Deer Parasite Management

Information Booklet

Deer Industry New Zealand

NZDFA
NZ Deer Farmers Association

P2P

These notes were compiled following a workshop with leading New Zealand deer veterinarians and parasitologists. A literature review was done to expand the details of the document.

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Contents

How to use this document

Please use this document to help with decision making around parasite management that will suit your farm situation.

We strongly recommend that you use this in conjunction with the Wormwise information book.

http://wormwise.co.nz/wp-content/uploads/2014/06/wormwise-handbook-July2019.pdf

We also recommend that you work with your vet, using the information in this booklet to determine the best drenching, monitoring and management programme for your farm.

Attempts have been made to keep this document user-friendly and avoid too much technical jargon. However, some people are interested in the scientific evidence behind the statements. This is especially the case with veterinarians who might be helping you understand the information and make decisions that suit your farm. The areas in grey boxes contain more technical details for those who would like to see what science is available or gain a more in-depth understanding of topics covered.

This document will be constantly updated. If you are reading a printed copy please check the publication date and, if some time has elapsed, check for latest updates on: https://deernz.org/deer-hub/health/major-issues/parasites/

Integrated farm management

Parasite management is just part of animal health planning which in turn is part of whole-farm planning. Different aspects of management shouldn't be considered in isolation. For example, what impact do decisions have on financial outcomes, pasture production and productivity, environmental sustainability and lifestyle?

Example: Impacts of specialist weaner feed decisions

Depending on the farm location, a summer/autumn feed system might include a specialist quality feed (e.g. lucerne, red clover, chicory) that hinds and fawns can be brought onto before weaning and fawns carry on after weaning. This can affect the production system in many areas. Better nutrition and parasite control will be one outcome, while better hind condition can improve conception rate and lead to earlier fawning the following year. Fawns that grow better post weaning will reach target kill weights earlier, opening up space during summer for other classes of stock or spelling pasture in drought-prone areas. Deeper-rooted forages can also increase animals' mineral intake, reducing potential for deficiencies. A carefully planned summer crop in the right environment can improve soil structure, organic matter and nutrient-holding potential of the soil and reduce runoff of sediment, phosphorus and pathogens, and reduce nitrate leaching.

Introduction

In the early years of deer farming it was found that deer suffered few issues with gut nematodes but could rapidly succumb to lungworm. Thus, lungworm control has been the main emphasis of parasite management on most deer farms with little attention paid to gut worms. It is now evident that gut (gastrointestinal) worms are a significant health issue for farmed deer. Whether it is due to the farming practices used, continual stocking of deer on improved pastures, selective breeding of deer that are more susceptible to parasites or adaption of parasites over the past 40 years of deer farming is not clear, but their management is now a critical part of deer farming practice.

Effective parasite management on deer farms requires an understanding of the relationship between the animals, the parasites and the environment. All deer farms will have some level of parasite contamination and it is neither desirable to allow this to get too high, nor to attempt to completely eradicate it. The challenge is for each farmer to achieve the right balance for their property.

Parasite management principles for deer farms are similar to other livestock farming systems. Many deer farms now have parasites that are resistant to one or more drench family actives and protecting against parasite resistance should be part of any farm plan. There is an excellent resource in "Wormwise" that describes parasite management principles for sheep and cattle. These are equally applicable to deer farmers with a few differences.

There has been little research done on parasitism in deer specifically. Much of what is known and recommended has been extrapolated from other species and from general farming practice. This document summarises current understanding and recommendations for parasite control in deer, drawing largely on consultation with parasitology researchers and deer veterinarians.

General goals of parasite management

- Minimise production losses due to parasitism
- Manage pasture contamination and therefore larval intake by susceptible animals
- Maximise the ability of the animal to grow and develop natural immunity to parasites
- Protect the ability of drenches to kill parasites

My goals

e.g. Number of drenches, pasture rotation, pasture contamination, faecal egg counts....

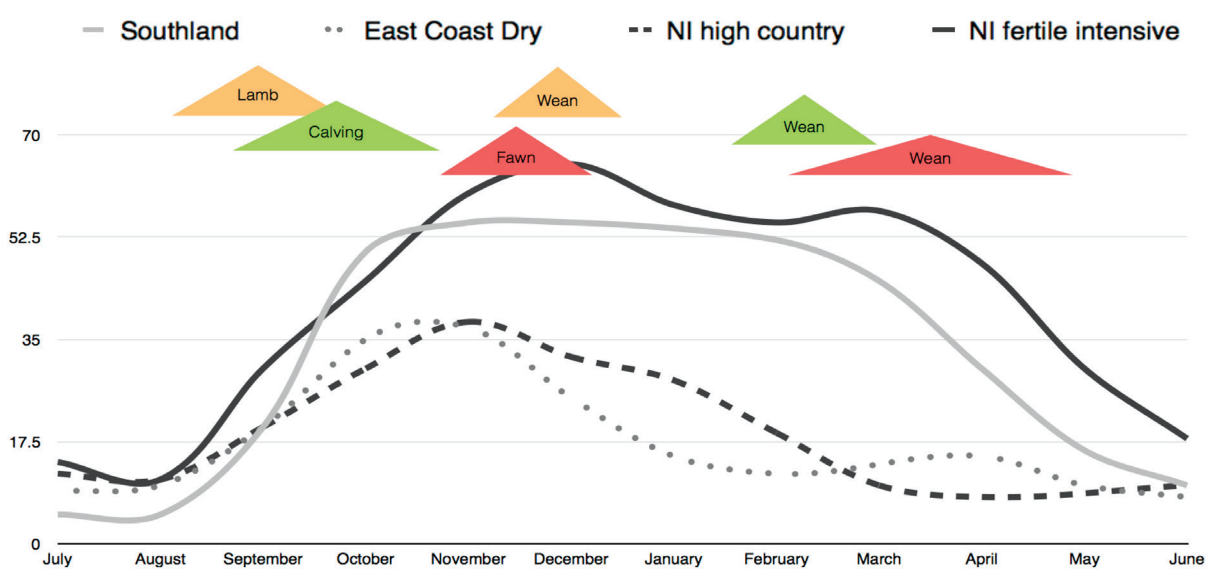
Key differences between deer, sheep and beef systems

Deer are tightly seasonal breeders and this has implications on the availability and quality of feed for young animals as well as the pattern of worm development in the animal and the environment.

While calving and lambing dates can be manipulated to suit the farm environment, deer are much more tightly controlled by daylength. Lactating hinds have a feed requirement of approximately twice their maintenance requirements and increased requirement occurs during mid to late summer and into autumn. Fawns will start to graze pasture and be exposed to their first parasite larvae a few weeks after birth and this will increase to significant pasture intake during mid to late summer. Pasture growth, quality and moisture content vary significantly across farms at this time of the year and this will impact the level of infection in young deer.

Weaning practices on deer farms vary from weaning in late February, to a "natural" weaning system in which young are not physically removed from the hinds. Generic recommendations such as "drench at weaning" cannot be applied across farms. Weaning date and age are likely to affect the ability of fawns to cope with parasite challenge and this needs to be understood on individual farms. In some cases, significant levels of parasitism may occur prior to weaning in March.

During fawning/calving, hinds are set-stocked, which in some cases will be for up to three months. Minimal intervention occurs during this time as it can lead to mis-mothering. This has implications for pasture management and quality, and exposure to parasite larvae. It also means that hinds with young at foot are often not closely inspected from late October until February or later.



pasture quality	good	good	very good	very good	good	declining	declining low	low	low to moderate	moderate	moderate	good
parasite risk	low (cold)	low (cold)	low	moderate	moderate	low (dry)	low (dry)	low (dry)	increasing high (wet summer)	very high	high	decreasing

Relationship between pasture growth, lambing, calving and fawning, feed quality and risk of parasite infection on different classes of land. Pasture quality is a combination of energy density (MJME/kgDM) and digestibility (%) which also affect palatability.

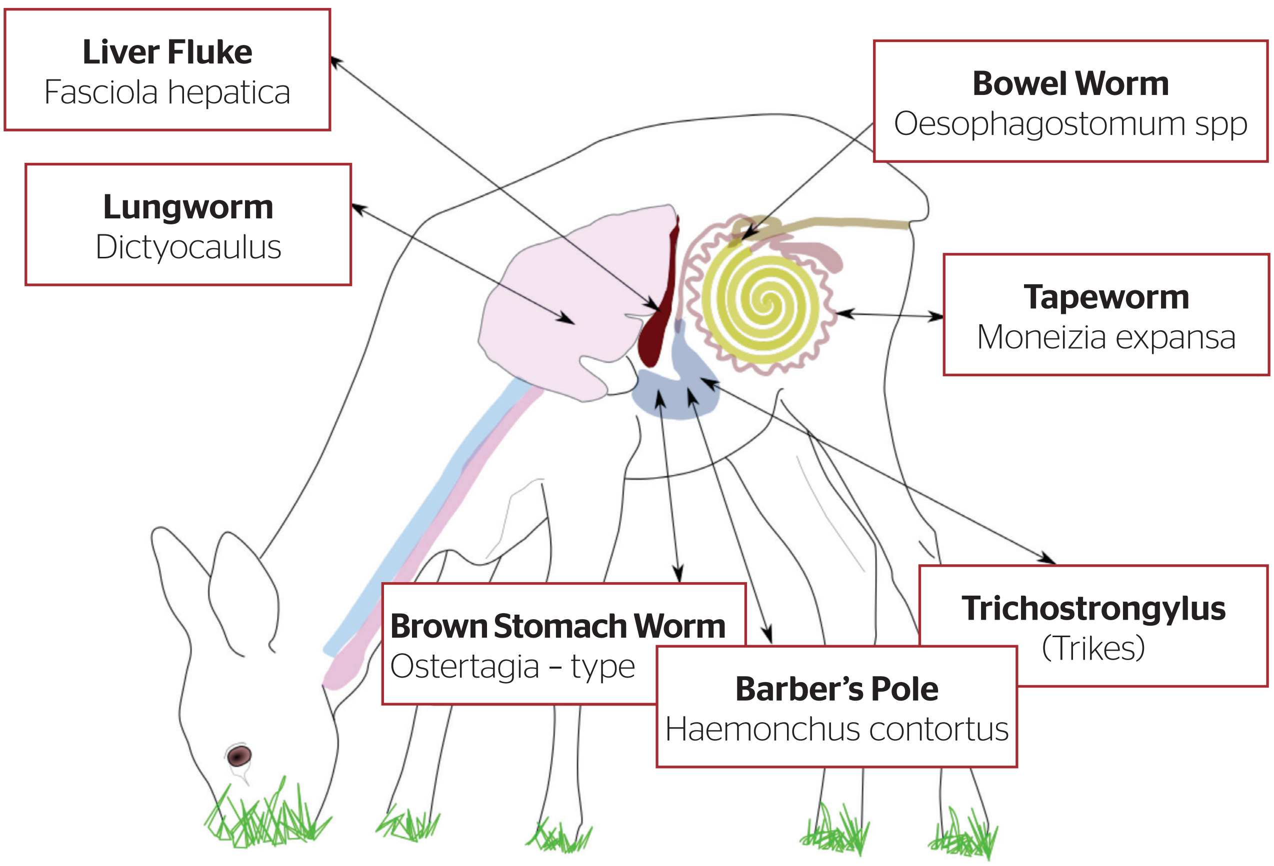
The generalized diagram above illustrates the relationship between birth and weaning and the available feed, feed quality and parasite risk on different classes of land and intensity of management. Note, this is very generalized and every farm will be different depending on the climate and species of forages grown and how they are managed. In general, hinds fawn during the time of year with highest pasture growth and are lactating at the time of year when pasture quality is low in both ME and protein.

The parasites that affect deer

Deer are affected by a range of parasites, some of which are shared with sheep and/or cattle. At least 35 species of parasite have been recovered from deer. Fortunately, not very many have been found to cause major health issues and those that do are pretty well confined to deer with little cross over with other livestock species.

The most problematic parasites of deer are lungworm and Ostertagia-type stomach worms. Other significant problems can occur with different parasites under certain circumstances, e.g. liver fluke can be a problem on the West Coast. Oesophagostomum has caused issues in the Manawatu.

The diagram below shows some of the major parasites that can be found in deer.



Lungworm

Dictyocaulus eckerti

Looks like: Adults in lungs are easily seen long, white, thread like.
Where adults are found: Airways in the lungs.
Lifecycle: Direct.

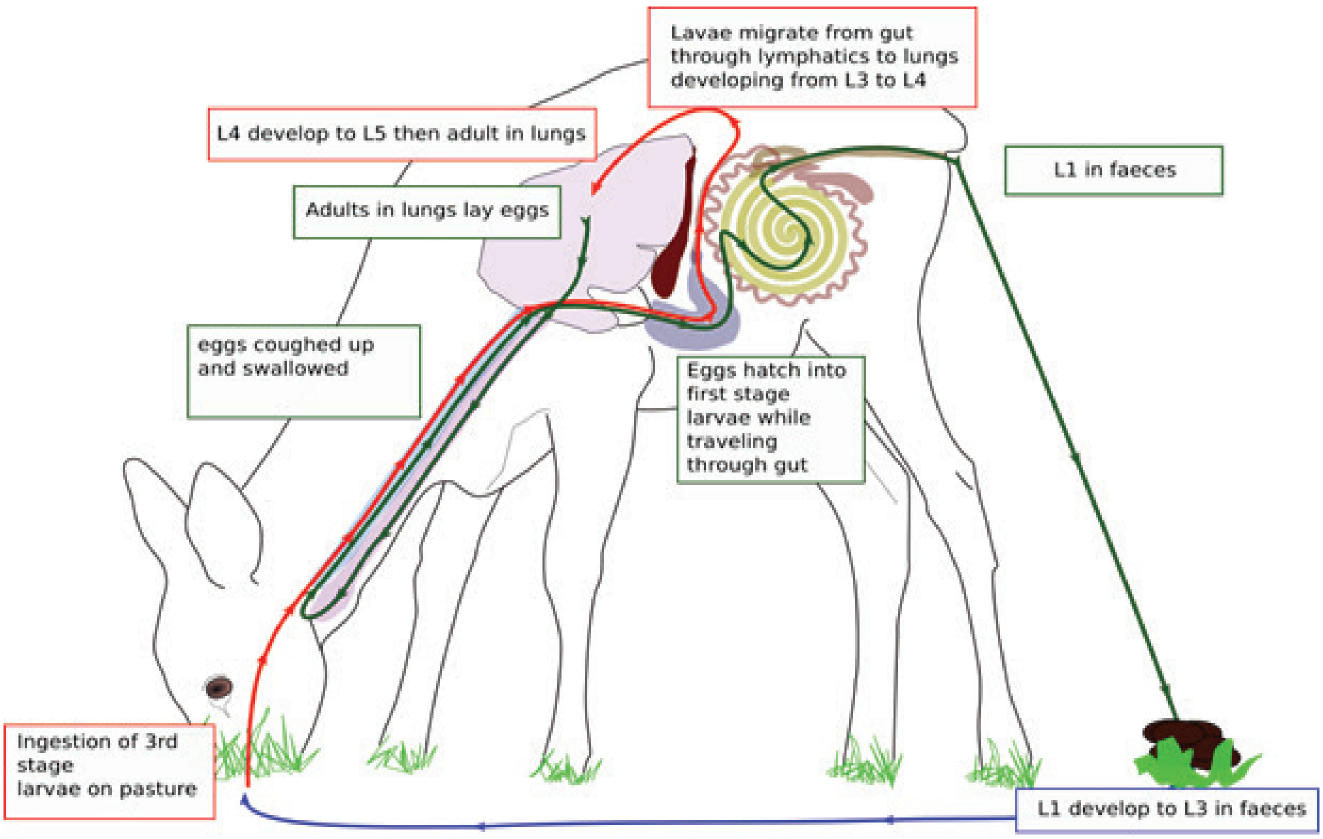
Eggs laid in the lungs, coughed up and swallowed. Hatch into L1 in gut and pass as L1 in faeces. In faecal pat, develop into L2 then L3. L3 move onto pasture and are ingested by the deer. The larvae migrate through the intestinal wall into the lymphatic system and through to the lungs. During this migratory stage, anthelmintics may not be effective. Larvae then develop to L5 and then adult stage in the airways.

Preferred climatic conditions: Moist, temperate, withstands cold. Wide geographic spread.

Pre patent period: 23 to 28 days from ingestion to larvae in faeces.

Time to develop on pasture: 5 days (under optimum conditions) to several weeks.

Survival on pasture: Susceptible to drying and freezing. Can over-winter on some pastures or in animals.



Schematic diagram of the lifecycle of lungworms in deer. The rumen has been removed in this diagram.

Affects deer by: Causing inflammation and blockage of the airways. Infection can build up very quickly when young susceptible animals graze contaminated pastures under warm, moist conditions.

Clinical signs: Cough, especially after running, failure to thrive, reduced weight gain, reduced appetite, lethargy.

Development of immunity: Good following exposure in otherwise healthy deer (immunity establishes at around 9 – 12 months of age). No immunity until exposure has occurred. Immunity can wane during times of stress even in adult animals. Adult deer shed small numbers of larvae and can be a source of contamination.

Other hosts: Can be picked up by cattle but generally grazing with any other species reduces that contamination level on pasture. Cattle lungworm can establish in deer at low numbers and is not generally a problem.

Ostertagia-type : Brown stomach worms (Osters/Tellies)

Teladorsagia (Ostertagia) circumcincta
Ostertagia leptospicularis, O. kolchida, O. ostertagi, O. lyrata
Spiculopteragia asymmetrica, Spiculopteragia spiculoptera, S. mathevossiani
S. (Apteragia) quadrispiculata

Looks Like: Slender brown 7 –12mm.

Where adults are found: Abomasum (True stomach).

Lifecycle: Direct.

Adult females in the abomasum lay up to 5,000 eggs per day. Eggs pass through gut into faeces and hatch in faeces to L1, then L2, then L3. L3 moves onto pasture and are ingested before developing to L4, L5, then adult in the abomasum. The L4 stage may burrow into the lining of the abomasum and have a period of suspended development. Anthelmintics are not very effective against L4 in the abomasal lining.

Preferred climatic conditions: Warm and moist for development outside host, a wide geographic spread. Well adapted to cool climates.

Pre patent period: 21 days. But may be considerably longer if larvae go into “hibernation” in the stomach.

