm, sheep/cattle ratio, stocking rate, other farm enterprises and climatic effects on the worm life cycle, key risk periods to stock from parasitism (i.e. when is it best for some stock to go undrenched), current ewe drenching policy (i.e. can undrenched ewes shedding susceptible larvae be grazed after newly drenched lambs), feed quantity and quality.

The Wormwise Technical Advisory Group believes there are general principles to be followed, and these will produce resultant gains in protecting anthelmintic efficacy:

- If feed quality and quantity is good, lambs are up to target weights and pasture is "clean", it would be an ideal time to leave some lambs undrenched
- The benefit of leaving some lambs undrenched (and a refugia of susceptible worms) is greatest when lambs are going onto "clean" pasture
- If feed supplies are low or poor quality, there is a greater risk parasitism in undrenched stock will impact on production
- If you are not using TST (LWG, FEC or LWT based) to identify animals which require treatment, and want to select animals as a proportion of the mob which won't be treated, start conservatively, i.e. start by leaving no more than 5% lambs undrenched rather than 20%. Leaving too many animals undrenched may create a problem later in the season with accumulated parasites contaminating the pastures
- A maximum of 10% undrenched may be adequate (the trial showed the same good impact on resistant worms whether 10 or 20% of lambs were left undrenched)
- Choose animals in the best condition, i.e. the heaviest, to remain undrenched. These undrenched animals can be drenched next time round and re-join the rest of the mob
- It does not matter if the same animals are excluded at each drenching, as long as their condition is satisfactory. Both animal welfare and animal production losses must be considered
- A comprehensive drench test (FECRT) should be carried out regularly, with frequency depending on drench resistance risk factors on each farm
- Even if a test shows worms on your farm are not resistant to any of the three main drench families, it would be beneficial to create refugia. This is because resistant genes are likely to be present on every farm and keeping them diluted is the best long-term option to retain the efficacy of drenches.

Finding a balance

Leaving a few animals undrenched can add to pasture contamination but it is likely acceptable productivity will continue.

Drench resistance could be a bigger long-term cost than short-term lowering of production. The cost of lower production from leaving some young stock undrenched is going to seem more acceptable as resistance to drenches becomes more widespread.

For example, lower production in the short term may be worth it, to delay the onset of a situation where 100% of a hogget mob is 5 kg lighter because of widespread drench resistance on a farm.

Knockout and exit drenching strategies

An exit drench is a short acting anthelmintic given to an animal treated with a long-acting drench or capsule, after the expected period of protection has expired. The exit drench must be fully effective on your farm and contain drench actives from different drench families to that of the long-acting product. The purpose of an exit drench is to kill parasites that have survived the long-acting drench or capsule treatment i.e. parasites that have reduced susceptibility or resistance to the actives in the long-acting product. This ensures these parasites will not continue to reproduce which reduces, but does not eliminate, the risk of creating a resistance problem on your farm subsequent to use of a long-acting product.

Use of long-acting drenches results in considerably more selection pressure for the development of resistance than use of short-acting oral drenches.

Knockout drenching is the substitution of one routine lamb drench with a drench containing either monepantel or derquantel. Resistant parasites, which have survived and accumulated from the preceding drenches, are then knocked out by the new active.

Knockout drenching has been shown to delay the onset of resistance to the existing routine drenches used. This works by reducing the period of reproductive advantage for resistant parasites over susceptible parasites, thereby reducing the resistant gene frequency in the population. The greatest benefit is seen when a knockout drench is given just as conditions become favourable for larval survival and development on pasture. The ideal timing for a knockout drench will generally be late summer/early autumn, to prevent an autumn larval peak of resistant parasites on pasture.

Quarantine treatment policy

One of the most likely ways drench-resistant worms are brought onto your farm is through introduced stock. A quarantine drenching policy must be part of your worm management strategy. Apply the quarantine drenching policy to all new stock brought onto the farm, including rams. It doesn't matter how long the animals stay on the farm, it takes less than a day to deposit resistant worms on pasture.

Risk factors for drench resistance and their management

This section identifies the risk factors for the development of drench resistance in sheep, and the actions you can take to reduce them.

Similar principles apply for cattle and deer, although at present specific recommendations are still being established.

