# 2. 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 get infected by a variety of different worm types. Worm eggs pass out in the animal's dung onto pasture, and animals get infected when they swallow infective (L3) larvae that have developed in the dung and get onto that pasture.

- The numbers of larvae on pasture are affected by weather. Warm moist conditions speed up larvae development resulting in greater numbers of eggs developing to 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 and in special cases even less.

- The numbers of eggs and larvae present on pasture are 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 round worms (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.

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

| | **SHEEP** | **CATTLE** |
|---|---|---|
| **STOMACH** | *Haemonchus* | *Ostertagia* |
| | *Ostertagia (Teladorsagia)* | *Trichostrongylus* |
| | *Trichostrongylus* | |

| | | |
|---|---|---|
| **SMALL INTESTINE** | *Trichostrongylus* | *Cooperia* |
| | *Nematodirus* | |
| | *Cooperia* | |

Scientists have told us recently that 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 what most people know it as.
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.*

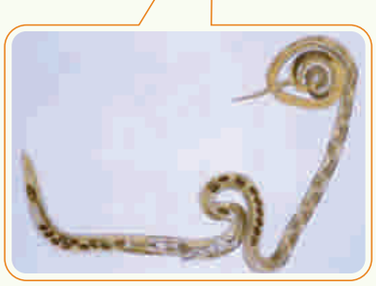
Although worms are often referred to by their scientific name, some have common names as well. For example, another name for *Haemonchus* is the Barber’s Pole.

Lungworms are another type of round worm that live 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.

## Geographic variations

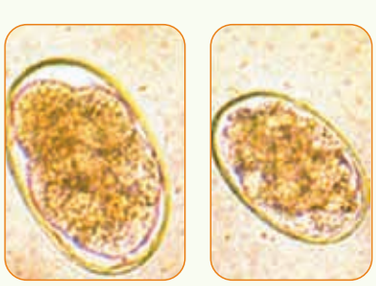
Most of the worms listed occur and cause problems in all areas of New Zealand. However, two – *Haemonchus* and *Cooperia* – are more of a problem in the warmer areas of the north because they require a higher temperature range for development. *Nematodirus* causes more problems in the colder south as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

Female worms are sexually mature and start laying eggs on average around 21 days after being eaten



Once in the gut L3 larvae moult to L4 (immature worms) which finally mature into adult worms

The eggs pass out in the dung



L3 larvae may survive for long periods, sometimes even longer than a year.

In the dung pat larvae hatch from the egg and go through 2 moults to become infective L3 larvae
( egg ➡ L1 ➡ L2 ➡L3 = 1 -10 weeks depending on environmental conditions )

The infective larvae migrate onto the herbage to be eaten by grazing animals

# The life cycle of round worms

The common round worms of sheep and cattle have three stages in their life cycle: egg, larva and adult. The adult stage is the worm that lives in the gut of the animal, You may see them when you cut open the stomach (abomasum) or small intestine of a sheep.

The immature worm hatches out from an egg in the dung pat. At hatching it is called a larva and for most worm species it will go through four larval stages. The first three stages of development take place in the dung pat and the fourth one inside the animal.

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 dews 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 then 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 huge.

*Nematodirus* has a life cycle which is slightly different 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 round worms.

Eggs of *Haemonchus/Barbers Pole* are different from other worm eggs in that they require a relatively higher 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 mucus discharge from the nose.

# Survival of eggs and larvae

The development of the worms from egg through the larval stages requires a moist environment and occurs at different rates at different temperatures. At low temperatures development is slow, where as in warmer temperatures it is faster. Temperatures of 20-25ºC are 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. Most eggs on pasture die during cold weather (average air temperature less than 10ºC). 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.

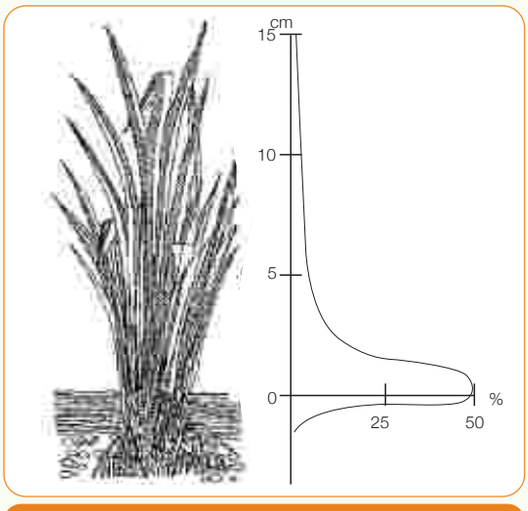
Infective larvae (L3) are relatively hardy. Once the larva has reached the infective third stage (L3), temperature and moisture will determine how long it survives.