Time to develop on pasture: 5 days to several weeks.

Survival on pasture: 3 to 12+ months. L3 are resistant to climatic conditions but L1 and L2 are susceptible to drying out and freezing. Temperatures above 10°C and moisture are required for development. L3 are double sheathed and cannot feed. Warm conditions will increase the rate of metabolism causing them to die off quicker. L3 can overwinter on pasture.

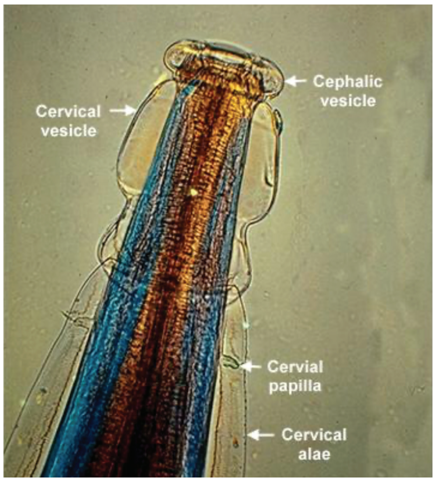
Affects deer by: Altering (increasing) the pH (making it less acidic) of the abomasum decreasing the digestion of food and potential impacts on microbes entering the abomasum from the reticulorumen.

Clinical signs: Light infections have negligible effects. As the rate of infection increases due to higher pasture burdens, reduced weight gain and decreased appetite occur. Severe infections result in weight loss, poor coat, bottle-jaw and soft faeces. Adult deer under stress can show signs of chronic weight loss that does not appear to respond to treatment. This can be confused with Johne's disease.

Other hosts: Cattle can share some of the Ostertagia-type species.

Development of Immunity: Immunity requires exposure in an otherwise healthy animal. Good immunity develops with age and exposure. Adult deer do not need treatment although they can still shed eggs from a wide range of parasite species and are likely to always carry a few egg laying adults. Immunity can wane during times of stress, particularly in adult wapiti deer.

Oesophagostomum



Oesophagostomum venulosum, Oe. radiatum, Oe. sikae

Looks Like: 1 – 2cm long

Where adults are found: Large intestine or terminal small intestine

Life cycle: Direct. The ensheathed L3 is eaten off the pasture. Other agents may also transfer the L3s.

L3s exsheath in the intestine and develop into L4s and into adults in the colon. Adults lay 5,000 – 12,000 eggs per day.

Preferred climatic conditions: Temperate climate. Probably overwinter in the animal as L4 in tissue nodules. Oe. radiatum may prefer a warmer climate and Oe venulosum has been found in deer from both North and South Islands.

Prepatent period: 35 days (32 to 45+) depending on the time of year that infection occurs.

Survival on pasture: Up to 12 months depending on climatic conditions. Susceptible to drying out. Can withstand cold.

Affects deer by: Forming nodules and inflammation in the wall of the large or small intestine.

Clinical signs: Ill thrift, diarrhoea. This parasite is more likely to be associated with diarrhoea than some of the others.

Development of Immunity: Adults may develop immunity to new infections but not to resident larvae in the mucosa of the intestine.

Evidence of Oesophagostomum in deer

In a trial investigating the efficacy of different formulations of ivermectin and moxidectin, Hoskin et al (2005) recovered Oesophagostomum adults from 8/10 untreated deer. All drenches were 100% effective against this species.

A survey of 59 farms from around the country (Tapia-Escárate et al, 2016) identified O. venulosum as the most common L3 larva cultured from faeces. This species is considered to be of minor pathological significance in sheep.

In a pathogenicity study at Massey University, Tapia-Escárate et al (2011) recorded nodules, inflammation and oedema of the terminal small intestine and large intestine. They considered these, along with clinical signs of reduced VFI and reduced weight gain to be due to Oesophogostomum sp, perhaps Oe. sikae, a species not previously identified in NZ. Although the clinical signs and pathology were considered to be due to these parasites, the authors reported that establishment rates following artificial trickle infection were low.

A trial investigating anthelmintic resistance in Southland (Lawrence et al, 2012) found 3/6 deer in the control group positive for Oesophagostomum/Chabertia, comprising 20% of total worms recovered from all 6 deer. There were none in any of the animals treated with moxidectin, oxfendazole or levamisole. This level of infection was not enough to prove drench efficacy but does indicate geographic spread of this parasite.

A case of ill thrift and diarrhoea with 7/70 mortality was reported to the diagnostic laboratory on a Manawatu deer farm in the October to December quarter (Anon, 2013). Post mortem revealed severe parasitic colitis thought to be due to Oesophagostomum sp. or Trichuris sp.

These observations

These observations support Oesophagostomum being a significant parasite of deer and any investigation into suspected parasitism should include checking for evidence of this parasite through faecal larval culture and/or post mortem.

Anon (2013). Quarterly report of diagnostic cases: October to December 2012. Surveillance 40(1)

Hoskin SO, Pomroy WE, Wilson PR, Ondris M and Mason P (2005). The efficacy of oral ivermectin, pour-on ivermectin and pour-on moxidectin against naturally acquired infections of lungworm and gastrointestinal parasites in young deer. Proceedings of the deer branch of the NZVA 22, 21-25

Lawrence DW, MacGibbon JT and Mason PC (2013) Efficacy of levamisole, moxidectin oral, moxidectin injectable and Monepantel against Ostertagia-type nematodes in deer. Proceedings of the deer branch of the NZVA 30,

Tapia-Escárate D, Pomroy WE, Wilson PR, Hoskin SO and Goodwin-Ray K (2011) A study of the pathogenicity and diagnosis of gastrointestinal parasites in young farmed deer. Proceedings of the deer branch of the NZVA, 2011, 81-86

Tapia-Escárate D (2016) A study on some aspects of the pathogenicity, diagnosis and control of gastrointestinal nematodes in deer. PhD Thesis, Massey University, 2016.

Technical notes

In a UK study, Connan (1997) found that of all of 151 animals from which samples were collected at the abattoir contained ostertagid type nematodes. Connan describes the seasonal pattern of EL4, with very few being found in September (our March) but being present in all stags in increasing number and proportion of total burden through the autumn. Most of the Ostertagids found when animals were killed during winter were EL4s and the proportion of adults didn't increase again until April (our October).

Several studies have shown that drenches are often not effectives against these parasites (Lawrence, 2011, Lawrence et al, 2013). This is especially true of the L4 larval stage found in th abomasum. These L4 may be burrowed into the wall of the abomasum and remain inactive. Even very high doses of the most potent drenches do not effectively kill this stage. In the trial work developing a new drench product (Flint and Lawrence, unpublished) very high doses of moxidectin, oxfendazole and levamisole in combination only achieved around 75% reduction in Ostertagia-type larvae. Any product with a label claim against Osteragia larvae should not be believed for deer.

There is indication that this group of parasites has developed true drench resistance on some farms. The most likely cause is repeated use of moxidectin pour-on (Lawrence, 2011). There is still debate amongst parasitologists as to whether the lack of efficacy of anthelmintics is due to the development of resistance or incorrect dosing or administration for this parasite. However, as an early slaughter trial (Mackintosh et al, 1985) showed 100% efficacy against adult gastrointestinal worms for febantel and ivermectin injection anthelmintics, it would seem that more recent trials with lower efficacy are in fact due to resistance.

A parasite investigation or indeed any investigation into ill thrift should always include specifically investigating this group of abomasum worms. Post mortem examination should include abomasum pH readings and investigation of damage to the abomasum lining. Where drench efficacy is investigated, if a post mortem worm count is to be done, it is worthwhile investigating EL4s both free in the lumen and by having a rumen digest done. Farms that have been found to have issues with encysted EL4s and cases that resemble fading elk syndrome should have a plan put in place to prevent infection during the autumn. Although drenching stags during the autumn can be challenging, two drenches, with the second in May and including moxidectin injection or high dose oral moxidectin could help reduce the problem. This has not been proven in a published trial.

Connan RM (1997) Hypobiosis in the ostertagids of red deer and the efficacy of ivermectin and fenbendazole against them. The Veterinary Record 140, 203-205

Lawerence D (2011) Cervine anthelmintics: The bubble has burst. Proceedings of the deer branch of the NZVA 2011, 87–92.

Mackintosh CG, Mason PC, Manley T, Baker K and Littlejohn R (1985). Efficacy and pharmacokinetics of febantel and ivermectin in red deer (Cervus elaphus). New Zealand Veterinary Journal 33, 127–131

Barber's pole worm

Haemonchus contortus

Looks like: Fairly large 20 – 34mm, red and white spiral

Where adults are found: Abomasum

Lifecycle: Direct, adults lay up to 10,000 eggs per female per day

Preferred climatic conditions: Hot, warm and moist

Prepatent period: 21 days

Time to develop on pasture: 4 days to several weeks

Survival on pasture: 2 – 3 months in warm wet conditions, 5 – 6 months in colder climate.

Affects deer by: Unknown. In other species a blood sucking parasite.

Clinical signs: No clinical signs directly related to this parasite have been reported in deer. In sheep and goats, Haemonchus can remove large amounts of blood resulting in anaemia (pale membranes in the gums and eyes), low protein, bottle jaw, scouring.

Development of immunity: Unknown.

Although Haemonchus contortus is often found in deer, it has not been reported to cause anaemia or production issues. Cross grazing with sheep may increase the levels of Haemonchus in deer. At this stage there is no indication to specifically investigate Haemonchus infection and any, if present, should be adequately controlled with routine parasite management. This is a parasite to keep an eye on for the future, particularly in warmer areas.

Trichostrongylus (Trikes)

Trichostrongylus axei
Trichostrongylus askivali (deer specific)

Looks like: Clear, difficult to see, 5 – 8mm long.

Where adults are found: Abomasum

Lifecycle: Direct, adults in abomasum lay 50 – 100 eggs per day.

Preferred climatic conditions: Wide range of environmental conditions

Prepatent period: 18 – 21 days

Time to develop on pasture: one week to several weeks, temperature dependant.

Survival on pasture: Survival is better at lower temperature

Affects deer by: Damage to the lining of the abomasum

Clinical signs: Not known to cause problems in deer.

Development of Immunity: Probably good

Trichostrongylus axei is one of the very few nematodes that has a wide host range including ruminants, horses and humans. It is commonly found in the abomasum of deer and its clinical significance is unknown. All drench trials have incidentally found excellent efficacy against Trichostrongylus and it does not require specific investigation.

T. askivali was discovered as a separate species from red deer in 1964 (Dunn, 1964). It was found to make up around 45% of the Trichostrongylus spp. isolated from red deer in Manawatu during a trial (Pomroy, 2011).

Liver fluke

Fasciola hepatica

This parasite is a trematode (not a nematode like the roundworms)

Looks like: Adults, life shaped, brown up to 30mm long.

Where adults are found: Bile ducts of the liver

Lifecycle: Indirect. Adults in the bile ducts lay eggs. The eggs pass into the gut and leave the host in the faeces. Eggs in shallow water hatch into miracidium which can infect the intermediate host which is a specific snail species (Lymnaea). The miracidium multiplies in the snail host and develops into cercariae over a period of 2 to 3 months. Cercariae swim for a short time and then encyst onto vegetation. This is the stage that can infect the final host (sheep, cattle, deer). Once inside the host's intestine, the metaceraria excyst and the young fluke burrows through the intestinal wall and migrates to the liver. It then spends several months travelling through the liver causing damage. About 7 weeks after ingestion, the flukes enter the bile ducts and mature into adults where they lay eggs. Water and Lymnaea snails are essential to complete the lifecycle.

Preferred climatic conditions: Wide climatic adaption but development will not occur below 10°C or in the absence of water.

Prepatent period: 7 weeks

Time to develop on pasture: 3 – 4 months including intermediate host stage.

Survival on pasture: Cysts are relatively robust. Other life stages depend on the presence of water and intermediate host snails.

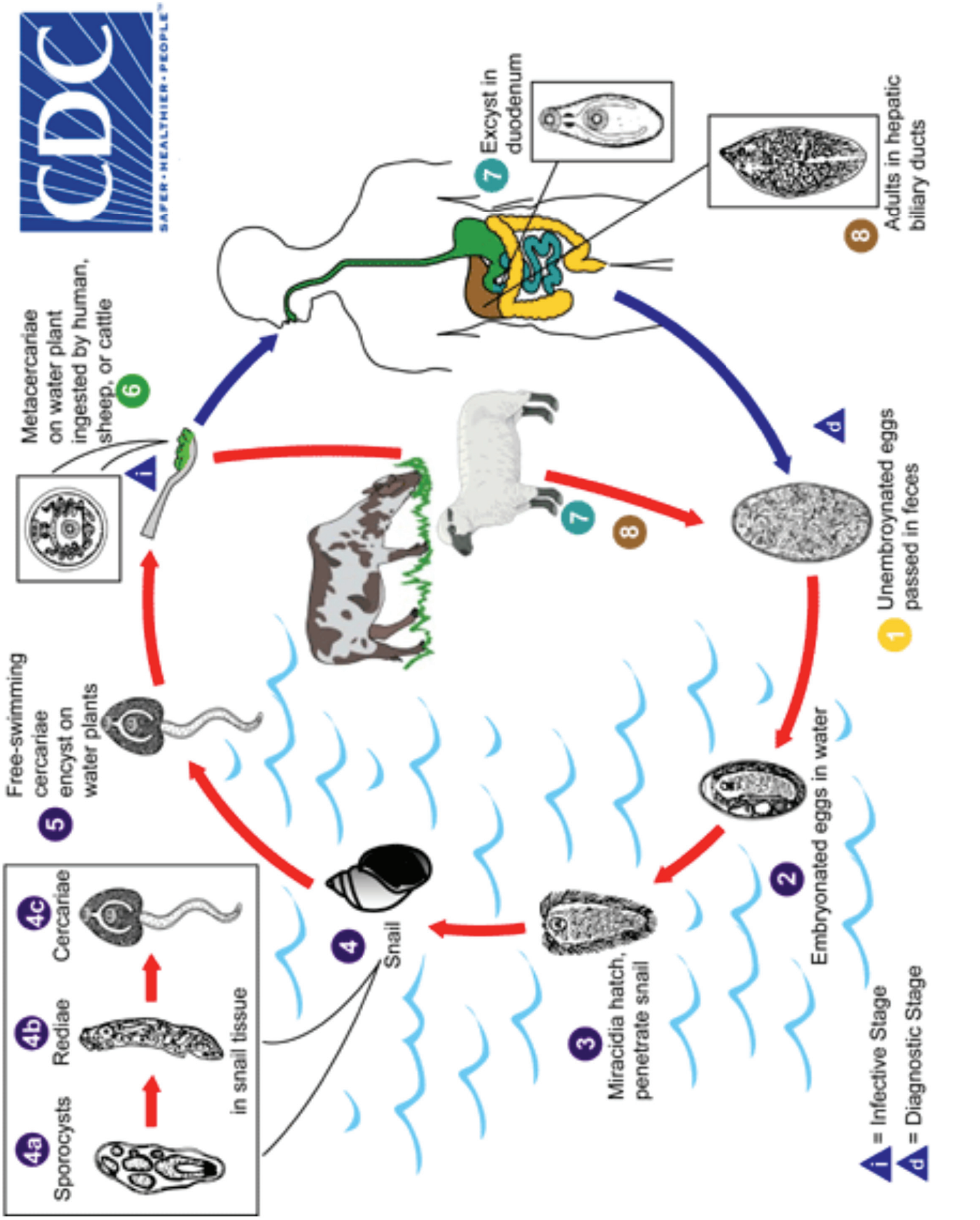
Affects deer by: Damage to liver tissue.

Clinical signs: Ill thrift

Development of Immunity: Unknown. Sheep do not develop immunity to adult flukes.

Liver fluke were recorded in deer in New Zealand in 1964 (Andrews, 1964) and considered to be pathogenic along with lungworm and hydatids tapeworms. Mason (1994) considered liver fluke less pathogenic in deer than in sheep and cattle and probably controlled with triclabendazole.

F. Hepatica can infect a range of animals including humans and causes the disease fascioliasis.


4a
Sporocysts
4b
Rediae
4c
Cercariae
in snail tissue
5
Free-swimming cercariae encyst on water plants
Metacercariae on water plant ingested by human, sheep, or cattle
6
CDC
SAFER·HEALTHIER·PEOPLE™
4
Snail
7
Excyst in duodenum
3
Miracidia hatch, penetrate snail
7
8
2
Embryonated eggs in water
1
Unembroynated eggs passed in feces
8
Adults in hepatic biliary ducts
i = Infective Stage
d = Diagnostic Stage

Tape worms

Suspected tapeworm segments on deer faeces, Manawatu

Moniezia expansa

Tape worm is not a nematode like the other roundworms. It is a cestode.

Looks like: Large white highly segmented flat, wide ribbon like.

Where adults are found: Small intestine

Lifecycle: Indirect. Segments are passed with the faeces of the ruminant hosts. These faeces contain eggs. The eggs are eaten by a soil mite (oribatid mite) within a day of being passed. The egg hatches inside the mite and develops to the infective stage. The mite along with the tapeworm is eaten by the ruminant (mites are small and ubiquitous so chances of infection are pretty good). The mite is digested and releases the immature tapeworm which develops to an adult in the small intestine. The tapeworm holds onto the host with a sucker and produces segments called proglottids that contain the eggs. These form a long chain, up to several metres long. Segments break off from time to time and can be found in the faeces.

Preferred climatic conditions: Wide climatic range.

Prepatent period: 30 – 52 days

Time to develop on pasture: Up to 4 months inside mites

Survival on pasture: Poor. Eggs are very susceptible to drying out but due to high numbers of eggs and high numbers of mites, a good number always survive.

Affects deer by: Does not appear to have any major effects on deer but the appearance of segments on the faeces can be alarming.

Clinical signs: None reported.

Development of immunity: Appears to be good from 5 months of age.

Tapeworms were first recorded in weaner deer at Invermay in 1976. At that time, they were not considered to be a health issue and the deer appeared to clear them at about 5 months of age (Mason and Moore, 1983).

Tissue worm

Elaphostrongylus cervi

Looks like: Long slender worm up to 60mm, coiled.

Where adults are found: Connective tissue between muscle blocks or nerves.

