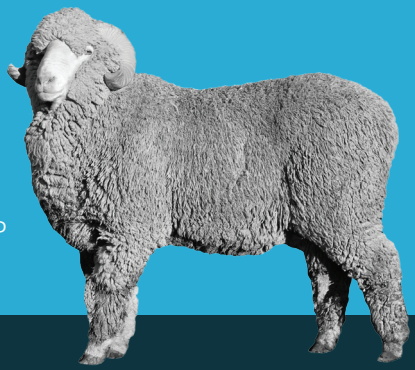
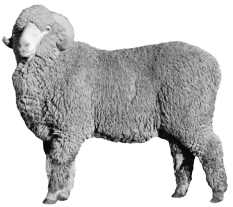
A GUIDE TO THE

MANAGEMENT OF FOOTROT IN SHEEP



2nd Edition | 2013 | **Chris Mulvaney**



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MANAGEMENT OF FOOTROT IN SHEEP

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UNLOCKING THE
PERFECT SHEEP(s)

CONTENTS

PREFACE

The key to managing footrot is to have a good understanding of the disease and the right attitude, including a focus on prevention rather than treatment.

Footrot is a bacterial disease caused by a very specific bacteria called *Dichelobacter nodosus (D. nodosus)*. High prevalence of the disease tends to coincide with periods of high pasture growth (warm and moist weather).

In sheep, susceptibility to footrot tends to increase with decreasing fibre diameter. Research suggests the level of susceptibility may be associated with genetic differences in the interdigital skin, which is the point of entry for *D. nodosus*.

Eradication is elusive but achievable. Successful management requires a planned, consistent approach. There is no silver bullet, and integrated control programmes must be designed for each property. Rather than complete eradication, a more realistic objective on most New Zealand high country properties is to minimise the number of lame sheep.

A successful management programme requires:

- Knowledge and understanding of the disease.
- Understanding of how a successful management programme works.
- Accurate diagnosis and treatment.

In addition, well designed and maintained facilities will improve the motivation of those involved.

Genetic marker technology must be regarded as having significant potential to improve footrot management programmes. The Lincoln Footrot Gene Marker Test has been commercially available since 2002. It is claimed that the test has been fully validated, but this information has not been available for any form of independent peer review.

The second edition of this booklet includes some updated research material and information targeted at those growers who are intending to enter the fine wool industry for the first time.

Some commercial products have been discussed. Mention or exclusion of any product does not necessarily infer endorsement or otherwise by the author or the publisher.

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Where product trade names are used, neither discrimination nor endorsement is intended.

Readers are advised to seek the most current information related to the use of any products or drugs to confirm dose rate, administration, contraindication and withholding times.

CHAPTER 1
INTRODUCTION

BACKGROUND

Footrot is a complex disease affecting sheep in New Zealand; it particularly affects fine wool sheep. The disease has a definite seasonal pattern with outbreaks occurring when weather conditions favour its spread.

Footrot is caused by the bacterium *Dichelobacter nodosus (D. nodosus)*, which is the current name. In the past, the bacterium has been called *Fusiformis nodosus* and *Bacteroides nodosus*.

W.I.B. Beveridge, a pioneer of footrot research, recognised footrot as "a contagious disease which may occur at any season, but outbreaks are mostly experienced at the time of the year when there is lush growth of pasture. The footrot agent can only survive in the sheep's foot. It will not multiply in soil or faeces."[1]

The key principles of Beveridge's eradication programme were:

- All infected sheep should be isolated after careful inspection of all the feet on all the sheep.
- Healthy sheep should be footbathed and go onto pasture that has not been grazed by sheep for at least two weeks prior.
- Infected sheep should be treated. There is a strong tendency for recovered sheep to suffer relapses. Hence, infected sheep should remain isolated until they have passed two careful examinations, at least one month apart.
- Eradication should only be attempted when the prevalence of the disease is less than 5%.

Beveridge's work highlighted several issues that remain relevant today:

- The reluctance of many growers to accept that the disease is contagious – it spreads from sheep to sheep.
- The disease spreads only when the sheep are rendered susceptible by lush, damp pasture and the infectious agent *(D. nodosus)* is present.
- Under dry conditions, spontaneous recovery occurs in a proportion of cases.
- The disease is a very long-standing one and, in some sheep, lesions persist for a year or more if they are not treated.