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 have. 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. Refer to M&WNZ R&D Brief 1. The effect of pasture species on lamb parasitism.

Most larvae are found in the first 2 cm of pasture height or in the first 1 cm 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 type of grazing management.




**The vertical distribution of infective larvae on grass.**

# The prepatent period

Typically it takes around 21-28 days from when a sheep ingests a worm larva to when worm eggs appear in dung samples.
This is called the prepatent period.

**It is important for two reasons:**

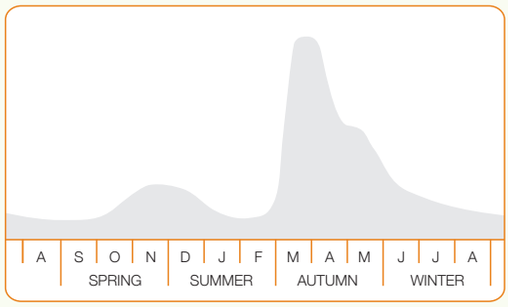
- The commonly recommended interval of 28 days between drenches in young stock is aimed at minimising pasture contamination with worm eggs.

- Worm egg counts are at best a picture of the levels of larval challenge on pasture three weeks ago. You may think sheep are free from worms but under the right conditions, they could have picked up a considerable burden. Naturally, if a sustained action drench was used, the period from drench to eggs in the dung is longer, being the length of action plus the 21-28 days.

# 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 conditions for larvae so their numbers on pasture increase. Therefore numbers build up through summer and early autumn but drop if hot dry weather occurs.

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




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

The numbers of eggs and larvae present on pasture are 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 pasture. 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.

# 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 numbers of worm eggs in faeces are 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 an immunity to worms, and so carry fewer numbers and pass fewer worm 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 peri-partum rise in egg counts (PPR) that occurs usually about mid-lactation. By the time of weaning, the ewe's immune response has recovered and egg counts return to normal.

Because of the peri-partum rise in eggs produced, there is a corresponding increase in numbers of larvae on pasture so that when the lambs start grazing there is a new generation of infective larvae on the pasture ready to infect them.

The PPR is greater for ewes with multiple lambs and young ewes having their first lamb.

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.

# Seasonal pattern in cattle

The seasonal pattern in cattle is similar to that of sheep though generally the autumn peak is a little later and possibly not quite as dramatic.

Calves born in spring get 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 the calves get re-infected. This results in an even heavier burden for the calf. The eggs from these worms cause a large peak of larvae on pasture in May/June.

As the calves mature they start to develop some resistance to worms and the 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 so are 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 larvae on pasture and as worms in the abomasum) occur later in about October, and drop off soon after. So it's 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 with larvae.

Climatics in different parts of the country have some effect on the patterns. Larval development on pasture is more rapid and continues for longer through the year in warmer areas.

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

# Specific worm types

## *Haemonchus*

Called Barber's Pole worm because of its Barber's Pole appearance.
Blood-sucking.
Lives in abomasum (4th stomach).
Quite large (20-30 mm).
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. Haemonchus is a blood-sucking worm which 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 also known as Teladorsagia in sheep*

Called brown stomach worm
Female worm lays 50-100 eggs per day.
Lives in abomasum (4th stomach)
Quite small (~10 mm)
The L3 larvae of Ostertagia are resilient and able to survive freezing on the pasture and dry conditions. In the sheep, adults can become arrested or inhibited for varying periods. They resume activity when environmental conditions become more favourable.
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 is the most significant worm for New Zealand cattle. The disease Ostertagia 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 cause loss of appetite, poor feed conversion and weight loss. Type I Ostertagiasis is of most importance in summer and autumn.