Lifecycle: Indirect. Females in the tissues lay eggs which either hatch in situ or travel in the blood to the lungs and hatch. Larvae travel up the airways to the mouth and are swallowed. They pass through the gut and are expelled with the faeces. First stage larvae are very resistant in the environment, surviving up to 2 years. The larvae penetrate the foot of a suitable snail or slug host and develop to 2nd stage larvae and then 3rd stage. This takes 27 – 50 days. Infective larvae can remain viable in the snail or slug for up to 2 years. The deer gets infected by eating the slug or snail. The larvae then travel to the tissues and develop to adults.

Preferred climatic conditions: Infection levels are highest in deer from the Fiordland region and infection rates on-farm are much lower. This is most likely due to the presence of the intermediate host snails.

Prepatent period: 3 – 4 months

Time to develop on pasture: 1 – 2 months in intermediate host.

Survival on pasture: Up to 2 years on pasture and 2 years in snail

Affects deer by: Causing damage to the tissues. Downgrading of carcasses. Lodging in or around the nerves, especially of the spine or brain can cause hind limb paralysis. In New Zealand farmed deer, problems associated with infection are rare and this parasite is not a common problem.

Clinical signs: Uncommon in New Zealand. Potentially ill thrift, hind limb paralysis and neurological signs.

Development of immunity: Adult deer probably do not develop immunity to this parasite as they can continue to shed first-stage larvae in the faeces for many years.

Elaphostrongylus cervi was first discovered in deer from Fiordland where the intermediate host is likely to be more readily found and consumed by deer. In a 1981 survey (Mason and Gladden, 1982), 34% of the 116 farms from which samples were collected had E. cervi larvae in faeces and 50% of farms with deer originating from Southland/Fiordland had evidence of E. cervi. In 1994 a shipment of red deer from New Zealand to Canada was terminated because tissue worm infection was detected and the validity of the diagnostic test came into question. This parasite is not a common problem in farmed deer in New Zealand although it can be quite difficult to diagnose.

Mason P and Gladden N (1982c) Survey investigates drenching practice and internal parasitism on deer farms. Surveillance 9 (4), 2-3

Above: Swampy areas provide an ideal environment for the snails that transfer liver fluke and tissue worm infection and also for ticks. These areas are better put into nutrient catchment zones or biodiversity planting.

Cooperia

Cooperia pectinata was recovered from a 6-month old weaner red deer in Taihape in 1981 (McKenna et al, 1981). This was the first time this species of Cooperia had been found in New Zealand.

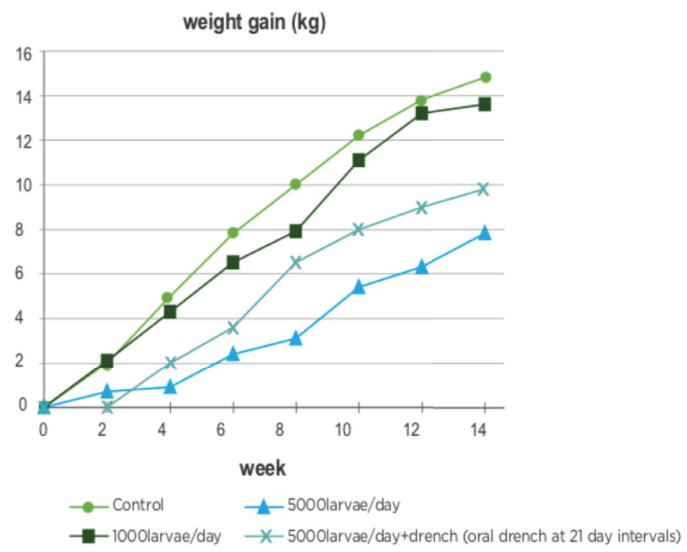
McKenna PB, Charleston WAG and Hughes PL (1981) Cooperia pectinata (Nematoda: Trichostrongylidae) in New Zealand. New Zealand Veterinary Journal 29 (3), 26-27.

Other internal parasites

Many other species of worms have been found in deer and new ones can be discovered at any time. Sheep and cattle worms might adapt to suit deer. It is important to be vigilant to the possibility of new parasite species in deer and not just assume the only one we need to worry about is lungworm.

Effects of parasites in deer

The diagram on the right is copied from the Wormwise booklet and is adapted from research done by Coop et al (1982) where lambs were either parasite free, or given a small dose of larvae and not drenched, or given a high dose of larvae and not drenched or given a high dose of larvae and drenched. It demonstrates that at low challenge levels, animals grew nearly as well as those with no challenge and at high parasite challenge levels, even regularly drenched animals grew more slowly than animals that are under a light challenge and not regularly drenched. While this research was done in lambs, there is no reason to suspect it would be any different in deer.



Tapia-Escárate et al (2011) challenged young weaned deer with high, medium, low and very low doses of mixed gastrointestinal nematodes. Development of clinical signs and reduction in weight gain were correlated with larval challenge. Very low dose challenged deer did not differ from control deer in any measured parameters (weight gain, VFI, albumin, globulin) but did develop higher faecal egg counts four weeks post infection. The actual weight data were not reported, hence why we have used a graph for work in lambs to illustrate this point above.

Deer will suffer little or no ill health or production impacts due to parasites when there is:

- A *very low* level of exposure to infective larvae
- Good all round nutrition including protein, fibre, sugars, macro and trace elements from a palatable feed source.
- Minimal stress due to weaning, weather, nutritional, transport and social stress.
- A genetic ability to develop a strong immune response to the parasites.

If this situation cannot be maintained, the following effects can be seen:

Reduced weight gain

Young deer infected with parasites have their growth rates decreased by at least 50% compared with deer that do not have parasites.

Hoskin et al (1999) found a 56% and 42% reduction in voluntary feed intake and liveweight gain respectively in red deer grazing annual ryegrass/WC that were trigger treated with four treatments compared with deer that were suppressively drenched every three weeks. In a subsequent study (Hoskin et al, 2003) a 55% reduction in liveweight gain was found in deer that were trigger treated compared with those that were suppressively treated.

The economic impact of reduced weight gain

If weight gain is reduced by 100g/d for 6 months of the year, that will mean a reduction in liveweight of about 18kg at 12 months of age. Even at half this rate, a liveweight reduction of 9kg equates to about 5kg of carcass weight, which could be worth up to $50/hd.

Furthermore, more deer will need to be carried through for longer and this has the dual cost of missing the peak chilled schedule (potentially lose $50-$100/hd) and the cost of extra feed to carry these animals through. This can be at a time when feed in costly or in short supply in summer dry situations. There will be a necessary reduction in other stock classes or feed may need to be purchased or grown specifically to carry these animals through to killable weights.

Young female deer that do not reach heavy enough weights to achieve puberty by 14 months of age will not get in fawn. In-fawn rates over 90% are achieved in well-grown yearling hinds.

There is increasing evidence that young stag growth and health during their first year of life affects their lifetime velvet production

Death

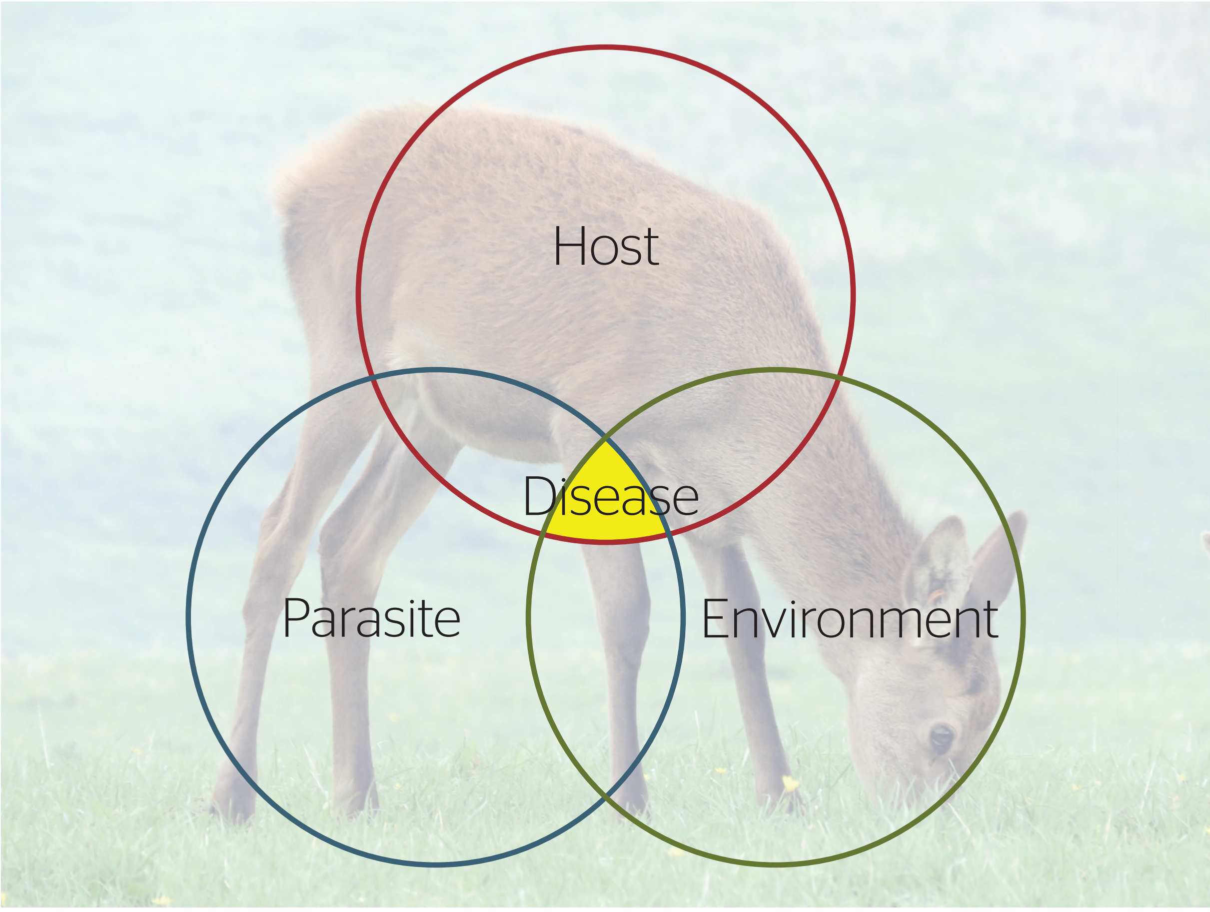
Under the conditions present on many farms running deer, parasite levels can build up very quickly. This is especially true for lungworm larvae in summer and autumn before young deer are able to develop immunity. This can and does result in death!

Ill thrift and death in adult deer

Fading elk syndrome has been described and is believed to be due to L4 Ostertagia-type larvae in the musoca of the abomasum.

Lawrence surveyed wapiti farmers and 19/25 farms from around the country had experienced fading elk syndrome during 2008 with an average incidence of 6.2% (range 0.1% to 24%). Eighteen deer showing signs of fading elk syndrome were subjected to euthanasia and post mortem. The results confirmed all deer, except one which was diagnosed with Johne’s disease, had significant abomasal parasite damage and elevations in abomasum pH. Both Osteragia type and Trichostrongylus were recovered from these deer, particularly those that had previously been treated with moxidectin pour-on.

Animal – Parasite – Environment interactions



Disease will only occur when conditions are right in all three of the host, agent (parasite) and environment, and when all three are present. We can use this to understand the conditions that increase the risk of problems due to parasitism and also to identify ways to disrupt the interactions and prevent disease from occurring.

Note that the elements may all be present, but if they are unsuitable then disease will not occur, thus each intersecting circle illustrates 'suitable conditions' not simply the presence of the condition.

The table below lists some of the factors that will make for a suitable relationship, resulting in disease and conversely things that will make it harder for disease to develop. In the column on the right are some ideas for how to swing things in the favour of health and away from disease.

	Suitable	Unsuitable	Some ways to create an unsuitable situation for disease
Animal	• Young • Naïve • Malnourished • Poor mineral balance • Suffering stress • Right host for that parasite • Grazes close to the ground	• Immune adult • Good nutrition • Genetically able to mount an immune response • Low stress • Correct mineral balance • Selects high-growing forages and plants alternative to grasses • Wrong host for that parasite	• Genetic selection for animals that develop immune response • Cross grazing with other species • Using adult stock to clean up • Check and correct any mineral, protein or energy deficiency • Low-stress weaning and feeding systems.
Environment	• Warm (>10°C) • Optimum temp 20-27°C • Moist • Mostly grass • Heavy grazing pressure • Set-stocked • Low pasture covers • Low soil biological activity • Faecal pat remains intact on soil for long periods • Moisture film on pasture • Non-decaying dead matter	• Dry – drought • High rainfall • Very cold conditions • Multi-species forages • High biological activity in soil • Dung pats break down rapidly • Warm and wet without presence of a host • Crops • Chicory, plantain, sulla, lucerne	• Rotational grazing (e.g. 4 days on, 3 months off) • Assess paddock risk before grazing – seasonal • Maintain high pasture covers • Use alternative forage species • Dung beetles • Promote soil activity and earthworms
Parasite	• Fit for survival • Right parasite to infect that host • Able to withstand long periods of dry, cold or absence of animals. • Able to bypass host immune system • Produces lots of eggs/ larvae • Resistant to drenches	• Weakened • Not adapted to the host • Exposed to toxins • Low fecundity • In the wrong place (carted or washed away) • Unable to withstand dry or freezing conditions. • Susceptible to drenches	• Drenching effectively • Nematode-eating fungi • Apple cider vinegar?? • Immune response of host • Dung beetles • Earthworms • Vaccination • Nematode-eating bacteria • Condensed tannins (sulla, lotus, willow)

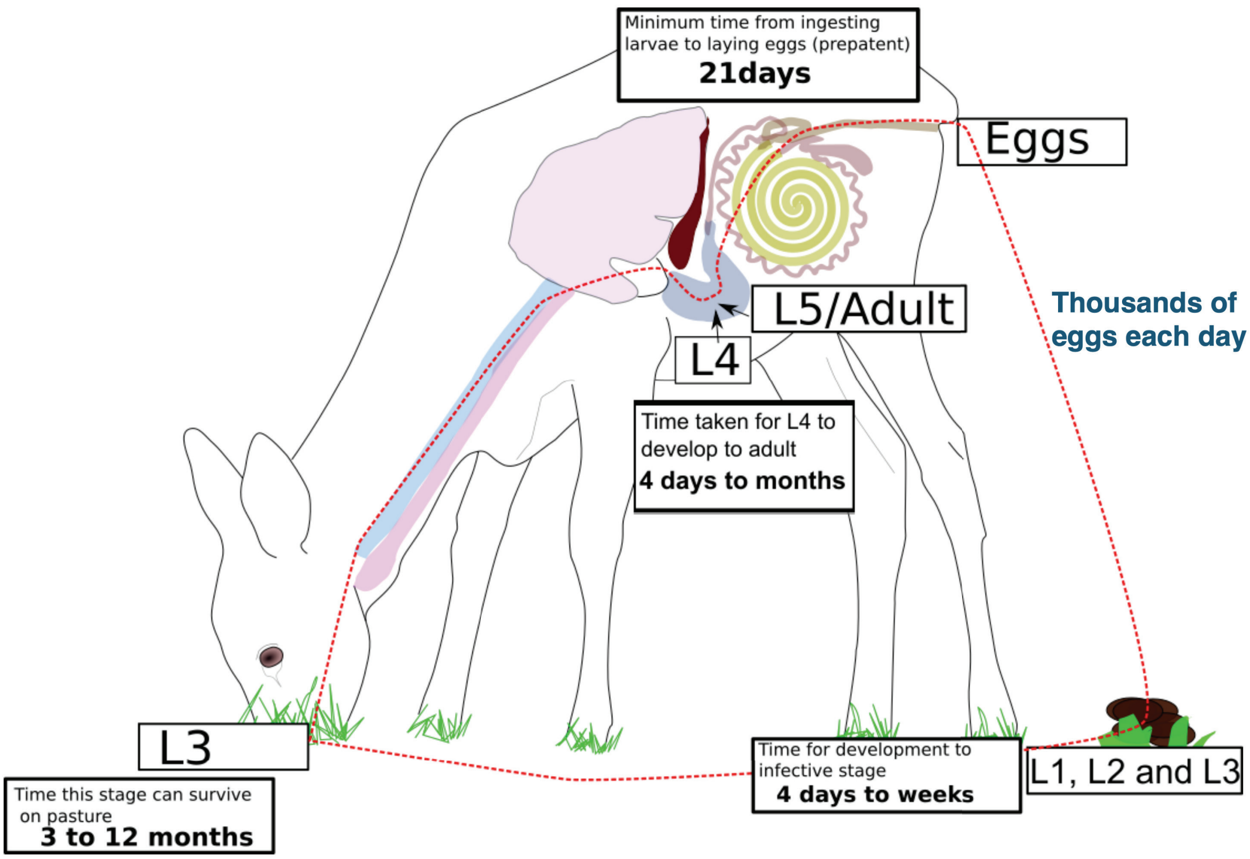
Notes:

Basic lifecycle

To better understand the potential intervention points, we need to first have a good grasp of the lifecycle.

Only a small portion of all the worms are in the animal. The majority are early life-cycle stages in the faeces, base of the pasture and in the topsoil. Each adult worm inside the animal produces thousands of eggs every day which continually go out to contaminate the environment. Only some of these will be eaten by a susceptible host. At any one time 10–15% of worms are in the animal and 85–90% of the worm population can be found on pasture and soil.

The diagram below shows the direct lifecycle of Ostertagia-type worms. For other species, the time frames will vary for the different stages and some larvae migrate to different organs. See the information above about each parasite if you really want to be a nerd about worms.



Lifecycle understanding and intervention

The numbers here relate to the diagram on the previous page.

1. Eggs or larvae produced by adult nematodes in the animal

- Eggs are produced by the adult parasites inside the animal. If adults are removed by drenching, there will be no eggs or larvae to contaminate the pasture for as long as the prepatent period (the length of time it takes for larvae that are eaten to develop into adults that shed their offspring in the faeces). This takes about 21 days for Ostertagias and a little longer for lungworm and bowel (large intestine) worms.

How can we affect this?

- Regular drenching every 28 days will reduce the build up of eggs and thus larvae on pasture.
- Some other products such as apple cider vinegar and copper oxide wire particles may reduce the number of eggs shed in the faeces although solid evidence is scant.