The key principles of Beveridge's programme remain the cornerstone of footrot control programmes. However, footrot is a complex disease, and none of the commercially available preventives or treatments are 100% effective. With the variability of bacterial virulence, susceptibility of the host, impact of the environment and the attitude of the grower, it is understandable that footrot remains a considerable challenge to the sheep industry.

PREVALANCE OF FOOTROT IN NEW ZEALAND

There have been very few surveys to determine the prevalence and importance of footrot in New Zealand.

In 1955, 67% of New Zealand sheep growers said they had footrot in their flocks every year. Even in drier regions 61% of the flocks were affected with footrot every year.[2]

Surveys conducted in 1979-80, 1980-81 and 1981-82 estimated the prevalence of "footscald / footrot" in New Zealand sheep flocks at 8.1%, 5.6% and 4.8% respectively.[3]

The dramatic reduction in the prevalence of footrot between the 1955 and 1979-82 surveys most likely reflects the heavy culling that was carried out, particularly in the coarse wool flocks. However, footrot continues to be well recognised as a serious limitation within the Merino and mid-micron wool industries and still remains a problematic disease in some coarse wool flocks.

A more recent survey[4] illustrates the significance of footrot within the Merino industry. Amongst these growers, footrot was cited as the second most important disease behind gastrointestinal parasitism. Footrot had been experienced in the previous five years by 80% of respondents.

ECONOMIC IMPACT

Footrot presents a significant financial cost to many New Zealand sheep growers. The cost is directly related to seasonal weather patterns, and can vary significantly from year to year. A large component of the total cost is in managing the disease, and for many properties the return on the investment made can be very unsatisfactory.

Most of the information related to the economic importance of footrot has come from work with Australian Merino sheep. The Australian work shows that affected sheep lose weight, produce less wool and have lower lambing performance, with potential annual losses of up to 7% greasy fleece weight and 12-15% loss of body weight in wethers.

The cost of footrot on New Zealand Merino properties has been estimated to be $3.55 per sheep ($1.63 for treatment and $1.92 for lost production), with a total annual cost to the Merino industry estimated to be in excess of $9 million.[5] Another study estimated the annual expenditure for footrot control in New Zealand to be $18-19 million.[6]

Footrot can have a disruptive impact on the day-to-day running of a sheep farm, especially during an outbreak and when control programmes are implemented. Footrot also has an indirect impact on footrot-free properties, limiting options for trading sheep and ram purchases.

There is little information regarding the impact of footrot on the productivity of coarse wool sheep breeds in New Zealand. It could be expected that clinical footrot will lead to weight loss and reduced wool production, but the economic loss may not be great enough to justify an intensive control programme in a coarse wool flock.

ANIMAL WELLBEING

Footrot is a very painful condition, and has animal welfare implications. In addition, sheep with footrot are more susceptible to fly strike, especially over the ribs and belly. Flies are attracted to the strong odour of the lesion discharge left on the wool while the sheep is sitting down.

It is not uncommon to observe fly strike in feet affected with chronic footrot.
The increasing drive to limit the levels of insecticide in wool by moving away from saturation dipping may increase the risk of sheep with footrot becoming struck on the lower parts of the body.

FOOTROT IN OTHER SPECIES

GOATS

Footrot is a common disease in a wide range of goat breeds. In goats, the disease tends to be more confined to the interdigital area of the foot; whereas in sheep there can be extensive under-running of the hoof. The reason for the difference in the way the disease is expressed in sheep and goats is unclear, but it may be associated with goats having much deeper interdigital spaces.[7]

There appears to be little consistency in the degree of virulence of *D. nodosus* strains when transferred from sheep to goats and vice versa.

There is debate over the role of goats in spreading footrot to sheep, but there seems to be general consensus that any goats present should be included as part of a footrot management programme in the sheep flock.

Goats should be regarded as a high risk factor.

CATTLE

D. nodosus has been reported in cattle,[8] where the lesions were described as erosion and separation of the bulbar horn. Other studies have reported a wide range of lesions, including ulceration, erosive inflammation, interdigital growths and a foul odour.

Not all affected cattle become lame and it appears that younger cattle are more likely to be infected.[9]

Infective material from bovine lesions caused typical footrot lesions after experimental transfer to sheep.[10] However, another study failed to transfer virulent footrot from sheep to cattle.[11] No studies have been conducted to establish the relationship between the existence of *D. nodosus* infection in both sheep and cattle on the same property.[12] The role of cattle in field conditions is not well understood. The probability that infected cattle may be the source of new infection and breakdown is low.