Risk factors involving ewes

In general, you should avoid routine drenching of ewes in your farming system. Maintaining a healthy, undrenched proportion of the ewe flock is highly desirable to minimise the selection for drench resistance, as this helps maintain a population of unselected worms.

Using long-acting products pre-lambing

Risk factor: high

The treatment of the whole flock of ewes before lambing with long-acting products is an important risk factor and selects for drench resistance. This is supported by trials, the nationwide survey and modelling data.

Post-lambing (docking) treatment of ewes

Risk factor: moderate

Trials show drenching ewes at docking time with an oral drench accelerates the development of drench resistance, compared with not drenching them. In New Zealand farming systems, ewes usually gain immunity to worms by docking time. Not drenching them at this time will ensure eggs, from a mixture of susceptible and resistant worms, are deposited on pasture, but should not result in production losses if animals are well fed.

Ewe drenching at other times

Ewe treatments at other times of the year, such as before mating or midwinter, may increase selection for drench resistance.

Risk reduction

Consider whether drenching ewes at a particular time of year is necessary (e.g. not all farmers pre-lamb drench) and whether other management practices can improve ewe condition without the need to drench. Alternatively, consider treating only part of a flock. The decision on whether to treat each group of ewes should be based on an analysis of all subsets of the flock and their management and potential productivity. This could include pregnancy rank selectives (triplets vs. twins vs. singles), age (hoggets, two-tooths, mixed age) or condition score.

Treating part of each mob will ensure some susceptible worms remain in the system and reduce selection for resistant worms.

In some districts, clinical *Haemonchosis* (barber's pole) can occur in ewes (usually two tooths) over summer, requiring prompt action. The strategic use of narrow spectrum products, e.g. closantel, may be warranted. Consult your animal health advisor.

Older sheep are generally more immune to worms. Well-fed ewes run in a balanced farming system (with cattle and with adequate control of worms in young sheep), do not require routine treatment.

Remember, if feed supplies are low or poor quality, or around lambing time, there is a risk parasitism in undrenched ewes may impact on production and animal welfare. Farmers must be vigilant and discuss options with their veterinarian or advisor and treat ewes where necessary.

Risk factors involving lambs

Preventative drenching of lambs remains the basis of worm control on New Zealand sheep farms. The aim of this system is to reduce the amount of pasture contamination by treating the most susceptible age group to prevent production-limiting parasitism and minimise the worm challenge to all sheep in autumn.

Preventative drenching (5–6 times) from weaning

Risk factor: low to high, depending on drenching policy and grazing management.

Simply counting the number of drenches used is not necessarily a good measure of selection for drench resistance.

Risk reduction

Consider the interval between drenches—28 days is preferable to 21 days, as 21 days is very close to the time it takes for new infections to establish and begin to produce eggs.

If lambs are drenched every 21 days any eggs being shed will generally be coming from worms that have survived the drench. A 28-day interval allows time for susceptible worms to re-infect the host and produce eggs, therefore ensuring a mixture of susceptible and drench-resistant eggs is deposited onto pasture.

Rather than having a lamb-only block (or lambs plus cattle), integrating an area with ewes is beneficial because eggs coming from the ewes are not likely to be drench-resistant if ewes are not being drenched.

While drenching lambs 'on demand' based on FEC is likely to reduce selection for drench resistance, unless monitoring is performed very carefully it is likely to result in increased larval challenge and lowered animal performance.

Low contaminated pasture

Risk factor: high

Low contaminated pasture includes newly sown pasture, crops, cattle areas and "drench and move". Drenching sheep onto "clean" pasture can select strongly for drench resistance. The main way to slow drench resistance is to ensure the susceptible worms on pasture vastly outnumber the resistant ones.

Risk reduction

Consider leaving a small proportion of the heaviest lambs undrenched, or follow the lambs with undrenched older sheep, or drench a few days before the lambs go onto "clean" pasture. This will allow the lambs to ingest some susceptible larvae after drenching and therefore increase the proportion of susceptible eggs deposited onto the "clean" pasture.

Where lambs are grazing "clean" pasture the drenching interval may be extended. Remember to monitor using FEC.

NB: giving fewer drenches on "clean" pastures may be just as selective for drench resistance as giving more on "dirtier" pastures. If lambs are shifted immediately after drenching, it is preferable to choose paddocks previously grazed, or to be grazed soon after by undrenched ewes. This will reduce the selection for drench resistance.