2. Egg hatching and larval development in dung

- Eggs hatch inside the dung pat when the environmental conditions are suitable. This requires moisture and temperatures greater than 10°C for most parasites.
- Larvae hatch out of the egg, feed and develop through 2 more stages.
- Under unfavourable conditions such as dry or cold, development may be arrested but when conditions become favourable, this can result in a high challenge developing in a short timeframe, e.g. autumn rains following a drought.

How can we affect this stage?

- Breaking up dung pats assists drying. Eggs, L1 and L2 stages are susceptible to drying and most will die if exposed to direct sunlight.
- Dung beetles that remove and bury dung can assist with breaking up dung pats and interrupt the lifecycle. There are several species of dung beetle now available in New Zealand (https://dungbeetles.co.nz/)
- Promoting earthworm activity can also help with breaking up the dung pat and incorporating it into the soil.
- Certain fungi capture nematodes and prevent them from developing. *Duddingtonia flagrans* in Bioworma® effectively prevents larvae developing and leaving the dung pat.
- Certain bacteria in the soil and dung pat can invade and kill nematodes. No commercial products are available for this yet.
- Condensed tannins in the diet and excreted in the faeces may also inhibit larval development

3. L3 on pasture

- Under ideal conditions, it takes only 4 – 7 days for eggs to develop to infective larvae for parasites with a direct lifecycle.
- L3 (third stage) larvae have a sheath around them. They do not feed and are resistant to harsh environmental conditions, particularly cold.
- L3 larvae move onto pasture and up the grass in the water film. The require water to move.
- Warm conditions will cause L3 larvae to move more and expend more energy.
- Spelling pastures for several months will result in gradual reduction of infective L3 larvae.

How can we affect this stage?

- Do not graze the animals for longer than it will take for eggs dropped in the faeces when they first went on to develop into infective parasites. If this is in winter, it may be several weeks, during autumn it may be a few days.
- Cultivating paddocks can destroy some of the larvae but has other negative consequences of soil structure and microbiology so is not recommended as a tool for parasite control.
- Spelling the paddock for long enough to ensure most of the L3 have died before grazing. This could be up to 12 months in cold climates but as little as 2 – 3 months under warm, moist conditions.
- Heavy rain will wash larvae off the pasture and into the soil. It can be used as a risk indicator for deciding whether to graze.

4. Ingestion of L3 with pasture

- This is the stage that infects animals for most of the important worms.
- The general rule of thumb is “When the pasture is growing well, the parasites are growing well”. That is, the conditions for good pasture growth also support larvae developing and movement up the grass blades.
- Larvae require water for movement up pasture.
- The majority of larvae will be found in the bottom 5cm of pasture.
- Larvae have a greater challenge moving up lucerne, clover, chicory and crop foliage than blade grass.

How can we affect this stage?

- Assess the risk and likely larval challenge. When is it likely to be high grazed with stock that is not affected by deer parasites, e.g. cattle, sheep, goats, horses? During growth times this could be 2 – 6 weeks post grazing with infected young stock.
- Pastures should not be grazed by young animals when peak L3 is expected.
- Maintain grazing residuals above 10cm.

5. Ingested larvae develop into adults

- This stage can cause health effects on the animal.
- Lungworm larvae migrate through the lymphatics to the lungs and are difficult to kill at this stage of migration.
- Ostertagia-type larvae can go into a stage of delayed development and burrow into the lining of the abomasum. They are very difficult to kill at this stage too.
- Immunity develops to incoming larvae (rather than to adults in the gut or lungs). Immune animals expel the larvae before they can develop into adults.
- Animals require low-level exposure to develop immunity.
- Healthy, well-fed animals will develop immunity faster.
- Some animals develop immunity at an earlier age than others and this is likely to have a genetic basis.
- Some tools, such as CARLA IgA testing may help identify animals that develop immunity sooner.
- Some parasites develop into fourth stage larvae and enter a hibernation stage within the animal, usually burrowed into the wall of the abomasum or intestine. This stage is very difficult to kill with anthelmintics.
- When fourth-stage larvae emerge and develop into adults they can damage the intestine or abomasum.

How can we affect this stage?

- Ensure the animals are otherwise healthy, well fed and disease free.
- Copper oxide wire particles may affect larval development in the abomasum.
- Select breeding sires based on a high CARLA score, meaning they have a stronger immune response to parasites.
- Feeds high in condensed tannins may inhibit parasite development.
- Allow a low level of exposure so that immunity can develop.

6. Adult nematodes

- Within the animal, adult nematodes mate and produce eggs or larvae.
- The number of eggs produced can be up to several hundred thousand.
- Adult parasites are susceptible to effective drenches and can be removed by drenching. Ostertagia L4 larvae and lungworm larvae migrating from the gut to the lungs do not appear to be effectively killed by drenches.
- All parasites can develop resistance to drenches and adults will survive and continue to lay eggs after drenching. The eggs of these parasites may hatch into larvae that are also resistant to the same drenches.
- When slaughter trials are done, adult nematodes in the abomasum, intestine or lungs are counted.

How can we affect this stage?

- If the level of parasitism is causing production losses, use an effective anthelmintic that is a combination of as many different actives as possible to eliminate the parasites in the animal.

Factors affecting the survival and movement of parasites on pasture

Development and movement of larvae on pasture was reviewed by Stromberg (1997) and is dependent on temperature, moisture, sward type and other local and environmental factors. Low temperatures will slow or stop larval development. Low moisture will kill developing larvae or force them under faecal pats to re-emerge when moisture levels increase. Dry pasture probably also prevents the movement of larvae onto the leaf where they will be consumed. Excessive rainfall may wash larvae away.

Once developed to the L3 stage, infective larvae are able to survive relatively long periods on pasture. This includes overwintering and survival through dry conditions. In a discussion following the delivery of Stromberg's paper, Barger observed that in very dry conditions such as an 18-month drought in Australia larvae were able to survive in the dung pats for the entire time. Once the rains come moved out onto pasture in very large numbers. This observation is reflected in New Zealand when some of the worst parasite outbreaks are seen following drought-breaking rain.

The L3 may become less infective over time due to depletion of energy reserves.

The distance that larvae will travel depends on moisture, temperature, sward type and other conditions and has been measured at between 5 and 40 cm from an artificial dung pat. Rain dispersal may be the most important means by which larvae are distributed on pasture, with rain drops breaking up the dung pat and splashing larvae up to 90cm in a moisture-rich environment (Grønvold, 1984; Grønvold and Høgh-Schmidt, 1989). Grazing following moderately heavy rain may be a high-risk situation

Risk Assessment

Do your own parasite risk assessment. The following table lists some risk factors. If you have a number of high risk factors, you will need to rely more on chemical control or make changes and adopt other control mechanisms.

Risk factors for pasture contamination and production effects of parasites in young deer

Risk factor	High risk	Low risk	Comments
EXAMPLE: Level of nutrition			
Deer as proportion of stock	High % deer	Low % deer	The ideal stock ratios are not known. A trial with 50:50 deer:cattle in rotation reduced parasite problems in young deer
Deer age	Mostly young	Mostly adult	E.g. Finishing farm higher risk than velvetting
Breed	High proportion wapiti genetics	English red deer	Wapiti, in general, are more susceptible to parasitism although some lines of wapiti may have better immunity, comparable with English red deer.
Genetics	Low CARLA deer	High CARLA deer	Using sires with high CARLA eBVs (either terminal or maternal replacement) wil reduce egg and larval output
Level of nutrition	Poor	Good	See notes on nutrition
Pasture height	High, good quality	Low, good quality or high poor quality	If deer are grazing higher in the sward they may have lower exposure to L3s.
Pasture type	Ryegrass dominant	Pure chicory	Other pure swards of alternative pastures may decrease risk but this has not been studied in deer. Beware mixed swards and coming off alternative forages.
Grazing management	Set stocked, or rotational deer only	Rotational with other species	Set stocked deer are continually ingesting all the parasites as soon as they are available. Rotational grazing allows for some of the parasites to die or be washed off pasture.

Task: Develop strategies to reduce drench use on your farm. For each risk factor below, mark where you are between high and low and record what actions you might take to manage the risk.

Date: ____________________ **Name/Farm:** ____________________

	High risk	Low risk	Action option
			Increase supplement allowance for weaners going into winter

Risk factor	High risk	Low risk	Comments
Intergrazing with cattle or sheep	No	Yes	Cross grazing in rotation according to pasture growth decreases risk as cattle/sheep can remove some deer parasites, especially lungworm
Weaning	Pre-rut weaning	Post-rut weaning	Post-rut weaned fawns need less drenching
Soil health	Poor	Good	Good soil health with high biological activity creates unfavourable environment for larval development
Cropping	No	Yes	Cultivation reduces larvae but needs to be balanced against the possible negative effect on soil structure. (low tillage better)
Supplements fed	Variable	Variable	If supplements are fed because pasture is very low, probably still high risk.
Irrigation	Yes	No	Depends on the location and normal weather patterns.
Winter temperatures	Warm	Cold	Larval development slows right down in a cold winter but many can overwinter and will not be killed by cold.
Summer weather	Wet or drought followed by rain	Dry	Wet summer (Dec/Jan) increases risk early in the year. Dry summer increases risk later in autumn
History	Deaths due to lungworm	No deaths	Circumstances can change from one year to the next.
Other e.g. introduction of dung beetles			

	High risk	Low risk	Action option

How do I know my deer have worms?

Clinical signs of parasitism

Clinical signs are the obvious abnormalities seen in an animal suffering from disease. These should not be used as a routine monitoring method as by the time outward signs become obvious, there will be marked production losses within the herd and a large build up of larvae on pasture.

Healthy deer are bright and alert, in good condition and with a sleek, shiny summer coat.

Clinical signs vary depending on the type of parasites involved. Lungworm causes a soft cough in a proportion of the herd; stomach worms are likely to cause a more insidious weight loss, ill thrift, loss of appetite and rough coat and bottle jaw; worms in the intestines may cause diarrhoea and dehydration. All of these signs can be due to other diseases, so diagnosis needs to be backed up with post mortem or laboratory tests. You also need to determine whether it is a herd issue or an individual animal issue. If it's just one animal there will be another underlying issue going on.

Cough

Lungworm infections cause weight loss and a soft cough. This is best observed after entering the paddock and allowing the deer to settle after running. The bike engine should be turned off to allow careful listening. Coughing may also be heard after the deer have run into the shed and been allowed to settle.

Poorly grown animal in poor condition with retained winter coat. Parasites may be an issue but if the rest of the herd is in good order, there is likely to be another underlying cause.

Coughing 10-30 minutes after drenching is often an indication that lungworm was present and the dying worms are coming loose into the airways.
In severe cases this can result in asphyxiation on dead lungworms.

Coat condition

While coat colour can vary between animals and coat condition is not related to production, growth or milk, poor, rough dull hair, tight skin, or failure to moult winter coat are all indications that all is not well on the inside. This may be due to parasites or a combination of factors. Weak or diseased deer will be "picked on" by others in the mob.

Evidence of soft faecal matter stuck to the tail of a stag that died of fading elk disease. Changes in faecal consistency can be due to anything that upset normal gut function and transition of digested material.

Diarrhoea / soft faeces

Scouring, diarrhoea or soft faeces may be a sign of parasitism but are not definitive. There may be other causes of scouring such as changes in diet or other disease conditions. Depending on the species of parasite involved, severe parasitism can occur without any evidence of diarrhoea.

Saggy bits

"Bottle jaw" is the term given for a pool of fluid in the skin under the jaw of the deer. This can happen with low blood protein levels. Another sign of low protein can be a "pot-bellied" look. The animal may appear fat, but when you put your hands on, they are bony and in poor condition.

Weight gain

The best tool for monitoring whether parasites are likely to be an issue in young deer is weight gain. Before outward signs are seen, deer will have reduced appetite and eat less, resulting in slower growth rates. Deer Industry New Zealand has published expected weight gain graphs for deer of different sexes and genetic make-up. These can be used as a guide, but it is better to record data specific to the farm as differences in genetics, climate and feed availability or supplementary feeding are likely to result in differences between farms.

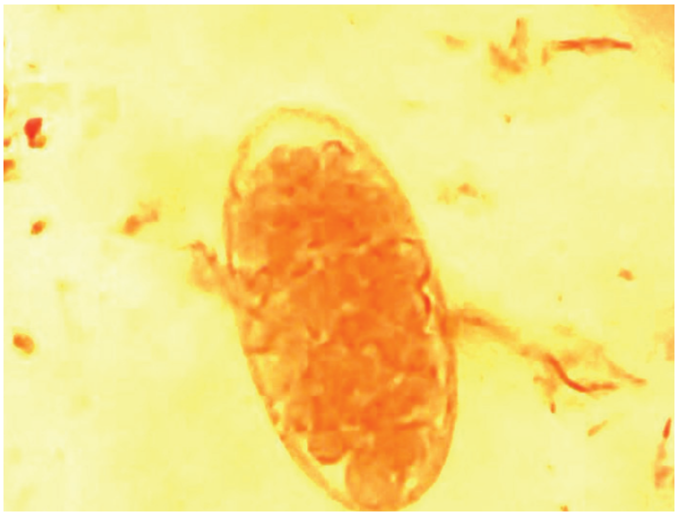
Hind in poor condition with loose, fluid filled tissue under the jaw. This is called 'bottle jaw' and is due to low blood protein levels. Several diseases can potentially cause low protein but a major consideration is parasites which interfere with the digestion and uptake of protein.

Using a growth rate trial to test drench response

Measuring the growth rates of two groups of weaners that have been given different drenching treatments can be used to compare efficacies. If planning to do this, follow these guidelines:

- At least 20 deer for each group
- Split the deer evenly according to sex and liveweight
- Mark animals in each treatment group by recording ear tags or taking EID recordings
- Run all deer together under the same feeding system. If the mobs are being split, make sure there are similar numbers of deer from each treatment group in each grazing mob.
- Weigh on the day of drenching and again 4 weeks later.
- As a rough guide, to be statistically certain there is a difference between treated and untreated, there should be at least a 20% difference in daily growth rates between the groups. This is due to the variation in growth rates between individual animals.

Faecal egg counting



For stomach and intestine worms, the number of eggs shed in the faeces of deer can be counted. This can be useful for indicating the general infection rate of the mob with gut worms or whether a parasite control programme is working.

Faecal egg counts are not useful for determining the number of adult or immature parasites within an individual animal because there is a poor correlation between gut worm burden and faecal egg count in deer.

Guidelines for faecal egg counting

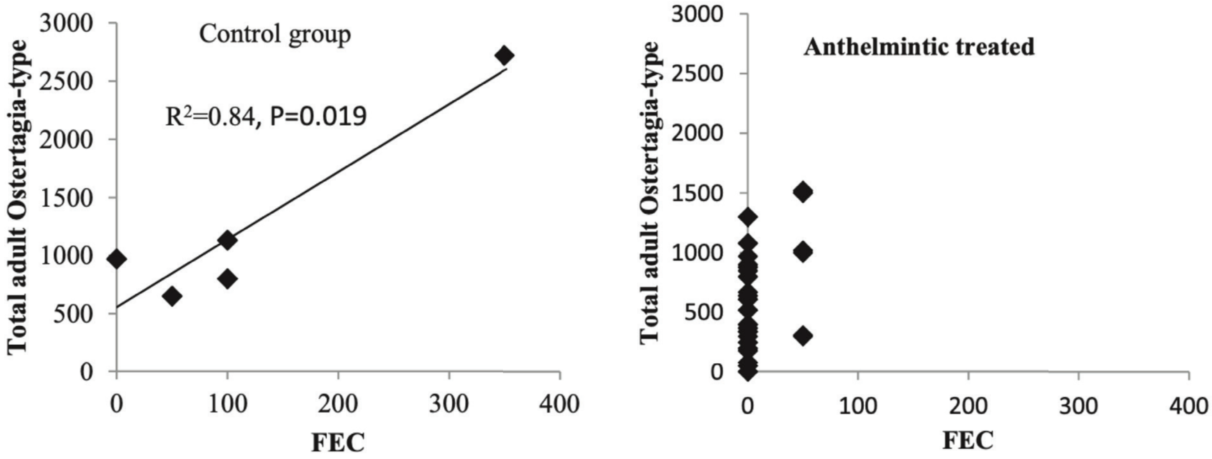
- Sample young deer less than 9 months of age
- Take 10 to 15 samples from the rectum, fresh in the paddock or fresh in the yards. Paddock collection can be done shortly after deer have been run onto clean pasture. If collecting in the shed, the animals can be put onto a clean yard for a few minutes. Move the deer out of the yard and make the collection before faecal pats have been tramped in.
- If comparing drenched and undrenched animals or if some of the mob have been left undrenched to enhance refugia, animals will have to be sampled individually and identified.

- The modified McMaster, if used, should be done using 4 grams of faeces so that each egg counted represents 25 eggs per gram. Other more sensitive methods are available at some laboratories. (Flotac). There is a flotation method that can detect as little as 0.3 eggs/gram depending on the sample size. For example, if using a 1g sample then 1 egg counted = 1 egg per gram.
- Flotac or other sensitive flotation method should be used in deer in preference to modified McMaster.
- A large amount of pooled faecal sample that is thoroughly mixed and then subsampled may give a better result in deer.
- Interpretation should be based on averages for the mob or treatment group and the proportion that have a positive egg count. Interpretation cannot be made on an individual animal basis.
- Significant parasitism is likely to be occurring at relatively low average faecal egg counts compared with sheep. For example, 100 – 500 eggs per gram may indicate significant mob infection. This will depend on the parasites involved and age of the animals.
- A post-drench check can be made 14 days after drenching; the count should be at or close to zero. At 28 days post drenching, the presence of some parasite eggs in the faeces indicates that there is a level of exposure that is desirable for maintaining refugia and promoting the development of immunity.
- It is common for adult hinds to be shedding small numbers of nematode eggs in the faeces but the significance of this is not yet fully understood.

Lungworm faecal larval count (FLC)

Two techniques can be used to detect and quantify lungworm larvae in faeces. These are the commonly used Baermann technique and a flotation method using Flotac apparatus (Bauer et al, 2010).