Footrot management programmes have been successful on properties where the role of cattle has been ignored despite mixed grazing. No attempt was made to determine whether *D. nodosus* was present in the cattle or not.[13]

DEER

A New Zealand study found *D. nodosus* in a hind, with separation of the horn at the heel, and infection was transmitted to sheep under laboratory conditions.[14]

CHAPTER 2
EPIDEMIOLOGY

EPIDEMIOLOGICAL FACTORS

Epidemiology is the study of diseases in populations. The three key factors that may interact with each other to have an impact on a disease are:

- The **agent** that causes the disease.
- The **host**, which is the animal that carries the disease.
- The circumstances within or external to the host that can affect the disease (the **environment**).

The epidemiology of footrot within a flock is a very complex interaction involving all three factors. An understanding of the known epidemiological factors relating to footrot is fundamental to successful control programmes. The epidemiology of footrot is usually very farm-specific, so control programmes must be designed on a property-by-property basis.

THE AGENT

Footrot often involves mixed bacterial infection, but *D. nodosus* will always be present. It is specific to a range of *D. nodosus* strains that produce proteolytic enzymes, which allow further bacterial invasion of the hoof. *D. nodosus* digests living dermis and feeds on collagen. It is the only bacterium that can digest hoof material. *D. nodosus* is anaerobic, which is the likely explanation for its limited survival outside the sheep's foot.

When the interdigital skin of the foot is wet for a prolonged period, the damaged skin becomes invaded by the bacterium *Fusobacterium necrophorum* (*F. necrophorum*), which is commonly found in soil and sheep faeces and can cause inflammation of the interdigital skin. It produces toxins that cause deeper damage to the skin, allowing other bacteria, including *D. nodosus*, to establish. *D. nodosus* and *F. necrophorum* mutually benefit each other, causing damage to the skin and utilising the by-products to enhance their survival.

D. nodosus infects only ruminants (mainly sheep and goats), and will only establish in the interdigital skin and in the hoof itself.

Attempts to establish infection on the body of a sheep have been unsuccessful.[1] However *D. nodosus* is able to survive for long periods within the interdigital skin and hoof of the host with no external signs that the hoof is infected.[2] There is a record of a sheep remaining clinically infected for three and a half years, and being able to pass the infection to other sheep throughout that period.[3] The long, and often hidden, persistence in the host is a common reason for new outbreaks in flocks that have been undergoing a management programme.

Under optimal conditions (>10°C soil temperature, with moisture), it has been estimated that *D. nodosus* can survive on pasture for a maximum of 7-10 days and up to six weeks in horn trimmings.[4]

D. nodosus can survive inside a sheep's foot for at least 12 months.

D. nodosus can only survive outside the sheep's foot for 7-10 days.

Infected sheep feet are the source of infection, NOT boots, truck tyres or birds.

There are differences in the virulence between the various strains of *D. nodosus*, so the severity of lesions may vary between genetically similar sheep, managed under similar conditions, but with different strains of *D. nodosus* present.[5] Multiple strains of *D. nodosus* are frequently found within a farm or a flock, with up to seven different strains isolated from individual flocks.[6] More than one strain can be found on an individual foot.[7]

A successful footrot management programme must be based on a combination of approaches, which includes measures that deal with any or all strains that may be present in the flock.

THE HOST

Amongst ruminants, sheep and goats are the most susceptible to *D. nodosus* infection, and susceptibility tends to increase with age.

Sheep that have been exposed to *D. nodosus* show considerable variation in their response to the infection. Further, they tend to develop only a short-lasting immune response, which is one of the reasons the disease is difficult to manage. Susceptibility to footrot infection varies between breeds, within breeds, between sire-lines and within flocks.[8]

Resistance (immunity) to footrot infection has been classified in several different ways:

- No clinical symptoms after exposure.
- Lack of intensive lesion progression.
- Spontaneous healing.
- Faster rate of healing following vaccination.
- No clinical symptoms after vaccination.

DIFFERENCES BETWEEN BREEDS

In general, the finer the wool, the more susceptible the sheep appears to be.

A study, which subjected several British breeds, as well as Merinos, to a natural footrot challenge, found that Romneys were the most resistant.[9] Resistance was associated with the development of only relatively benign lesions of shorter duration in the interdigital skin and less under-running. There was no difference between Romneys and Merinos in the way that the lesions healed. The resistance appeared to be associated with the epidermis in the interdigital skin. When the interdigital skin was scarified, there was no difference between the breeds.