Type II 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. Because it is the maturing larvae that cause the damage, not the adult worms, their presence will not be detected by faecal egg counts (FEC).

## *Trichostrongylus*

Called black scour worm.
Adult female worms lay 100-200 eggs per day.
There are two common strains of Trichostrongylus. Adult Trichostrongylus axei worms (also called stomach hair worm) live in the abomasum, and Trichostrongylus colubriformis (black scour worm) live in the small intestine. Both cause damage to the lining of the gut.
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. The effects of Trichostrongylus in cattle are intermediate between Ostertagia and Cooperia.
However, Trichostrongylus worms can be very damaging in sheep.

## *Nematodirus*

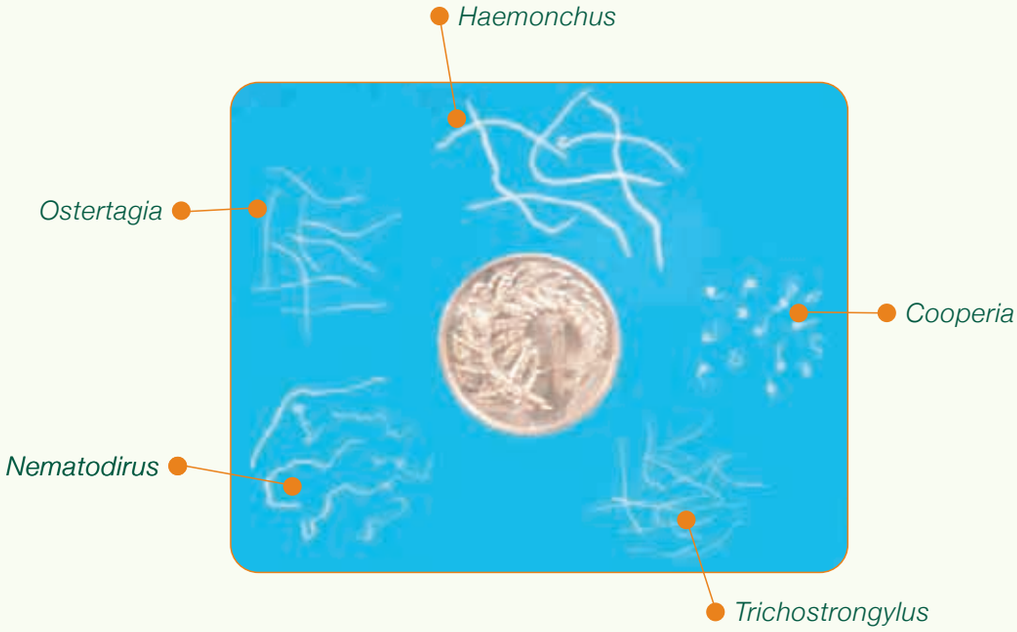
Called the thin necked intestinal worm.
The female worm in the small intestine lays 25-30 eggs per day. These pass out in the dung.
The larvae develop to 3rd stage (L3) in the egg shell over a period of two months or more. The combination of egg shell and L3 sheath make it able to survive desiccation and cold. It survives winter in large numbers. This over wintering 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 is 10-15 mm long and is 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 they can lay large numbers of eggs and large populations can develop, making Cooperia a significant worm in intensive cattle farming systems.

## Lungworms

The major lungworm in New Zealand is Dictyocaulus (D. filaria in sheep and D. vivparous in cattle). Dictyocaulus worms are white, long (several centimetres) and thin with few identifying features. They are commonly found in frothy material in the airways in 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 are passed out in the faeces. They develop on pasture and are eaten by the animals. Larvae travel from the gut through the tissues to the lungs.


Haemonchus
Ostertagia
Cooperia
Nematodirus
Trichostrongylus

# Liverfluke

The adult liver fluke (*Fasciola hepatica*) is a flat leaf-shaped parasite (about 20 mm x 10 mm) 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 get infected they must graze damp areas where the snail lives.

Eggs from the adult fluke pass out in the faeces onto pasture where they can get eaten by the snail host. After going through several developmental stages inside the snail and on the pasture, the infective stage (called metacercariae) on the pasture 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. In areas where the average temperature is higher than 10°C, they can be present all year round.

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. Usually by about eight months of age, animals 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.