This indicates the number of egg-laying adults present in the lungs. But be cautious interpreting the results. If the animal has been infected with larvae within the previous 3 weeks it will not show up on a lungworm larval count. So a low count doesn’t necessarily mean you are not about to get a major outbreak of lungworm. The FLC should not be interpreted in isolation and factors such as growth rates, clinical signs of lungworm, drenching history, level of nutrition and grazing management should also be taken into account.



From Mackintosh et al, 2012. These graphs show the poor relationship between faecal egg count using the modified McMaster (at a subsample of 1:50) and total gut worm count at slaughter. The lower graph shows drenched deer and the likely egg laying suppression that occurs when parasites are partially resistant to drenching.

Faecal larval culture

This test needs to be specially requested and will identify which parasites are infecting the animals. It takes about 10 days to get the results back. Faecal larval cultures are useful for understanding which parasites are infecting the deer and also very useful as part of a drench efficacy test as it will tell you which parasites are not being adequately controlled by the drenches.

Pasture larval counts

It is possible to collect a pasture sample and quantify the number of larvae present. This is a specialist technique as it is difficult to get consistent results and there are a large number of free-living nematodes that need to be differentiated from the parasitic larvae of grazing animals.

Before doing a pasture larval count, discuss with the parasitologist what you want to measure. If it is the total burden on the paddock, then carefully walking to paddock and sampling the right parts, being sure to take cuts right down at ground level is important. If wanting to find out how many larvae the animals are likely to be ingesting, then more consideration will need to go into what fraction of the pasture they are likely to be consuming.

Technical notes on faecal egg counting

Faecal egg counts in deer are generally low and not well correlated with infection level, age or drenching history when a modified McMaster method is used.

A 1981 survey of 116 deer farms (Mason and Gladden, 1982c) revealed positive strongyle faecal egg counts on 84% of red deer farms and 11/12 fallow deer farms. There were also small numbers of capillaria recovered and 27/108 red deer farms had small numbers of coccidian oocysts (Eimeria sp.). Strongyle egg counts ranged up to 200 eggs per gram with around 50% of samples positive. There was no relationship between the presence of eggs in the faeces and either age or drenching history. The sensitivity and methodology of faecal egg counting was not stated.

In a small trial using seven red deer and seven wapiti x red F1 hybrid deer, Parsons et al (1994) found that wapiti tended to have higher FEC but lower lungworm larval counts compared with red deer weaners. The average FECs ranged from zero to 47 eggs per gram. These were measured using a modified McMaster method with 4 grams of faeces (sensitivity 25epg). 100% of hybrid deer and 60% of red deer had positive counts in late February with declining numbers showing positive egg counts at later sampling dates. It is possible that a more sensitive FEC method would have detected a higher percent of positively infected animals. Faecal larval count averages ranged from 0 to around 30 lpg, with the maximum number of infected deer occurring later in the season (May and June). Less than 50% of animals in each mob had positive FLC during February, whereas 100% had FLCs at 3 sampling times during May and June in both groups. This pattern likely reflects that unusually dry summer period in the year of the trial.

Flotac with a sensitivity of 1 egg per gram was used by Druijf et al (2011) to monitor FECs in adult hinds from 4th November until 21 January. The float method, using magnesium sulphate as the flotation solution was also used to count lungworm larvae. The summarised results are tabulated below and show that a high proportion of hinds shed low numbers of eggs throughout the summer with declining numbers from November until January.

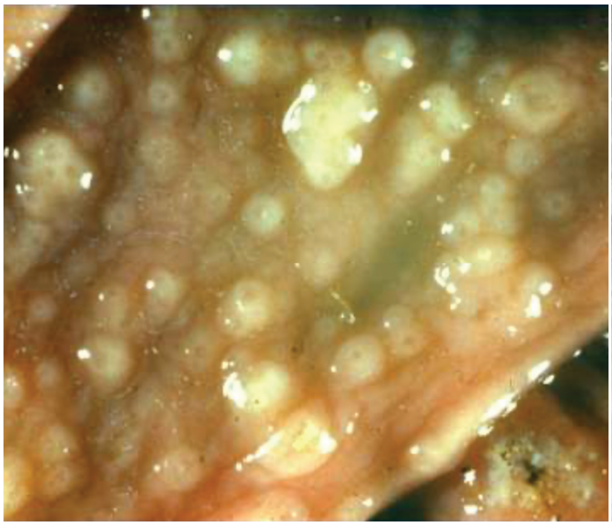
Druijf JM, Wilson PR and Pomroy WJ (2011) Do farmed red deer hinds display post-parturient faecal egg count rise?. Proceedings of the Deer branch of the NZVA. 75-80.

Mason P (1982c) Survey investigates drenching practice and internal parasitism on deer farms. Surveillance 9 (4), 2-3.

Parsons S, Mackintosh CG and Wharton DA (1994) A comparison of lungworm faecal larval counts and trichostrongyloid faecal egg counts between red deer (Cervus elaphus) and red deer x wapiti F1 hybrids. New Zealand Veterinary Journal 42 (3) 110-113.

	Nematode eggs			Lungworm larvae
Date	% ve	mean	Range	No +ve
4 November	97%	11	1-50	3
2 December	92%	14	2-44	0
15 December	89%	7	1-20	0
12 January	82%	13	3-66	0
21 January	72%	6	3-27	1

Post mortem



Severe nodules in the abomasum wall in a deer that died from fading elk disease. These interfere with the normal function of the abomasum and decrease acid production.

Adult lungworm crawling out of the mouth of a deer during post-mortem.

Post-mortem investigation is the best way to determine the level of parasitism in an individual animal. If a random selection of 10 animals from the mob are tested, it can give a good indication of the status of the mob. Post mortem is, however, an expensive option if the animal cannot be slaughtered for human consumption. Samples can be collected from the deer slaughter premises but collecting samples in spring when animals are slaughtered is a retrospective approach and may not be of much help going forward.

All drench efficacy trials in deer require the animals to be slaughtered and the adult parasites present inside the animals to be counted.

Drench efficacy trials

In deer, the only reliable way of testing the efficacy of drenches and whether drench resistance is present is to do a slaughter trial.

- 20 deer are required
- Half are drenched and the other half are not drenched
- All deer are killed 10-14 days after drenching
- The gastrointestinal tract and lungs are removed and sent to the parasitology lab
- The total number of worms is counted by taking a sample aliquot.
- The worms are identified to the species level.

If there is a 95% or greater reduction in worms in the treated group compared with the untreated group, the drench is effective. It is common for drenches to be more effective against some types of worms than others.

Unfortunately this is a very expensive proceedure.

The management toolkit

In addition to the information provided by Wormwise, the following pages give information on options for parasite control. Each farmer should determine which of these are going to work for them and plan how to incorporate them into a productive, profitable farm system.

Current agreed best practice advice is to minimise pasture contamination by young deer by using a "suppressive drenching programme". This is described below. This should be done alongside other steps to reduce larval challenge to livestock and enhance the development of natural immunity. Steps should also be taken to prolong the efficacy of drenches by preventing parasites from becoming resistant to them.

In a perfect world, we would farm multi-species livestock, plant diverse, biologically active systems where there is no shortage in quality feed, minerals, protein or moisture, animals develop strong natural immunity and there is no need for chemical inputs. Our temperate climate makes such a system hard to achieve while maintaining profitability so we have to apply active management to prevent disease.

Monitoring

Some monitoring is required to ensure that the parasite management plan is working.

While applying good management practices makes sense, it is going to make a big difference if you know the current level of parasitism on your farm and track how this changes with different management. Monitoring is essential if reducing the number of drenches.

Nutrition and parasite control

The importance of nutrition to parasite control, and indeed most animal health issues, cannot be overstated. Better-fed animals have the following advantages:

- Able to withstand parasite challenge and grow in the face of parasitism.
- Develop better immunity faster.
- Exposed to a lower level of parasite challenge because they are not forced to continually graze down low on the same pastures.

Generally, healthy, well-fed adult animals should have a level of natural immunity such that they never require drenching. Malnutrition or other concurrent disease can cause this immunity to wane.

Key points about deer nutrition

- For optimum performance, post-grazing residuals should be at least 1500kgDM for growing weaners, lactating hinds, replacement hinds and velveting stags.
- This should be good quality, green, leafy pasture.
- Growing deer should have crude protein levels of 18%.
- Deer prefer variety in their diet and generally perform better on mixed-species pastures that contain a high percentage of clover and herbs compared with traditional ryegrass and white clover pastures.
- Deer perform exceptionally well on pastures dominant in red clover, sulla or chicory.
- Most crops grown for sheep and cattle are quite suitable for deer with good results on commercial farms using rape, kale, swedes, fodder beet and annual or short-rotation ryegrasses.
- Supplementary feeding with products such as hay, baleage, silage, maize, barley, palm kernel and other supplements will help to maintain good nutrition, but the effect on parasite challenge will vary depending on the grazing conditions of the animals.

Take extra care with dietary change:

- Especially during the deer's first autumn.
- If using a specialist forage have several paddocks so that the deer can rotate around on the same feed.
- Accustom the young deer to the feed when they are on their mothers, e.g. bring hinds and fawns onto weaner feed for about a week prior to weaning. If planning to supplement weaners after weaning, provide the same supplement to the hinds with fawns at foot.

Preventative drenching programme

Photo: Richard Hilson

Deer in their first year of life produce the greatest concentration of worm eggs in their dung and are also the most susceptible to parasite infection. A preventative drenching programme will be standard on most farms that pre rut wean. This preventative drenching programme has two main objectives:

- Maintain a low level of pasture contamination by breaking the lifecycle, preventing adult worms from laying eggs.
- Prevent production losses due to parasitism by eliminating adult and some larval worms from the animal.

The preventative drenching programme should allow a low level of challenge so that animals can develop natural immunity. It should ensure that there is a population of parasites that are not exposed to the drenches so that the parasites do not become resistant to the drench (see drench resistance and refugia later).

Preventative drenching programmes will vary from farm to farm depending on the risk and the farm location. Review the risk table on page 28. The table below is a ready reckoner guideline for a preventative drenching programme based on risk. Do not take this as the definitive plan. However you go about this, you will need to monitor the animals to see how the programme is working.

Summary of decisions regarding a preventative drenching programme for rising 1-year-old deer. (See risk table in the monitoring section)

	High risk	**Moderate Risk**	**Low Risk**
When to start drenching	February	1 March	March/April
How often to drench	Every 3-4 weeks	Every 4 weeks	Every 4-6 weeks
Which products to use	Combination oral drench	Combination oral drench	Combination oral drench
When to stop drenching	August/ September	July/August	June/July

When to start drenching

This will vary from farm to farm. Under a high-risk situation such as high deer stocking rate, fawns and hinds set stocked and a history of lungworm on the farm, it may be necessary to start drenching in February or as soon as the first summer rains come. A high summer risk is more likely to occur in Southland than in the North Island. Conversely, where there is a low deer stocking rate, rotational grazing, intergrazing with sheep and/or cattle, high level of nutrition and late weaning it may not be necessary to start drenching until late March or April or not at all. In most cases, drenching will start around 1 March.

Weather conditions play a very important part in deciding when young deer should get their first drench. If there has been significant rain during January, larvae will start developing on pasture and building up high numbers of infective L3s. Therefore, it may be necessary to start drenching earlier. If there has been a prolonged dry period over summer, it will not be necessary to start drenching until the first rains come.

How often to drench

Again, this will depend on the farm situation.

Regardless of the product used, it is assumed that drenches have little or no persistent activity against lungworm or the important gut worms in deer. Drenching every four weeks (28 days) is a compromise between minimising pasture contamination while allowing a few parasites to develop that are not exposed to the drenches. This drenching interval can be shortened if there is a very high risk of lungworm, or extended if alternative methods are used to reduce pasture contamination. If extending the drenching interval, monitoring the animals is important.

Which products to use

In all cases a combination drench is recommended. It would be ideal to know the drench resistance status of parasites on the property before deciding which drenches to use. Working out drench resistance status is challenging in deer. The use of combination drenches has been shown to reduce or reverse parasite resistance in other species. There have been multiple reports of drench resistance on deer farms in New Zealand. Pour-on macrocyclic lactone products (MLs or -mectins) have been shown to be less effective that oral or injectable products if there is resistance on the property. The widespread use of pour-on products is likely to have accelerated the development of resistance on many farms. The use of pour-on drenches is strongly discouraged. See more on drenches later.

Many combination drench products are available and none of these are registered for use in deer. See discretionary use of drenches later. The value of including the levamisole drench family in combination treatments for deer is not clear and there are no strong recommendations on whether or not it should be included. However, levamisole is the most toxic of the three commonly used drench families and also the one most likely to result in residues in animal products.

How many drenches/when to stop

This depends on the farm situation. The number of drenches can range from none to 6 or more depending on the risk factors. If a regular drenching programme has been adhered to from late summer/early autumn and pasture contamination has been kept low while allowing animals to develop immunity, the last drench may be around June or July. Where parasite levels have not been adequately controlled, deer are not able to be fully fed or the weather conditions remain mild and damp through winter, drenching may have to continue until August or September. In some cases, drenching in spring may be of benefit, particularly in replacement hinds. Drench withholding periods and planned slaughter dates are also be a factor in deciding when to stop drenching.

Which animals to drench

It is important that some undrenched animals are grazed on the pastures that the drenched animals are grazing so that parasites that are not exposed to the drenches remain in the gene pool. That can be done by grazing some undrenched adult stock through the paddocks from time to time or by leaving a proportion of the young deer undrenched each time (see refugia later).

Leaving young animals undrenched is likely to slow their growth rates so this needs to be weighed up against the other options for maintaining refugia.

Drenching adult stock

As mentioned above, healthy, well-fed adult deer should require little or no drenching as they will have developed natural immunity. Under conditions of high stress, such as breeding stags or bulls during the roar, or poor nutrition of breeding hinds, and sometimes lactation in young hinds, immunity can wane and adult animals can die from parasitism. Wapiti bulls and cows appear particularly susceptible to infection of the abomasum with *Ostertagia*-like parasites during the autumn. This condition was formerly known as fading elk syndrome and all wapiti sire bulls should be drenched at the end of mating. By the time adult deer show signs of gut parasitism, it can be difficult to treat; therefore it is better to identify stock that are at risk during autumn and treat them before winter. Affected deer may require two drenches given 10 – 14 days apart.

Managing the nutrition of at-risk adult stock is critical to the success of drenching. A single drench in an underweight animal is likely to be inadequate for bringing the animal back to a high level of production. Concurrent trace element deficiencies may be present in these animals and this should be addressed in consultation with your veterinarian.

Quarantine drenching

When new animals are brought onto the property, the parasites they contain and their resistance status are not known (see Resistance below). Quarantine drenching is recommended so that new parasites are not brought onto the property, but it is imperative that this is done correctly as there is the potential to introduce a highly resistant strain if managed poorly. Unfortunately, we cannot rely on faecal egg counts to determine when deer are safe to put onto pastures on the new farm.

If possible get the following information from the source property:

- Drench resistance status of the farm
- When the animals were last drenched
- What product was used, what dose rate and application method.

It is safest to assume that the animals coming on have parasites and that some of these may be resistant to drenches.

Drench all animals with a combination oral drench (see drenches below). Ensure that all animals are administered the full dose appropriate for their body weight. Ideally, this drench should contain moxidectin, oxfendazole and levamisole. Be careful with drenches that contain trace elements when increasing the dose rate. Also be aware that stressed animals that have been transported and off food and water are at a higher risk of drench toxicity.

Hold in the yards or a sacrifice area for 24 – 48 hours to allow all current eggs and worms to pass out of the system. Allow hay/baleage and water during this time.

A second drench could be used 2 – 7 days later if the risk is high.

When introducing the new animals to pasture, run them on a prepared area that has only been grazed by undrenched animals and is likely to contain a high number of susceptible worms. Keep them on this area for as long as possible and the pasture covers will allow – at least 24 hours. These will help to dilute out any worms that have survived the quarantine drench and reduce the chances of them being introduced to the rest of the farm.

New deer should not be run on the main pastures until a quarantine procedure has been followed. Photo: DINZ

Quarantine drenching summary

- Obtain history about the animals
- Use combination drench with high potency (actives must be at an optimal dose rate for deer)
- Hold animals off pastures after drenching if practical
- Place on "wormy" paddock that has had undrenched animals previously
- Caution with toxicity in stressed animals.

Drench resistance

Drench resistance is well covered in the Beef + Lamb NZ Wormwise document. Resistance to drenches occurs due to natural selection. Drenches are highly effective at killing adult worms within the animal and very few will survive. Occasionally a worm may appear that has a genetic difference that allows it to survive the drench. This parasite is said to be "resistant" to the drench. It is likely that resistant parasites occur quite often but do not survive and reproduce for other reasons. The presence of resistant worms on a farm is not detected until there is a problem and the drench appears to be not working as well. By this stage there will be a large population of resistant parasites in the animals and on the pastures.

There is evidence of gut worm (Ostertagia) drench resistance on deer farms that have either conducted a slaughter trial that shows the drenches are not effective or have seen improvements when changing to an effective combination drench .

There have been no reports of drench-resistant lungworm. Levamisole does not work against lungworm but this is not due to resistance.

The table below summarises factors that will increase or decrease the chances of resistance developing on a farm. It is a matter of chance. Just like playing Lotto, the number of tickets you buy doesn't appear to increase your chances of winning the jackpot. Some farms will appear to have all the odds stacked against them and still not have drench resistance, but you are gambling with shortened odds.

Factors likely to speed up or slow down development of drench resistance

Resistance more likely	Resistance less likely
A large population of worms to choose from. Poorly managed, highly contaminated pastures.	Low baseline number of parasites to select from.
Large amount of drench being used, increasing selection pressure.	Reduced drench inputs.
Long-acting drenches that provide a slow release over a long period.	Short-acting drenches only.
Drenching all animals at every drench and only running regularly drenched animals on pastures.	Running some undrenched animals on the pastures.
Using drenches with single actives (either white, ML or clear).	Using combination drenches with as many highly effective actives as possible.
Drenching at intervals shorter than 28 days.	Strategically timed drenches that allow small numbers of worms that are not exposed to drenches to remain in the gene pool.
All-grass system.	Use of crops and forages to reduce pasture contamination and thus reduce the need for drenches.
Moving animals to clean (6 or more months with no deer) pastures after drenching.	Leaving animals on the same pasture after drenching.
Under dosing	Dose to the correct liveweight
No dose delivery check of drench gun	Regular drench gun calibration

Evidence of anthelmintic resistance in deer

To date, the only parasite genera of deer with published evidence of resistance is the *Ostertagia*-type group.