In another study, which screened out sheep that were resistant to repeated exposure to an artificial footrot challenge, a particular plasma cell (phagocyte) was found in the interdigital skin in the resistant sheep.[10] There were no differences between the resistant and susceptible sheep in the anatomy of the feet or in the way lesions healed. The study recommended culling infected sheep and breeding from rams that had never had footrot themselves, but were bred from an infected flock. Another breeder also found no correlation between foot conformation and tolerance to footrot in his selected Merinos.[11]

Susceptibility to footrot is more likely to be associated with immunity than with foot conformation.

DIFFERENCES WITHIN BREEDS

Within-breed variation of susceptibility to footrot is recognised as being genetic in origin, with heritability estimates in the range of 0.15 to 0.30.[12] An intense 15-year selection programme, based on footrot being a trait that can be bred for, was used to breed Corriedale sheep that did not develop clinical footrot when exposed to a challenge.[13]

More recent research at Lincoln University has discovered a gene marker in sheep that appears to be associated with tolerance to footrot, and the technology is discussed further in Chapter 9.

THE ENVIRONMENT

Prolonged exposure of feet to moisture and faecal contamination during warm weather must be regarded as the starting point in a footrot outbreak.

MOISTURE

Little is known of the impact of moisture on the survival of *D. nodosus* in the environment. However, moisture is a pre-requisite for the development and spread of footrot.[14] Sheep with healthy and dry interdigital skin will not develop footrot. The interdigital skin must be damaged by prolonged exposure to moisture before *D. nodosus* infection will occur.[15]

Sheep with healthy, dry feet will NOT get footrot.

TEMPERATURE

Temperature is the other critical factor in the development of footrot lesions and the spread of the disease. New outbreaks of footrot will only occur when environmental temperatures are above 10ºC.[16]

It is likely that the lower temperature in the interdigital skin area lessens the ability of *D. nodosus* to multiply and establish infection.

Nearly 22.5% of North Island growers and 36.7% of South Island growers believed outbreaks of footrot occurred in ewes during the winter.[17] The South Island growers believed footrot outbreaks were most common during autumn, then winter, then spring, then summer. The high rate of outbreaks observed during the colder months is more likely to be a development of lameness, rather than an outbreak of footrot. Sheep infected during autumn can go into the winter with low-grade infections and a proportion of these sheep may be obviously lame. During the winter, the lesions will slowly worsen and lameness will become more obvious.

New footrot outbreaks will only occur when environmental temperatures are above 10°C.

PASTURE LENGTH AND DENSITY

There is evidence that pasture length and density can influence footrot. Lush pastures,[18] dense pastures,[19] short green pastures, and abrasion by long mature pastures,[20] have all been implicated in the development and spread of the disease. It is likely that the real effect of pastures is associated with their ability to retain moisture, causing superficial damage to the interdigital skin. Soil type and drainage do not appear to be risk factors for footrot.[21]

The risk of a new footrot outbreak is greatest when the grass is actively growing.

OTHER PHYSICAL DAMAGE TO THE INTERDIGITAL SKIN

Penetration by grass seeds, damage from stones, exposure to ground frost, skin abrasion and bleeding after excessive paring have all been suspected as risk factors for footrot, but they have not been verified as causes.

STOCKING RATES

Increased stocking rates will increase the rate of disease spread between the sheep.[22]

INTER-REGIONAL DIFFERENCES

The seasonal challenge of footrot in regions with hot, dry summers and cold winters may be restricted to only a few months of the year. In more temperate areas of New Zealand, it is likely that the challenge periods will extend to several months, or even all year round in some environments.

The profound impact of moisture and temperature on the development and spread of footrot can be used for predicting outbreaks of the disease. This local knowledge can also be implemented in footrot control plans for individual farms.

INTERACTIONS BETWEEN THE AGENT, HOST AND ENVIRONMENT

Footrot is a result of the three factors discussed above (agent, host and environment) interacting with each other. The complexity of this interaction means that, within any flock of sheep infected with footrot, there is likely to be:

- A wide variation in the clinical symptoms, ranging from no lesions at all, to sheep with all four feet showing extensive under-running.
- Sheep that show natural remission, even during challenge periods.
- Sheep that heal naturally during dry conditions.
- Sheep that appear to heal much more readily than others following treatment.