General risk factors

Buying stock with resistant worms

Risk factor: high

Sheep

Trading of sheep must be considered a high-risk factor, as more than 60% of sheep farms in New Zealand have drench resistant worms of some sort. What is more, there are now farms which have documented severe triple-drench resistance in more than one parasite species.

Cattle

Most, if not all, Cooperia infecting cattle are resistant to the macrocyclic lactone (ML) anthelmintics, and many are also resistant to the benzimidazoles (BZ). However, a major concern is the recent development of ML resistance in Ostertagia. No current survey data is available, but at least 7 confirmed cases have been documented in the North Island. Unfortunately, levamisole has variable, and often poor, efficacy against this parasite and so dual combination products containing only a ML and levamisole cannot be relied upon to remove resistant Ostertagia.

Deer

Similarly, the identification of ML resistance in Ostertagia is a significant concern in the deer industry. Due to the need for slaughter studies (and their associated cost) to determine the parasite status in deer, widespread surveys have not been undertaken. However, worm status has been investigated on a dozen farms in both the North and South Islands in the last decade, and all have shown some degree of ML resistance in Ostertagia.

Risk reduction

Following a strict quarantine procedure for all incoming stock, and holding them off pasture for 24 hours, is now essential to minimise the risk of introducing resistant parasites onto your farm. Try to avoid putting the new animals onto clean pasture.
In sheep, quarantine treatments MUST involve the use of a product containing either monepantel or derquantel. (Current best practice options for quarantine drenching of sheep, cattle and deer are found in Chapter 3).
The risk (sheep) is also able to be reduced by buying stock from farms able to document a low drench-resistance status.

Using a single active

Risk factor: moderate to high

Using single active drenches will always be more selective for drench resistance than using a combination with another effective drench family.

By far the best time to use combination drenches is when they are still effective on their own, i.e. when drench-resistant genes are rare in the worm population. Saving combination drenches until you need them is ***not*** the right approach.

Risk reduction

Regular drench resistance testing will tell you the resistance status on your farm and whether it is changing. All the evidence available indicates combination drenches are better for slowing the development of resistance.

Triple active drenches will be better than double actives, but will also be more expensive. The best time to use combinations is when resistance is rare (i.e. when single active drenches are still working). The extra expense provides insurance against the future development of resistance. The continuous use of combination drenches needs to be accompanied by routine drench testing of all single active drenches to monitor whether the resistance status of the farm is changing.

Continued use of ineffective product

Risk factor: high

Where drench resistance is established on a farm, continued use of an ineffective product can rapidly increase the gene frequency of drench-resistant worms.

Risk reduction

Use regular drench checks (at least once a year) and drench tests to determine drench efficacy on farm.

Other practices to reduce or delay worm resistance to drenches:

- Avoid drenching lambs onto "clean" pasture unless you have a plan to introduce/maintain refugia, e.g. leave a proportion undrenched or follow with undrenched ewes
- Avoid drenching more frequently than every 28 days unless there is a special need
- Avoid treating the whole flock with a long-acting drench before lambing
- Use effective combination drenches, even if drench resistance has not been identified on your farm
- Weigh animals and apply the correct dose, using the correct technique, as per the label instructions.

Drenches

There is a wide variety of drenches on the market with a bewildering array of different brand names. You need to know a little about the different sorts to help you choose appropriately. By understanding the different categories described below and reading the product label, you will have a better idea of what to use.

Drench is another name for anthelmintic—a substance that kills target worms when administered to the animal.

Once the animal has absorbed the drench from the gut or injection site (or through the skin for pour-ons) the chemical enters the blood stream and is circulated around the body. It affects the worms when they pass through the gut of the animal.

Drenches can be divided into their chemical families or action groups—each having a different effect on the worm.

They can also be classified according to how many worm types they target (broad spectrum or narrow spectrum) and whether they are short or long-acting (persistent).

Broad spectrum drenches are effective against a wide range of different internal parasites, whereas narrow spectrum drenches kill only a limited range of parasites.

Broad spectrum drenches fall into one of five action groups: benzimidazoles, levamisole/morantel or macrocyclic lactones (MLs), amino-acetonitrile derivatives (AADs) and spiroindole (Si).