During the mid-1990s macrocyclic lactone pour-on formulations were developed for use in deer. These were found to be highly effective against lungworm and gut worms in deer (Mackintosh et al, 1993; Waldrup et al, 1998).

In **2005**, in **Manawatu**, Hoskin et al found that ivermectin oral (200µg/kg, Bomectin®) and ivermectin pour-on (500µg/kg, Ivomec®) were only 31% and 68% effective against adult *Ostertagia*-type nematodes, whereas moxidectin pour-on (500µg/kg, Cydectin®) was 94% effective based on slaughter and gut worm counts. At that time it was not known whether this was due to the development of resistance or inadequate dosing for control of *Ostertagia*-type nematodes in deer. The numbers of adult *Ostertagia* in the control animals was not high (average 272) and 5% aliquots were counted. So, a count of 20 equates to 1 adult counted in the aliquot. All of the treatments were highly effective against *Dictyocaulus* and *Oesophagostomum*.

On a property in Southland where drench resistance was suspected (Lawrence et al, 2012), moxidectin injection was 100% effective and moxidectin oral was 97.9% effective against *Ostertagia*-type adults. Efficacies of oxfendazole, levamisole and monepantel were all poor at 72%, 72% and 87% respectively. This is unlikely to be due to resistance against these drenches as oxfendazole and levamisole had only ever been used in triple combinations on this property, and monepantel had never been used. Speciation was done in this trial and moxidectin, oxfendazole and levamisole were all 100% effective against *Ostertagia* osteragi, moxidectin oral had lower efficacy against Spiculopteragia asymmetrtica but good against other species. Both oxfendazole and levamisole had poor efficacies against *Ostertagia* leptospicularis, Spiculopteragia spiculoptera and Spiculopteragia asymmetrica but 100% against *Ostertagia* ostertagi.

A case of inadequate efficacy of Eprinomectin pour-on was reported in Waikato in 2013 (Hodgson, 2013). The formulation had an efficacy of 74% against abomasa *Ostertagia*-type parasites with several species surviving treatment.

In 2014, Mackintosh et al reported declining efficacy of moxidectin and abamectin on an Otago farm that had used pour-ons for 20 years. Previously this research group had reported good efficacy of ML pour-ons. The efficacies were 100% against lungworm and Oesophagostomum but against adult *Ostertagia* were 26, 28 and 77% for moxidection pour-on, oral and injection, respectively and 34%, 70% and 72% for abamectin pour-on, oral and injection, respectively.

Hodgson BAS (2013) A study to estimate the efficacy of Eprinomectin pour-on by comparing the faecal egg count reduction to the worm count reduction on a commercial deer farm. Proceedings of the New Zealand Veterinary Association conference 2013, 275–279

Hoskin SO, Pomroy WE, Wilson PR, Ondris M and Mason P (2005). The efficacy of oral ivermectin, pour-on ivermectin and pour-on moxidectin against naturally acquired infections of lungworm and gastrointestinal parasites in young deer. Proceedings of the deer branch of the NZVA 22, 21-25

Lawrence D (2011) Cervine anthelmintics: The bubble has burst. Proceedings of the deer branch of the NZVA 87–92

Lawrence DW, MacGibbon JT and Mason PC (2013) Efficacy of levamisole, moxidectin oral, moxidectin injectable and Monepantel against Ostertagia-type nematodes in deer. Proceedings of the deer branch of the NZVA 30

Mackintosh C, Cowie C, Fraser K, Johnstone P and Mason P (2014). Reduced efficacy of moxidectin and abamectin in young red deer (Cervus elaphus) after 20 years of moxidectin pour-on use on a New Zealand deer farm. Veterinary Parasitology 199 (1-2), 81-92

Waldrup KA, Mackintosh CG, Duffy MS, Labes RE, Johnstone PD, Taylor MJ and Murphy AW (1998) The efficacy of a pour-on formulation of moxidectin in young red and wapiti-hybrid deer. New Zealand Veterinary Journal 46 (5), 182-185

Refugia

The concept of refugia is to maintain a population of parasites on the farm that are not resistant to the drenches because they have not been exposed to drench. Refugia is important for managing drench resistance and has been proven to be effective in sheep.

Sources of undrenched animals:

1. A proportion of the weaner mob (say 5 – 10%)
2. Older animals such as mature hinds or rising two-year-old hinds. These should be grazed on the pastures either with the young drenched deer or alternately, following after the young deer in a grazing rotation. These undrenched animals will be picking up some resistant parasites from the pasture. If possible they should not be drenched after grazing the pastures of concern as this will select for the resistant parasites that they have picked up, defeating the purpose.

The concept of using a 28-day drenching interval and a short-acting drench is based around the fact that the drench will kill sensitive parasites, leaving some resistant ones. The deer will immediately become infected with new larvae from the pasture but it will be at least 21 – 24 days before they are mature and laying eggs. So for the first three weeks, egg output will be from resistant parasites and then for about one week it will be from a mixture of sensitive, resistant and crossbred parasites.

Ways to maintain refugia

- Maintain a 28-day or longer drenching interval in young animals
- Determine the start and end points of the preventative drench programme based on risk
- Do not give additional drenches unless required
- Option 1: Leave a proportion of the weaner mob undrenched
- Option 2: Run some hinds (say 10%) with the weaners
- Option 3: Run hinds through the paddocks after the weaners in rotation
- Option 4 and 5: As for 2 and 3 but with R2 hinds or stags
- Move deer onto contaminated pasture after drenching
- Do not drench adult stock
- Use alternative pasture management to reduce the number of required drenches.

Anthelmintics

There is a massive number of anthelmintic products on the market and this can be daunting to the farmer who wants to know which is the best to use for their stock. The choice is made a little less daunting by knowing that only a small number of active ingredients make up these products. Combination products are recommended in almost all situations. This makes things a little more difficult as most of the combination drenches also have added trace minerals and most also contain levamisole. Depending on the circumstances, these may not always be desirable. Finally, it appears that deer require higher dose rates of all of the drench actives to achieve the same effect as in other species. The only combination that achieves this and that is registered for use in deer is Cervidae Oral (triple oral combination).

Then comes the issue of residues and withholding times. Most drenching decisions will have some form of "discretionary use" involved and there are legal requirements around the use of all registered veterinary medicines. The most important of these are:

The user must have sought adequate expert advice to ensure that:

a) The animals will not experience any pain or suffering.

b) No residues above the Maximum Permissible Levels (MPL) will occur in the meat.

The use of drenches in deer has been shown to vary widely between farms and between years. In the early 1980s the benzimidazoles (white drenches) were the most commonly used anthelmintics. Five years later, ivermectin and moxidectin were more widely used and by 2005, moxidectin had become the most popular drench on deer farms. More recently there has been an increase in combination drench use.

Up until Cervidae Oral (triple oral combination) was registered in July 2021, there were a number of drenches registered for use in deer, none of which were effective. The historical table below, from www.deernz.org, shows all products previously registered with the ACVM for use in deer.

Table 1. Anthelmintics registered for use in deer (June 2013)

Type/family	Active ingredient	Route of admin	Brand name	WHT
White	oxfendazole	oral only	Oxfen C Bomatak	10 days
	albendazole	oral only	Valbazen	7 days
	fenbendazole	oral only	Panacur 100	10 days
Macrocylic lactone (ML)	moxidectin	pour-on	Cydectin Pour-on Exodus Pour-on	Nil
	abamectin	pour-on	Genesis Pour-on Baymec Pour-on Bomectin Gold Pour-on	28 day
	eprinomectin	pour-on	Eprinex Pour-on	7 days
	ivermectin	pour-on	Noromectin Pour-on	21 days

The choice was limited and the dose rates on the packets are inadequate to achieve control. There is no option for farmers other than to use products off-label (higher dose rates and/or unregistered). This means using alternative products under the guidance of a vet and then having to take steps to ensure no residues in the animals.

Technical notes about drench families

Benzimidazoles (BZs)

The first BZ was discovered in 1961 and resistance was recorded within 5 years. These chemicals interfere with tubulin formation, which is required for multiple functions. Resistance occurs by a single genetic mutation. Resistance is now very widely spread in sheep and goats in all major areas of the world where these species are farmed.

Early work by Mason (1982) found that fenbendazole and oxfendazole were effective against lungworm based on shedding of lungworm larvae, but albendazole and mebendazole had only limited efficacy against lungworm. A slaughter trial using albendazole demonstrated less than 85% efficacy against adult and immature lungworm. Mackintosh et al (1985) found that febantel had 85% and 99.8% efficacy against immature and mature lungworm, respectively in 5 three-month old red deer calves.

In a trial on a Southland deer farm (Lawrence, 2011) with known resistance of Ostertagia to moxidectin, oxfendazole at triple the recommended dose rate (13.6mg/kg) was significantly more effective (87%) than using the standard dose rate (4.53mg/kg) against adult Ostertagia-type nematodes (54%). This is still not highly effective but suggests either resistance or that the recommended dose rate is too low for deer.

BZs are short acting and are metabolised rapidly in deer. Mackintosh et al (1985) measured plasma fenbendazole, oxfendazole and oxfendazole sulphone at 12, 18, 24, 30, 36, 48, 72, 96, 120, 144 and 168 hours after administration of 7.5mg/kg of febantel. Plasma levels peaked at between 3 and 12 hours and were all but gone within 72 hours. (See figure below).

As the BZs have a wide safety margin and it is assumed that deer require a higher dose rate than cattle or sheep to achieve the same level of anthelmintic activity, it is recommended that the dose rate of plain BZ is three to four times what would be used for sheep and cattle. Further dose titrations are required to validate this recommendation.

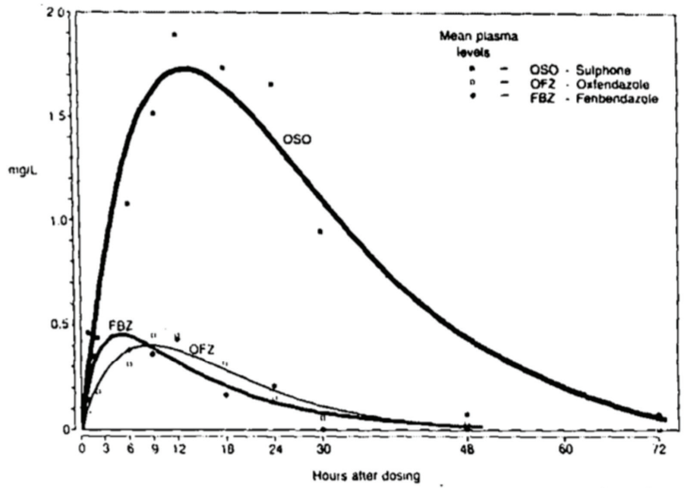


Fig. 2. Fitted curves for plasma levels of the febantel metabolites fenbendazole, oxfendazole and sulphone.

Curve of plasma levels of febantel metabolites fenbendazole, oxfendazole and sulphone after administration of 7.5mg/kg febantel by mouth. From Mackintosh et al, 1985

BZs have no persistent activity, so new infective larvae will be picked up soon after drenching. This is good from a refugia standpoint, but on pastures with high lungworm burdens, problems can be seen in young deer within 3 weeks of drenching.

Key points about BZs

- Short acting.
- Broad spectrum.
- Resistance develops rapidly.
- Oxfendazole is the recommended choice.
- These drugs should be used in combination with ML and possibly levamisole.
- It is probable that the dose rate needs to be higher (up to 4x) than sheep and cattle.
- The risk of residues in meat is very low 42 days after treatment.

Macrocyclic lactones (MLs)

Avermectins are produced by the soil-dwelling bacteria, Streptomyces avermitilis. This bacterium is a member of the Acitomycetes group and may have developed the ability to form these chemicals to protect plants from soil pathogens as they are symbiotic inhabitants of many plants.

Avermectins were discovered in 1978 when a soil sample containing an actinomycete of interest was collected and the bacteria isolated. The research and development was handed over to Merck Sharpe and Dome who went on the develop the anthelmintic compounds. Ivermectin was developed by Merck in the 1980s. It came onto the market in 1988 and the first report of resistance was made 5 years later in 1993.

Several new, semisynthetic drugs were developed including the highly potent moxidectin and abamectin. MLs are highly potent drugs that interfere with several ion channels but in particular glutamate gated chlorine channels. This causes paralysis and expulsion of the parasites. MLs have also been found to be toxic to a range of insects and mites and resistance is likely to develop quickly with overuse of the drugs. Non-lethal doses can result in paralysis of the oesophageal and uterine muscles and a suppression of egg laying. This can be seen as a zero faecal egg count after drenching when the adults have not actually been killed.

The discovery of avermectins has made a huge impact on human health. It radically lowered the incidence of the human parasite-induced diseases river blindness and lymphatic filariasis, winning its discoverers a half share of the Nobel prize in 2005.

ML products have variable claims of persistent activity against different parasites in sheep and cattle. The length of this persistent activity depends, in part, on the route of administration of the drug. Pour-on and injectable formulations have a longer period of activity than oral dosing. No studies have been done in deer to evaluate the persistent activity of ML products. As deer may metabolise drugs faster, persistent activity against lungworm or gut worms cannot be assumed. Anecdotal observations would certainly suggest that ML pour ons were achieving persistent activity against lungworm in the past.

MLs vary in their potency. Ivermectin is less potent than other MLs against Ostertagia-type parasites and should be avoided. Up to 100% efficacy has been reported for moxidectin against lungworm and Ostertagia-type parasites. Abamectin may be slightly less potent than moxidectin and has been associated with signs of toxicity in deer. Being in the milbimycin group, moxidectin can maintain efficacy against some parasites that become resistant to abamectins.

Caution should be exercised when increasing the dose rate as toxicity can occur in underweight and ill thrifty animals that have very little fat reserves. Breeding stags after the roar can be at risk as well as tail-end weaners.

Macrocyclic lactones take longer to be eliminated from the animal than BZs. The plasma concentrations achieved and elimination time depend on the formulation and delivery method. Peak plasma levels are highest and last the longest after injection, intermediately following oral administration and reach low levels for prolonged periods after pour-on application (Mackintosh et al, 2014; Lawrence et al 2012).

The fact that many pour-ons have a nil withholding time is testament to the very low plasma and tissue levels achieved following this route of administration. It is therefore not surprising that pour-ons have had low efficacy against hard-to-kill worms and accelerated the development of resistance. Their continued efficacy against lungworm is simply due to the potency of the drug and marked sensitivity of this parasite to it.

Key points about MLs

- High potency. Moxidectin and abamectin most potent and best options.
- Persistent activity cannot be assumed in deer.
- Resistance develops rapidly and is widespread on deer farms.
- Should be used in combination with oxfendazole and possibly levamisole.
- Do not use pour-on formulations.
- Caution with overdosing animals in poor condition.
- There is very low risk of residues 49 days after treatment with moxidectin.

Levamisole

Levamisole is generally considered to be ineffective against parasites in deer. All the trial work done in deer (three experiments) has shown that it produces less than 100% kill for any parasites. At the standard dose rate, it was ineffective against lungworm and at 2.5 times the standard dose it reduced Ostertagia types by less than 50%. One trial showed a reduction of 72% against Ostertagia-type parasites. It has been hypothesised that the decreased efficacy of levamisole in deer compared with cattle might be because deer eliminate levamisole from the blood stream very rapidly so that high enough concentrations are not achieved for long enough. Levamisole acts by causing spasmodic paralysis in the parasite.

Levamisole may still have a role to play on deer farms, however. While it should never be used on its own, in combination with an ML and a BZ, it may help to prolong and protect or enhance the efficacy of the other actives and slow the development of resistance. Resistance to levamisole is less common on cattle farms compared with other drench families and resistance to levamisole on deer farms is unlikely because it has had very little use in deer to date.

Of the commonly used classes of drench, levamisole is most often associated with toxicity and there has been a report of levamisole toxicity in deer. Increasing the dose rate over 2x the standard cattle dose should not be done owing to the risk of causing pain or distress in the animals.

Residues may be an issue when levamisole is included in the drench combination. Although early work suggested that deer eliminate levamisole very rapidly, a residue trial found that 2/9 deer had levels of levamisole in the fat that were above the MPL at 42 days after treatment.

Key points about levamisole

- Not effective on its own.
- Can be included in a combination drench and may be of benefit.
- Risk of toxicity; do not dose more than 2x sheep/cattle.

Monepantel (Zolvix)

The amino acetonitrile derivative, monepantel, is commercially available for use in sheep (Zolvix®, Novartis). While reasonable efficacy was found against most nematodes of sheep with the possible exceptions of Nematodirus spathiger, Oesophagostomum venulosum and Trichuris ovis it was found to be less effective in deer in a trial in Southland. After administering 2x the standard sheep dose, there was an 87% reduction in Osteragia-type adult nematodes in abomasa washings compared with untreated deer.

Derquantel and Abamectin (Startect)

A slaughter trial on 10-month-old deer using the standard sheep dose rate of Startect produced an 82% efficacy against adult Ostertagia. This product cannot be recommended for parasite control in deer.

Combination drenches

Combination drenches are recommended in nearly all cases

The use of combination drenches has been shown to decrease the rate of drench resistance on sheep farms and in some cases, when used in combination with changes in management practices, reverse resistance so that the parasites are no longer resistant to the individual drenches. Using a combination drench of as many actives as possible is better than rotating drench families on an annual or semi-annual basis. There has been no trial work to establish the effect of using combination drenches on deer farms but there is no reason to expect it would be different from sheep farms except that there are only two highly effective actives for deer, whereas sheep farmers now have at least four different classes of active compounds to work with.

It is likely to be of benefit to use a combination that contains levamisole, even though this drug is not very effective on its own. Even if it kills 50% of the parasites, that will be a 50% reduction in the chance of ML/BZ resistant worms remaining.

There may also be an additive effect of levamisole in that it may weaken parasites and make them more susceptible to the other drenches or vice versa.

Cervidae Oral is a triple oral combination drench registered for use in deer (July 2021).

The actives (moxidectin, oxfendazole and levamisole) in Cervidae Oral are at levels considered optimal for deer and its use will therefore have the greatest chance of delaying the development of drench resistance on deer farms.Cervidae Oral has a 28-day withholding time.