The rate of development of footrot outbreaks, and the size of those outbreaks, can vary significantly between seasons and between flocks. The extent of any footrot infection in an individual sheep and in a flock of sheep is dependent on a combination of:

- The number of infected sheep in the flock.
- The virulence of *D. nodosus*.
- The level of host susceptibility at the time.
- The environmental conditions at the time.

The rate of bacterial multiplication will be greatest when high numbers of bacteria are present during moist conditions at temperatures around 20ºC. The rate of development of the outbreak in flocks with a low number of infected feet will be slow until the numbers of bacteria build up.

If the challenge period is short, then the current outbreak may not be significant. However, without effective control, the numbers of bacteria will be higher at the next challenge, so the next outbreak will develop faster and to a greater level (Fig. 1, below).

This concept is really important, and few growers understand how these factors impact on outbreaks. Growers tend to work on footrot management when the incidence of lame sheep becomes worryingly high. The intensity of footrot control is generally directly related to the number of lame sheep in the flock. Outbreaks on properties that "haven't had footrot for three years" are quite common following a year or two of drought where there has been very low or no challenge and a low incidence of lameness. As the number of lame sheep decreases, inspection processes cease, so the actual number of infected sheep going into the new challenge is unknown. Generally, the source of the next outbreak is internal, not external.

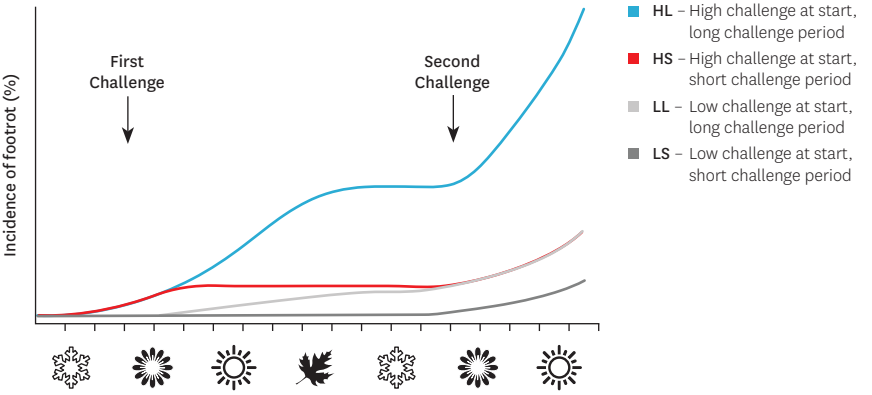


Figure 1. *Diagrammatic representation of the effect of the starting level and length of the challenge period on the rate of development of a footrot outbreak.*

SPONTANEOUS CURE AND IMPROVEMENT

Spontaneous cure in dry conditions is a recognised phenomenon. Similarly, spontaneous improvement has also been observed in dry conditions, where, although sheep are still infected, lesions dry up and reduce in severity, so the affected sheep may no longer be lame.[23] Some sheep become carriers and carry the bacteria for months, or even years, into the next challenge season.

However, spontaneous cure will also occur under conditions that are suitable for spread. This effect is often recorded in the result of footrot treatment trials. An example is shown in Table 1, below.

In the untreated control mob, there was an overall reduction in the number of infected sheep over the 63 days, despite a significant number of new infections developing.

Inspection Day	No. Infected Sheep (%)	No. Infected Feet (%)	No. Feet Healed	No. New Feet Infections
0	56 (86)	142 (55)	–	–
14	55 (85)	122 (47)	53	33
28	53 (82)	118 (45)	35	31
35	47 (72)	92 (35)	36	10
63	39 (60)	71 (28)	35	14

Table 1. *Prevalence, natural remission and spread of footrot in 65 untreated sheep for the duration of the trial.*[24]

KEY EPIDEMIOLOGICAL POINTS RELATED TO "CHALLENGE":

The **footrot outbreak** will only occur when:

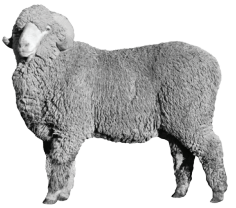
- *D. nodosus* is present AND
- Feet are constantly moist AND
- The temperature is above 10˚C.

The **rate of the spread of footrot** is greater with:

- Higher numbers of infected sheep in the mob at the start of the outbreak.
- Temperatures in the range of 15-20°C, with moist conditions underfoot.
- A higher stocking rate.
- Lower host tolerance to footrot.

The **size of a footrot outbreak** will be greater with:

- A higher rate of increase in the numbers of infected sheep.
- The longer the duration of the challenge period.