Benzimidazoles, or BZs, are sometimes called white drenches although not all are white. They act by preventing the worm from absorbing nutrients, causing it to starve to death.

The BZs generally have broad spectrum activity against most important worms in sheep and cattle, although activity against lungworm and inhibited worm larval stages may not be as good as the MLs. Albendazole also has some activity against liver fluke, while triclabendazole is only effective against liver fluke. The other BZs have no fluke activity.

Levamisole and morantel are sometimes called clear drenches, although, again, not all are clear. They affect the worm's nervous system and paralyse it. Levamisole is effective against most worms with the exception of inhibited L4 larvae of *Ostertagia* in cattle. This should be a consideration in the prevention of Type II ostertagiasis in cattle (refer to chapter 2). However, activity against inhibited *Ostertagia* (*Teladorsagia*) larvae in sheep is satisfactory. Morantel has a similar spectrum to levamisole.

Macrocyclic lactones, or MLs, include avermectins and milbemycins. They are sometimes called endectocides as they have activity against both internal and external parasites. They work by paralysing the worm, but through a different mechanism from the clear drenches. They are highly effective against worms, including lungworm and inhibited larval stages in both sheep and cattle.

Amino-acetonitrile derivatives (AAD), of which monepantel is the first member, act on a particular nicotinic acetylcholine receptor subunit (Hco-MPTL-1) that occurs only in nematodes and not in other organisms. Monepantel blocks these receptors and the affected worms are paralysed and die or are expelled. Monepantel has a unique mode of action compared with all other available anthelmintics.

Spiroindoles (SI) is the latest class of anthelmintics to be developed. The first member of this group is derquantel and its mode of action sets it apart from other anthelminitic families. Derquantel acts as a nicotinic cholinergic antagonist, by blocking the effect of acetylcholine, to cause flaccid paralysis and expulsion of nematodes.

Derquantel has excellent efficacy against most significant nematodes in sheep, including *Haemonchus contortus, Trichostrongylus colubriformis* and *Nematodirus* species. However, derquantel has less than 95% efficacy against *Teladorsagia (Ostertagia) circumcincta* and some large bowel worms. The combination of derquantel with a second anthelmintic, from a different chemical class, into a single product provides a better spectrum of anthelmintic activity.

Combination drenches were developed because of the emergence of drench resistance, and contain mixtures of different action groups formulated to contain an effective concentration of each component, in a stable product. Worms resistant to one active ingredient will generally be killed by the other. Combinations of two or three broad spectrum action groups are now available as oral drenches, and ML/levamisole combinations are available as pour-ons and injectables for cattle.

Narrow spectrum drenches include clorsulon, closantel and praziquantel, which are used for killing specific worms such as liver fluke or tapeworms. Closantel has persistent activity against *Haemonchus* (barber's pole worm).

Drench groups and their active ingredients

Drench family	Active ingredients of group	Drench family	Active ingredients of group
Broad spectrum		**Narrow spectrum**	
Benzimidazoles	Albendazole febantel fenbendazole mebendazole netobimin oxfendazole ricobendazole	Benzmidazole	Triclabendazole
Levamisoles	Levamisole morantel	Benzoenedisulponamide	Clorsulon
Macrocyclic lactones	Abamectin doramectin eprinomectin ivermectin moxidectin	Salicylanilide	Closantel Oxyclosanide Niclosamide
Amino-acetonitrile derivative	Monepantel	Nitrophenolic compounds	Nitroxynil
Spiroindoles	Derquantel	Pyrazinoisoquinoline	Praziquantel
		Tetrahydropyrimidine	Morantel

Formulations

Drenches can be administered to sheep and cattle by a variety of different methods. Drench formulation and method of administration can make a difference to drench efficacy and length of activity against different worm species as well as the withholding period. For this reason it is important to read the label carefully and to follow the specific recommendations for each particular product.

Drench administration

If a drench is to be effective it has to be administered correctly.

Key points are:

- Do not under-dose. Weigh representative stock to ensure correct dose is given
- Select a dose volume based on the bodyweight of the largest animals in the group
- Read drench labels carefully
- Set and check the reliability of the drench gun by squirting several doses into an accurate measuring vessel
- Re-check the dose delivery each day the gun is used or after every 200 doses, whichever comes first
- Ensure your drench gun receives regular maintenance.