Legal issues

Cervidae Oral being the exception, there are no other products currently registered for use in deer that have high enough concentrations of effective compounds. This means that proper drenching involves the use of products off-label and registered with the ACVM for use in species other than deer. It is prudent to get a veterinary prescription for the use of off-label products. Veterinarians (and farmers) are advised to the following cascade when selecting a product to use:

Off-label use

From the MPI website: https://www.mpi.govt.nz/processing/agricultural-compounds-and-vet-medicines/acvm-guidance-for-veterinarians/#deciding-on-treatment

When deciding what product to use, you should follow the risk management-based product use "cascade", with #1 as your first choice:

1. On-label use of a NZ-authorised veterinary product (No suitable deer drenches exist)
2. Off-label use of a NZ-authorised veterinary product (Several exist but label dosing for other species is thought to be too low for deer)
3. Off-label use of a NZ-authorised (Medsafe) human product (Not appropriate for deer drench)
4. Import of an overseas product (veterinary product preferred but human product acceptable). (Not necessary for deer drench at this stage.)

We are currently faced with requiring to use an off-label NZ-authorised veterinary product. Note that off-label use includes increasing the dose rate administered above that specified on the packaging.

There is a large list of drench products available for use in cattle and sheep but there is little or no testing of their efficacy in deer.

Withholding times

Own use of veterinary medicines: You must not cause residues in produce you sell for human consumption.

ACVM Act (1997) Part 5, section 55, 3

Every veterinarian commits an offence who knowingly fails to provide any client with information to prevent the occurrence, in any primary produce from any animal treated with an agricultural compound, of residues of that compound which contravene any requirements of the Dairy Industry Act 1952, the Meat Act 1981, the Animal Products Act 1999, or the Food Act 1981 or any regulations or notices in force under those Acts.

Beyond drenching

While drenching is often the focus of parasite control on many farms, some achieve good control with minimal or no drenching. Relying on drench is the “ambulance at the bottom of the cliff” approach. Remember only around 10% of the parasite population is in the animal at any one time.This section describes some possible methods that can be used to reduce the need for drenching. Many of these practices will result in an overall healthier, more productive, profitable and sustainable farm.

Rotational grazing

Rotational grazing is one of the most important management strategies for improving pasture production and preventing the build up of disease on paddocks.

For parasite control, the optimum rotational grazing timeframes are:

1. Stock in the paddock for no longer than the time taken for larvae to develop in the faeces. This is 4 days at 25°C and high relative humidity, with some variation between parasite species. No development will occur below 5°C and very little or none below 10°C depending on the parasite. Larvae will not develop and migrate in the absence of moisture so stock can safely be left on longer if it is very dry. However, as soon as the rains come, there is high risk within 4 days.
2. Stock do not return to the paddock until the majority of larvae have developed and expended all their energy and died. Under warm conditions this might be around 3 months and under cold conditions up to 12 months. Obviously, this length of time between grazing is not going to be conducive to good pasture utilisation. If grazing rotation is combined with other methods, such as leaving high residuals and encouraging breakdown of dung, this inter-grazing period should be able to be reduced.

When animals are set stocked on pasture under moderate stocking rates:

- Plants that are preferred are continually grazed, resulting in plant shock and reduced growth in the individual plants.
- Plants of low preference are avoided, resulting in seeding and spread of undesirable plants.
- Plants have poorer root structure due to lower photosynthesis and decreased sugar production to support root function.
- Plants are less able to cope with insect and disease pressures.
- Soil microorganisms are depleted as roots are less able to produce the sugars required to support them.
- There may be a depletion in soil organic matter and mineralisation of soil nutrients making nutrients less available for plant uptake.
- The total stock carrying capacity and annual pasture production is decreased.
- Animals are continually exposed to ever-increasing build-up of parasites and other pathogens on pasture.

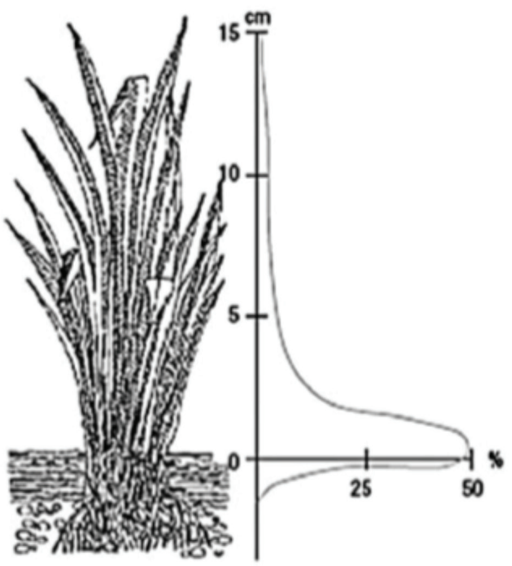
- Every parasite that hatches into an infective larva has the possibility of being eaten as animals are always present. Parasites can more easily complete their lifecycle.
- Rotational grazing better mimics natural grazing systems.
- Under very low stocking rates, deer are more settled in a constant environment, especially at the time of fawning.

Rotational grazing is not without its drawbacks, however. These include:

- The need for fencing, a major expense particularly on hill country.
- On extensive or high country properties with very large blocks, only very slow rotations are possible.
- Deer are not that easy to keep behind temporary electric fencing on small areas, although this can be done with dedication.
- Mustering on extensive country can be expensive and inefficient, often requiring helicopters.
- Increased labour costs from having to continually move stock.
- Grazing to timeframes to reduce parasite challenge might result in loss of feed quality.
- Under ideal pasture-growing conditions, maximum larval challenge might occur when pasture needs to be grazed.

Pasture height

Using pasture height as a tool can only be done successfully in conjunction with rotational grazing. Simply decreasing stocking rate is unlikely to achieve the same effects. It is post-grazing residual that is critical as far as pasture height is concerned.



The vertical distribution of infective larvae on grass.

In one study, 80% of L3 were in the bottom 5cm of pasture height (Pegoraro et al, 2008). The Wormwise manual has a diagram (reproduced here) showing that 50% of the L3 larvae are in the bottom 2cm of pasture and top 1cm of soil. Far fewer larvae are present at the tops of long blades of grass.

There is no difference between the different species of grass in their ability to harbour infective larvae. Ryegrass, cocksfoot, prairie grass and all other blade grass species transfer infective larvae very effectively.

It is likely to be more difficult for parasite larvae to climb up long pasture, particularly when there is a high legume and herb content or lack of moisture. The upper parts of the pasture will dry out more quickly, whereas the base of the pasture maintains a higher level of moisture, more even temperature and less exposure to direct sun and UV light. Larvae have been shown to survive better at the base of long pasture where there is a build up of litter protecting moisture and temperature.

Long pasture grazing has other benefits for nutrition, animal, plant and soil health:

The better nutrition offered to the animals will result in higher growth rates and a more robust immune system. Even if deer are carrying a few parasites the effects of these will be minimal.

Photo May 2019, Kaipara. Post Rut weaning, rotational grazing on high pasture covers that are still green and leafy. Deer pick through the sward for the plants that they like, so simply maintaining high pasture covers will not guarantee that they don't eat close to the base of the sward. The risk of contamination on this pasture will depend on what species were last grazed, when it was last grazed and the level of faecal contamination and weather events since last grazing. Moving animals before pasture covers drop too low is very important.

Sustained long pasture grazing (taking ⅓ to ½ of the available pasture and allowing pastures to grow to longer lengths year on year) can result in a healthy pasture due to deeper rooting plants, better soil stability and organic matter and more stable fungal populations. A wider range of plant species will also develop in the sward from less continual grazing pressure.

Grazing with as many animals as possible for as short a time as possible is the general principle behind regenerative agriculture. This results in minimal grazing shock to the plants and a good ratio of plant residual and manure to allow for increase in organic matter through microbial activity. If animals are in a paddock for less than 3 days, there is no chance of the eggs that have been shed developing to the L3 infective stage before the animals are moved on.

Cross/co-grazing

Cross grazing or co-grazing are often quoted as important tools for parasite control. Research results are mixed with some even concluding that cross grazing decreased lamb exposure to parasites and therefore decreased development of immunity.

Other benefits of multi-species grazing systems include pasture control, improved pasture quality and economic diversification. Most parasites appear to be fairly host specific; a few worms will infect multiple hosts. The idea of cross grazing is that the other species (e.g. cattle) are able to "clean up" deer parasites by eating them with the pasture and killing them as they pass through the animal. To achieve best results, cross grazing should be done when the highest pasture L3 burden is expected and when there is moisture on the grass.

Research on cross-species infections

When housed deer and sheep were artificially challenged with sheep parasites, the rate of establishment was lower in the deer than the sheep (Tapia-Escárate et al, 2015). Least Square Mean establishment rates for *Haemonchus contortus, Teladorsagia circumcincta, Cooperia curticei, Trichostrongylus* spp and Oesophagostomum + Chabertia spp were 18.6%, 35.5%, 30.7%, 74.9%, and 19% in sheep and 10.5%, 1%, 0.1%, 1% and 4.8% in deer. Only *Haemonchus contortus* and *Oesphagostomum* venulosum originating from sheep established in significant numbers in the deer.

Tapia-Escárate D, Pomroy WE, Scott I, Wilson PR and Lopez-Villalobos N (2015) Establishment rate of sheep gastrointestinal nematodes in farmed red deer (*Cervus elaphus*).

Research has shown that cross grazing deer with either sheep or cattle dramatically reduced lungworm infection in the deer. Pre-grazing fawning paddocks with sheep and cattle for several months prior to fawning is likely to be useful for reducing lungworm infection.

In an indoor trial, all sheep GI parasites established at a significantly lower rate in deer than in sheep (Tapia-Escárate et al, 2014a). When deer were cross grazed with sheep, they established fewer Ostertagia, more Trichostrongylus and required as many drenches as straight deer grazing (Tapia-Escárate et al, 2014b). In that trial, cross grazing sheep and deer was not helpful for gut worm control.

Cattle-originating parasites were fed to parasite-free deer and calves keep indoors (Tapia-Escárate et al, 2014a). Cooperia spp. and *Ostertagia ostertagi* established at lower rates in deer than in cattle. The rate of establishment of *Trichostrongylus axei* and *Haemonchus contortus* was higher in deer than in cattle. No small intestinal parasites of cattle established in deer. When cattle were cross grazed with deer, the deer required fewer drenches and grew faster than when either straight deer were grazed or deer and sheep were grazed together. (Tapia-Escárate et al, 2014b).

Post-rut weaning

Although there is no research data available, it is commonly reported that young deer require less drenching if they are post-rut weaned. Post-rut weaning is practised on a number of deer farms and is often the subject of great debate! There are pros and cons for both pre- and post-rut weaning and you should choose the system that fits your feed supply, management and personal preferences.

While the fawn is with its mother and consuming milk it has reduced exposure to grass and parasites. There may be some antibodies in the milk that provide "passive" immunity to the fawn. This is not the same as the fawn developing its own immunity. The fawn may have a higher protein intake allowing it to keep growing even when it has some parasites in its gut, and the fawn will be in a relatively stress-free environment, having its mother to run to for comfort and milk when it experiences fear or distress.

Weaning is a stressful time for both fawn and hind, but it can be made less stressful by:

- getting the fawns accustomed to people, dogs and bikes prior to weaning
- teaching the fawns to go through gateways prior to weaning
- moving fawns onto the weaning paddock prior to weaning so they are familiar with it
- getting fawns accustomed to the feed they will be weaned onto prior to weaning
- offering supplementary feed such as maize or barley before weaning and continuing this after weaning
- ensuring there is plenty of quality, palatable feed available to wean onto
- tagging and vaccinating either before or after weaning as separate events
- bringing the hinds and fawns through the yards quietly and without "doing" anything to the fawns
- not mixing mobs at the time of weaning
- bringing the hinds and fawns onto the weaning paddocks and then removing the hinds and leaving the fawns behind
- OR moving hinds into the paddock next door with a secure fence in between.

If post-rut weaning, it is critical that plenty of good quality feed is available for both hinds and fawns. If there is inadequate feed:

- hinds will use body fat to produce milk for the fawns
- conception will be delayed at the next mating. Post-rut weaned hinds usually conceive about 2 weeks later than pre-rut weaned hinds on average
- conception rate may be reduced
- fawns will be slower to adapt their rumen to digest pasture rather than milk
- there will be a higher risk of parasites and other diseases in the hinds.

If feed is tight during February and March it is better to wean the fawn onto the best available feed and/or supplements and allow the hind to regain condition for mating. An investment into feeding the fawns in this period can prevent ongoing losses in hind performance over the next 1 – 2 years.

CARLA® saliva test

CarLA (Carbohydrate Larval Antigen, written as CARLA) is a protective coat found on the surface of the infective stage larvae (L3) of all the parasitic gastrointestinal nematodes that infect livestock in New Zealand. The CARLA coat is exposed once the larvae are ex-sheathed in the animal's rumen and is likely to be important in determining where in the host the larvae need to reside. About 3–5 days after the larvae are ingested by the host, the CARLA coat is released from the L3 as it develops towards being an adult worm. Once released, it can stimulate the immune system of the host to eventually produce antibody to CARLA. Antibody to CARLA produced at the mucosal surfaces that larvae invade, binds to the surface of incoming larvae and prevents them from establishing. Antibody to CARLA is produced at most mucosal sites, so can be sampled in saliva, a mucosal secretion.

CARLA response was measured as part of the Deer Progeny Test work done by AgResearch. They found some promising results.

Studies have shown that in both sheep and deer, elevated CARLA in saliva is significantly associated with reduced FEC and faecal larval counts (lungworm L1s) in deer. By preventing the larvae from establishing in the host, adult worm burden is reduced. Animals with high CARLA responses tend to be more productive than animals with low or no CARLA. With reduced adult burden, energy normally required to combat worms is available for production.

Testing in New Zealand has shown the optimal time to sample deer is either late autumn at about 6 months of age (heritability 20%) or in spring at about 10 months of age (heritability 45%). Once the CARLA antibody response has developed it will be maintained if animals are grazing pastures infected with parasite larvae. Cold conditions, feeding animals on crops or hot dry weather will lower exposure to larval challenge which in turn will reduce the CARLA response. Drenching won't affect the CARLA response as it is stimulated by in-coming larvae picked up off pasture.

A large trial carried in 2019 at AgResearch Invermay gave a clear understanding of the relationship between CARLA and measures of parasite output in young deer. For each 3-fold increase in CARLA, lungworm larval counts reduced by ~14% in April and in June by ~50%. For FEC, counts were reduced by ~18% in April and in June by ~30%. March-October liveweight gains increased by ~7% for males and ~4% for females for each 3-fold increase in June CARLA.

Deer Select has now developed a breeding value for CARLA and all studs that choose to measure this trait can have their animal's merit for CARLA predicted from young animal test data. The advantage of BVs is merit of close relatives can also be predicted, e.g dams, sires and half siblings. The CARLABV also accounts for non-genetic effects such as age and mob effects, and other environmental effects

As of 2020, there are about eight Red and eight Wapiti studs recording the CARLA trait and producing breeding values. This is a relatively recent trait, but the following is a guide to CARLA breeding values in young males (sale animals):

- Above average: > +20
- High: > +50
- Very high: > +100.

There are above average CARLA animals at every level of weight 12 merit. This is a very real tool that can be used in conjunction with other traits when selecting breeding stags for purchase to breed progeny with improved immune to parasite challenges.

There are two ways the deer industry can benefit from utilising CARLA:

1. Commercial farmers can CARLA test their replacement hinds as rising yearlings (at 6 months or 10 months). The results will be raw data and there are limitations with this. They are farm/herd specific and cannot be compared with other farms. However, the invaluable information is that the raw data will provide relativity within a herd. This will allow selection decisions to be made on replacements. This should be supported by purchasing sires with improved CARLA BVs to ensure on-going improvement
2. Breeders can CARLA test their rising yearlings and those on Deer Select will then get CARLAeBVs for their deer. The CARLAeBV of an animal provides the genetic component of CARLA that an individual animal will pass on to its progeny. This provides a powerful tool for farmers to use when selecting a sire.

Saliva sampling to determine CARLA responses can be carried out by deer farmers using sampling kits provided by AgResearch. Saliva is collected by swabbing the cheek area of deer with a cotton swab.

Contact the CARLA Saliva test unit at: Carlasalivatest@agresearch.co.nz or phone: 0800 422752

Alternative forages

Chicory

Cichorium intybus

The benefits of chicory are probably owing to its high palatability and improved mineral and nutrient density along with the structure of the plant not being ideally suited to parasite migrations. There may be another compound in chicory that directly affects the development or motility of parasite larvae. Chicory is related to dandelions and is a member of the daisy family. It has a large tap root for which it is cultivated for inulin production and is one of the oldest plant food sources and medicinal plants. The tap root, combined with chicory's ability to form symbiotic relationships with mycorrhizal fungi make it highly drought tolerant and increases the ability to take up nutrients through the soil profile. It is also a useful plant for soil improvement.

Deer grazing pure chicory required less drenching than deer grazing perennial ryegrass/white clover based on faecal egg counts and clinical signs (Hoskin et al, 1999, 2003). Other trials in lambs have had mixed results. Generally growth rates are improved but direct effects on larvae or adult parasites show mixed results.

A word of warning: During winter in the trial above, the weaners grazing chicory were moved onto grass due to the chicory being dormant. This resulted in a spike in lungworm and weight loss after transition onto grass and 2 drenches were required during winter.

The get the best benefit, it would be grazed like in the picture shown, but this would be a pretty uncommon way to graze deer. Chicory-dominant swards are likely to be more effective than grass-dominant swards with a bit of chicory included. Continual grazing as part of a mixed sward will quickly result in chicory being "grazed out".

Chicory requires special treatment so do your homework before including it in your pasture plan.

Photo: I Evans. Strip grazing chicory. Although this crop has gone to seed, this is an excellent way to provide a clean crop of a forage that reduces the need for drenching

Lucerne

Lucerne does not appear to have any direct effect on parasites infecting lambs. Substituting 30% of lamb diet with lucerne while the rest was ryegrass did not affect parasite levels in the lambs (Knight et al, 1996). Parasitised lambs grazing lucerne had lower growth rates and higher worm burdens than those grazing sulla (Niezen et al, 1996). It is not clear what the difference would be grazing pure stands of lucerne. Lucerne is a great plant for many purposes including high-quality summer forage, cutting and conserving as silage, baleage or hay or as a pasture legume in light soils where its grazing can be carefully managed. Lucerne really comes into its own in dryland due to its deep rooting structure.