Read drench labels carefully

Important points to check:

- Active ingredients
- Dose rate (ml/kg live weight)
- Withholding period
- Safety precautions for operators
- Storage and handling, e.g. shake well before use
- Expiry date
- Storage conditions.

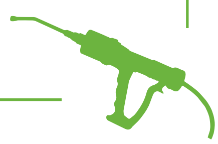
Wormwise agreed principles

- Healthy animals harbour worms and always will—eradication is neither an appropriate goal nor an achievable one.
- Well-fed animals are less affected by worms than those under nutritional stress.
- Older animals are generally less susceptible to worms than younger ones, and at times, can be used to reduce the number of infective larvae on pastures.
- Animals vary in their susceptibility to worms (genetic variability).
- Animals can be selectively bred for resistance or resilience to roundworms.
- When breeding for a characteristic, increased selection pressure will result in more rapid change occurring (applies both to livestock and worms).
- Breeding for a single trait leads to a more rapid change than breeding for a combination of traits.
- Most of the year there are more worms, in the various life stages, on pasture, than inside the animals.
- Each anthelmintic is a finite resource and should be used to achieve the greatest sustainable benefits for the farmer.
- The way in which you use drenches and manage worms can change the rate at which you select for resistant worms.
- Every farm is unique so effective worm management may be different for each farm.
- Use of long-acting drenches may hasten the development of drench resistance.
- Once present on a farm, worm resistance to anthelmintics is permanent.

Key points

Parasitism is a major cause of production loss in livestock.

Based on current information, many New Zealand farmers are using anthelmintics in a manner which will result in drench-resistant worms and drench failure.



Glossary

Abomasum	The fourth stomach of a ruminant
Anthelmintic	Also known as a drench. A drug used to kill internal parasites. Some are also effective against various external parasites
Benzimidazole	A group of anthelmintics also called white drenches or BZs
Broad spectrum	A term used to describe the drenches that control a large number of internal parasites
Cestode	The scientific classification for tapeworms
Challenge	Exposure to parasites, either by artificial (experimental) infection or from grazing worm-contaminated pastures
Clear drench	A common name for the levamisole drenches
Clinical parasitism	The visible effects of worms such as scouring or weight loss, or reduced weight gain
Combination drench	A specially formulated mixture of two or more anthelmintics
CRC	Controlled release capsule
Drench Check	A check on drenching efficacy by doing a faecal egg count after drenching
FECRT	A test for drench resistance parasites. Faecal egg counts are done before and after drenching
Epg	Eggs per gram of faeces
FEC	Faecal egg count; a measurement of roundworm eggs in faeces, expressed as eggs per gram (epg)
Host resistance	The varying ability of a host animal to resist infection by a disease-producing organism such as a roundworm
Immunity	The ability to resist and overcome infection
Larva	An immature or juvenile stage (plural: larvae)
Larval culture	A laboratory procedure involving the incubation of worm eggs in faeces until they develop into the infective larval stage, at which time they can be identified
Levamisole	A group of anthelmintics that includes levamisole and morantel; also called clear drenches
Macrocyclic lactones	A group of anthelmintics that includes the avermectins and milbemycins; often referred to as MLs
Narrow spectrum	A term used to describe the drenches that control only a small number of internal parasites
Nematode	The scientific classification for roundworms
Peri-partum rise	An increase in worm egg output by adult ewes that occurs around lambing time
Prepatent period	The time from when a sheep ingests a worm larva to when worm eggs appear in the dung
Refugia	A worm population not exposed to drenching. Using some undrenched animals to create a refugia will result in non-resistant worms remaining in the population, and this can be a useful tool in delaying resistance
Subclinical parasitism	The unseen effects of worm infection, which can reduce weight gain and suppress appetite
Susceptible	An animal or parasites lacking resistance, i.e. animals that are readily infected by parasites, or parasites that can be killed by a drench
Trematode	The scientific classification for flukes
White drench	A common name for the benzimidazole group of anthelmintics
Worms	Roundworms

wormwise
national worm management strategy

beef+lamb new zealand

Ministry for Primary Industries
Manatū Ahu Matua

AGCARM

NZVA
New Zealand Veterinary Association