Sulla

Hedysarum coronarium

Sulla is a 2-3-year legume originating from the Mediterranean region. Several trials in lambs have shown sulla to either reduce parasite burdens, prevent the impacts of parasite challenge or allow lambs to grow in spite of parasite infection. Deer have also been shown to perform well on sulla. It is thought that the high animal performance on sulla is due to its relatively high levels of condensed tannins. Performance is consistently better on Sulla than on lucerne which is a similar type of legume but possibly a bit less digestible. With a crude protein of up to 26% and high condensed tannin levels protecting the protein along with high digestibility and ME ranging from 10.5 to 13MJME it is obvious why this is a rocket fuel for spring finishing.

You need to do your homework before growing sulla and it really should be treated as a 2-year crop with high spring production and summer dormancy. It requires free draining soils and a relatively high pH (5.8 +) and does not tolerate high salinity. Sulla does well in dry regions.

Condensed tannins (CT)

Tannins exist in plants in a range of different forms. Some condensed tannins form complexes with proteins in the feed in the rumen. This makes these proteins unavailable to the rumen microbes which means they can not break them down to form urea and also results in lower methane production. The protein enters the abomasum (rumen bypass) and here the bond with the condensed tannin is broken and the protein is then available for the animal to utilise. In addition, by some unknown mechanism condensed tannins appear to have impacts on worms decreasing egg hatching and larval development. This all sounds very promising. Ruminants only have a certain tolerance for condensed tannins in their feed and high levels decrease feed intake and thus production. Deer, fortunately have a higher tolerance for condensed tannins than cattle or sheep and animals can be adapted to cope with higher intakes over time.

One challenge is working out how to go about including more condensed tannins in the diet of the deer as most high-CT plants do not go well in grass-based grazing pastures.

Deer have shown improved lactation, growth, trace element status and resilience to internal parasites when fed diets containing forages high in CTs (Hoskin et al, 2003). Deer produce a protein in their saliva that is able to bind CTs thus allowing them to consume higher quantities than sheep or cattle.

High-CT plants have been found to affect parasites in lambs. In the lab, CT extracts from Lotus species, sulla, sainfoin, Dorycnium species, and Rumex obtusifolius (dock) have been found to impact worm development (Molan et al, 1999, Molan and Faraj, 2010). In feeding trials, high-CT feeds including Quebracho extract (Athanasiadou et al, 2000), sulla (Niezen et al 1995) had an impact on faecal egg counts but only sulla resulted in higher growth rates in lambs. Neizen et al also found that sulla produced better results than lucerne in the face of parasite challenge.

Some plants high in condensed tannins (there will be many more)

- *Acacia Angustissima*
- Sulla (*Hedysarum coronarium*)
- *Lotus coniculatus*
- *Lotus peduculatis*
- Sainfoin (*Onobrychis*)
- Dock (*Rumex obtusifolius*)
- Willow (Salix sp)
- Pine bark

Goats have also shown a positive response to CTs as far as parasitism goes. Pomroy et al (2004) found that goats grazing a high -CT plant (*Sericea lespedeza*) for 15 days had lower faecal egg counts and lower total egg output compared with goats grazing a grass-based sward. The survival of eggs to L3 was also greatly reduced on the high-CT feed. Goats also appear to have a higher tolerance for high-CT forages and will readily eat large quantities of dock. Min et al (2005) also found that Angora goats grazing forage high in CTs (also *Sericea lespedeza*) had lower faecal egg counts and reduced larval development than those on a control grass-based forage. In this study a rotational grazing between the high CT and the control forages resulted in burdens somewhere between each showing that just adding a high CT forage into the grazing rotation can assist with reducing parasite burdens.

Outdoor grazing trials with different forages have been less successful. Tamaleoukas et al (2005) found only a marginal benefit of feeding chicory and no benefit of feeding sulla or lotus compared with grass/clover pasture on establishment of Teladorsagia circumcinta. Marley et al (2003) reported variable results from a two-year trial with no effect of chicory or birdsfoot trefoil on mixed natural infection parasite egg hatchability in the faeces of lambs grazed on different diets.

More trial work on the effects of mixed forages and alternative forages on parasitism in deer is needed.

More information about condensed tannins: Effects on methane production

Tannins are polyphenols produced by plants that are able to form complexes with proteins and metal ions (Neumann et al, 2017). They are divided into hydrolysable (HT) which are considered toxic to ruminants and CTs which have had more focus as both anti nutritional factors and beneficial compounds.

Condensed tannins consist of flavan-3-ol subunits.

Antinutritional factors of condensed tannins

CTs have an astringent taste which can reduce voluntary feed intake. Not all CTs have the same effect and it seems to be related to how strongly the CT binds protein. A plant that produced CTs with a strong affinity for binding protein is more astringent than one with a lower protein-binding affinity. Decreased feed intake causes reduced growth rates and poorer overall nutrition.

CTs form complexes with albumin, gelatin, lime, lead acetate, alkaloids, and many other metals and trace elements.

It is possible for ruminants to adapt to a higher CT diet by gradually increasing the rate of inclusion.

An in-vitro (In the lab, not in the animal) study assessing the effects of different levels of CT on methogenesis and dry matter decomposition in rumen fluid found that increasing CT to 30mg per 1 gram of dry matter decreased methane production by 47% while only decreasing DM digestion by 7%. Increasing the level of CTs further reduced methane production but also decreased DM digestion (Tan et al, 2011).

Tan HY, Sieo CC, Abdullah N, Liang JB, Huang XD and Ho YW (2011) Effects of condensed tannins from Leucaena on methane production, rumen fermentation and populations of methanogens and protozoa in vitro. Animal Feed, Science and Technology 169 (3-4), 185–193

Willow

Willow may be useful as part of a parasite management programme but should not be relied on as a sole treatment for infected animals. It is hypothesised that the high CT levels in the willow is responsible for reduced survival of parasites.

There may be other compounds present as yet undetermined. Willow bark is the original source of the anti-inflammatory painkiller, aspirin. It is an ancient medicine dating back to ancient Egypt Sumar civilisations.

Daiz Lira (2005) found that lambs with continual access to willow grazing blocks grew significantly faster and had lower parasite burdens than those rotationally grazed on-off willow blocks and lambs grazed on grass-based pastures. The lambs were drenched before the trial and did increase in parasite burdens throughout the trial, so grazing willow did not completely prevent infection. Mupeyo (2010) found that feeding willow reduced the faecal egg output for *Haemonchus* and *Teladorsagia* and reduced the number of adult *Haemonchus* in the abomasum. Those fed willow had lower egg counts and lower total worm counts when slaughtered compared with those fed lucerne. (Mupeyo et al, 2011). In a field trial, lambs fed willow blocks had similar parasite burdens to those on ryegrass and white clover, but had higher levels of immune measures including CARLA and slower growth rates (Ramírez-Restrepo et al, 2010). Willow also increased the growth rates and conception rates (+17 lambs/100 ewes) of hoggets (Musonda et al, 2009).

Flax (e.g. Phormium tenax)

A study in calves found that feeding flax did not reduce faecal egg counts (Litherland et al, 2008). Flax does not appear to have any direct anthelmintic properties.

Farmer observations have been that when deer have free access to flax plants they will chew on them at certain times of the year and not at other times. This may provide fibre or minerals that the animal needs. While there may not be compounds in the plant that directly affect the worms, if it helps maintain a healthy digestive system it is likely to make the animal more resilient. Having partially fenced blocks of fodder shrubs such as flax, willow, tree lucerne, poplar etc. is potentially useful although more robust science specific to deer is needed to back this up.

Other plants with anti-parasitic properties

Various other plants have been studied for their anthelmintic properties. For example, a trial in sheep found that alcohol extracts of wormwood (Artemisia sp.) were quite effective at reducing faecal egg counts (Tariq et al, 2009) or preventing further deterioration in infected sheep (Cala et al, 2014).

Raspberry canes have been found to have an anti-nematode compound. Although these plants would not be grown as forage for livestock, they could potentially be used as pharmaceutical adjuncts.

Cropping and supplementary feeding

Cultivating the soils will destroy many but not all parasites on the paddock. But cultivation on its own is a poor strategy for parasite management owing to the damage to soil structure and function. Crops such as brassicas, beets and even lucerne and chicory have a different leaf structure to grasses. This may make it more difficult for parasite larvae to move up the plant and be eaten by the animal. In addition, the time taken for crops to grow provides a good opportunity for dung to be broken down and larvae to die off. The added nutritional benefit of supplementary feeding will also help animals to develop natural immunity to parasites. In general, crops are likely to decrease parasite burdens but severe parasitism has been recorded in young stock grazing crop. This is likely to be due to the transition phase onto the crop. Deer take some time to adjust to a new diet and will preferentially graze the remaining grasses on the shoulders of the paddock or on a run-off paddock before significantly increasing the intake of the crop. This factor, combined with a temporary state of nutritional stress while the animal adapts to its new diet, can result in problems.

Guidelines when using crops

Utilise crops for their benefit in providing feed and alternative leaf structure and generally higher cover above ground. Cultivate only as required and not at the expense of damaging soil structure and organic content.

Transition management: If deer are closed straight onto an unfamiliar crop, they often seek out every blade of grass they can find during the transition phase. These areas can quickly become contaminated. Because they are continually grazed closely, maximum larval intake can occur from these areas. Having access to a run-off paddock is a better way of managing transition and preventing build up of parasites onto any grassy areas in the crop paddock.

Drenching: If drenching prior to moving onto the crop, leave a proportion of the animals undrenched to ensure refugia is available. If drenching all the animals going onto a crop, which is a relatively clean paddock as far as parasites goes, it will mean only parasites that survived the drench will be passed onto the paddock.

Manage dietary balance: This is just good feeding practice but having adequate protein and minerals in the diet improves the resilience of the animals (ability to grow and perform even with some parasites in the gut) and the ability to develop immunity. Having a balanced diet on a winter crop will also improve growth rates meaning less time on spring pasture and less requirement for spring drenching. Good quality spring cut or high legume content baleage is a good option for supplementing most crops.

Fodder beet bulbs are low in, calcium, phosphorus, magnesium, cobalt, copper, iodine and selenium. The leaves are generally considerably higher in all of these minerals. The amino acids are not well balanced, being low in arginine and citrulline (DairyNZ).

Consider mixed forage crops or succession planted crops: These will minimise soil damage and also reduce nitrogen leaching and sediment run-off as well as providing ongoing feed. An example of succession planting is to sow rape and plantain together in autumn, graze in winter and then broadcast clover in spring.

Back-fence where possible to avoid animals revisiting contaminated areas.

Beware of dung splash onto bulbs: Many of the L3 larvae are distributed by rain falling onto the dung pat and splashing them out across the pasture. These could easily contaminate partially eaten bulbs.

Monitor: Although crops are most likely to have a very low parasite challenge, circumstances can lead to problems. This is most likely when there is an imbalanced diet, a small amount of available grass and conditions during the grazing period are warm and wet.

Monitor regularly for growth rates, body condition and coat condition. Consider faecal egg counts if in doubt.

Baleage or silage

Good quality baleage or silage is relatively parasite free, although there may be some larvae in baleage. Spring-cut grass or high legume baleage is a useful supplementary feed during summer or for young deer on crops such as fodder beet which has low protein later in the winter.

If animals are being kept on a grass platform at low covers and fed baleage it can lead to a highly contaminated environment with grazing short pastures and high infection levels.

Irrigation

Irrigation could have either positive or negative impacts on parasite transmission.

Under dry conditions, irrigation can provide the necessary moisture for larvae to develop to the infectious stage. If this is coupled with warm conditions and set stocking or a fast rotation length, it could greatly increase the larval challenge. Irrigation can also help to spread parasite larvae out onto the pasture as it has been shown the raindrops are one of the main ways that larvae are spread out from the dung pat. If pasture moisture levels are maintained this could increase the number of larvae that are available to be eaten by the host.

On the other hand, irrigation could help to spread larvae out and expose them to sunlight and soil organisms. If there is increased earthworm activity and rate of dung pat dispersal, it could assist the removal of infective larvae from the paddock. Increased breakdown of plant litter on the soil surface can expose surface larvae to drying out and UV radiation. Under a slower rotational grazing system and less frequent irrigation so that the soil surface can dry out, it is possible that larvae will develop during irrigation and then be exposed to drying out between irrigation rounds.

The only way to really assess the impacts of irrigation on parasite levels is to do pasture larvae counts at different times during the irrigation cycle.

Apple cider vinegar

Cider vinegar, which is available through rural supply stores is claimed by some to have various animal health benefits, including parasite control. At this point there is no research into its use in deer and research into its efficacy in other livestock species has been limited with no compelling results thus far.

Copper oxide wire particles

Several studies in sheep and goats have shown that copper oxide wire particles (COWPs) can reduce faecal egg counts compared with no treatment (Burke et al, 2007; Knox, 2008; Soli et al, 2010). These studies tend to focus on *Haemonchus contortus*. They appear less effective against other genera and not against intestinal worms (only those in the abomasum). The COWPs are effective on existing worms in the abomasum and not effective as a preventative. No trials have been done to evaluate the effects of COWPs in deer.

COWPs should only be used where there is a relatively low copper level in the feed being offered and not in conjunction with other copper treatments or additives. If there is a deficiency in copper, it can affect multiple functions including the ability to develop immunity. Parasites in the abomasum that increase the pH (such as *Ostertagia*) decrease the uptake of copper following COWP administration.

It is unknown whether other forms of copper supplementation have the same effect. It may be the direct contact of the COWP with the nematodes in the abomasum that has the effect rather than blood copper levels. All types of COWPs were equally effective against H. contortus (Burke et al, 2016). It also appears that COWPs may increase the efficacy of anthelmintics.

Mackintosh et al, did not find an added benefit (in terms of parasite killing efficacy in deer) from using mineralised drenches compared with non-mineralised drenches.

Earthworms

"It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures" (Charles Darwin, 1881). There is certainly a huge amount of information available about earthworms.

Earthworms cannot be applied as a tool themselves. But we can provide the right conditions for earthworms to flourish and then allow them to perform their many useful functions. Hotter (1977) observed that earthworms are responsible for removal of large amounts of dung on pasture. It seems plausible that rapid removal of dung would result in lower survival rates of parasitic helminths, particularly under dry or very cold conditions, in a similar way to the effects of dung beetles.

Earthworms are a useful indicator of soil organic matter status and soil health. In a symbiotic-type arrangement, healthy plants and soils sustain earthworm populations and earthworms assist the nutrient cycling to sustain soil and plant health. Studies have found that having a healthy population of earthworms is associated with 30 – 100% higher pasture production. Vermicast is many times higher in available nitrogen, phosphorus and potassium than surrounding topsoil; these minerals are very plant available and are not locked up in the soil. A UK study found that plants were able to better withstand drought when earthworms were present. Compost worms can remove soil contaminants as well as rapidly converting decaying organic material into a rich growing medium.

There is seasonal variation in the number of earthworms in the soil and their activity with, the greatest impact being drought. During summer, earthworms can bury deep into the soil and coil into a tight knot to prevent drying out (called estivation).

Many soils have low earthworm populations, which may be due to:

- Acidifying fertilisers, especially nitrogenous fertilisers such as ammonium sulphate, mono-ammonium phosphate and DAP and to a lesser extent, superphosphate. It is important to add lime to ensure the pH does not drop.
- DDT
- Lime sulphur
- Cultivation (one of the biggest contributors to the decline and possibly extinction of some species of earthworm has been conversion from pastoral to arable farming). Heavy cropping is likely to have a similar effect on pastoral farms, especially with heavy use of herbicides, insecticides and acidifying fertilisers.

Dung beetles

Dung beetles are now available in New Zealand from Dung Beetle Innovations. They are not cheap but now that some farms are getting dung beetles established it may be possible to start introducing them from one farm to another. They reproduce relatively slowly and fly to new areas in search of dung. It can take several years to develop populations that will have a significant impact on the soil and parasite larvae.

Dung beetles and coprophagous (i.e. dung eating) beetles have been shown to greatly reduce pasture larval levels and infection rate in calves by burying and spreading fresh dung (Fincher, 1973, 1975; Bergstrom et al, 1976, Bryan 1973, 1976).

The recently imported dung beetles are the tunneller types that actively bury dung balls into the soil. In New Zealand, we have established populations of 'dwellers' that do not bury dung and are small insects well adapted to horse manure.

Dung beetles are susceptible to macrocylic lactones (-mectins) so if drenching with this class of drug and wanting to maintain dung beetle populations, drenched animals should be quarantined for a few days and some animals should be left undrenched to ensure there is a safe feed supply.

Fungi

Several species of fungi have been discovered that are able to reduce the development of larvae in the dung pats. They do this by a number of means, one of which is to ensnare the larvae in a loop of fungal hyphae.

One that has undergone commercial development is Duddingtonia flagrans IAH 1297. This fungus reduces the rate of development of and movement of infective larvae into pasture by 53 – 99% from infected horse, cattle and goat dung (Healey et al, 2018). This trial used the commercially available product BioWorma®. The results of this trial along with anecdotal reports from goat farmers that have used the product show that it can be very effective at breaking the lifecycle by preventing infective larvae being ingested by susceptible hosts. The current major drawbacks are:

- the need to feed high volumes of product continually during the parasite risk period
- the product has a poor palatability
- the high cost per animal if used as recommended.

Further development would be needed to make this cost effective for commercial farmers but there is promise as an adjunct tool. Fungi are free-living soil inhabitants so there may be other avenues for utilising them.

Soil bacteria and other possibilities

There are always other possibilities as we discover more about the intricate relationships between animals, plants, microbes, fungi and diseases. For example, a soil bacterium has been discovered that can invade the nematode in the dung pat and eat it from the inside out.

Final word

None of the alternative treatments discussed are as effective at eliminating parasites as the chemical drenches that are currently registered with the ACVM. None are likely to be effective on their own at controlling parasites enough to prevent production losses. However, used in combination, a selection of tools that suit the farm situation can reduce the need for chemical drenching and improve sustainable production.

Nature has many solutions and there are bound to be others we are yet to discover that can be useful to our farm systems.

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