CHAPTER 3
DEVELOPMENT OF FOOTROT

FOOT SCORING SYSTEM

It is important to have a simple, accurate system to identify the various stages of footrot for the correct planning of a footrot management programme. A scoring system is described in this chapter. Of critical importance is being able to recognise the lesions themselves, to assess whether the disease is actively spreading or not.

Figure 2. *Anatomy of a sheep's foot.*

1. Axial groove
2. Wall (Abaxial surface)
3. Heel
4. Interdigital skin
5. Sole (Plantar surface)
6. Toe

SCORE 0
CLEAN AND NORMAL

Figure 3. *Score 0, clean and normal.*

The hoof has a normal shape (although in this example it is slightly overgrown). The interdigital skin is dry.

SCORE 1
WATER MACERATION

Figure 4. *Score 1, water maceration.*

Following continued exposure to water, the interdigital skin becomes susceptible to invasion by bacteria that are living in the environment.

Apart from a slight whitening of the skin, and mild pitting of the very soft horn tissue, there will be no obvious signs that sheep are suffering from a mild skin infection. The prevailing weather conditions are a better indication that water maceration is occurring.

D. nodosus may or may not be present.

The term "scald" should not be used.

It is a confusing term that is often used to describe water maceration, OID or early footrot.

SCORE 2
OVINE INTERDIGITAL DERMATITIS

Figure 5. *Score 2, ovine digital dermatitis (OID).*

Following the damage caused by water maceration, bacteria create inflammation, which causes a mild skin infection in the interdigital area. *F. necrophorum*, which is a very common bacterium in the farm environment due to faecal contamination, invades the already damaged skin and causes more extensive damage.

Often other bacteria may be present in the infection, but *F. necrophorum* must be present for the development of footrot. It produces a number of toxins that both damage the superficial layers of the interdigital skin, and that protect the bacteria from the host's immune system.

At this point, there is an extensive skin infection present. The skin is moist and red, and often there is a discharge of pus. Many sheep within a mob may be affected, but few will show signs of lameness (although sheep with OID can be acutely lame).[1]

***D. nodosus* may or may not be present.**

D. nodosus is present in many feet with only outward signs of OID,[2] but unless there is some erosion or under-running of the hoof material, it is not possible to distinguish between OID and the early signs of footrot (the initial invasion of *D. nodosus*).

SCORE 3
EARLY FOOTROT

Figure 6. *Score 3, early footrot.*

If *D. nodosus* is present in the flock in large enough numbers, it will combine with *F. necrophorum* to invade and destroy the softer hoof material and then the harder hoof area. *D. nodosus* is the only bacteria known to be able to digest hoof.

D. nodosus itself multiplies slowly, but it produces a factor that increases the multiplication and invasiveness of *F. necrophorum*. These two bacteria help each other survive within the footrot lesions.

The main lesion is an inflammation of the interdigital skin, with associated discharges of pus. To be given a score 3, there must be some erosion or under-running of the hoof material, under the axial grooves (Fig. 6), extending to the softer area of the heels.

***D. nodosus* must be present.**

SCORE 4
ADVANCED FOOTROT

Figure 7. *Score 4, advanced footrot.*

Under favourable challenge conditions, advanced lesions can be seen within 7-14 days of the development of OID.

There will be more extensive under-running from the axial area, with a progressive separation of the soft and then hard hoof tissues (Fig. 7).

Often the entire sole becomes under-run and the infection extends up the walls of the hoof.

The presence of score 4 lesions, along with scores 1, 2 & 3 within a mob, suggests the outbreak is in the actively spreading phase.

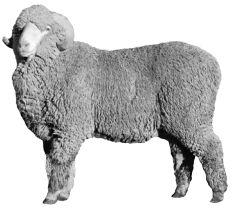
SCORE 5
CHRONIC FOOTROT

Figure 8. *Score 5, chronic footrot.*

Chronic footrot occurs over time when the infection persists into non-challenge periods.

The affected hoof is often grossly misshapen and the lesions are more confined to the hoof than the interdigital area.

Score 5 lesions may be seen during both challenge and non-challenge periods.



CHAPTER 4
DIFFERENTIAL DIAGNOSIS

CONDITIONS THAT MAY BE CONFUSED WITH FOOTORT

There are several conditions that may cause lameness in sheep that can be confused with footrot.[1] These conditions may sometimes be the only cause of lameness in the flock, or may be concurrent with footrot. A number of affected sheep must be examined closely to establish an accurate diagnosis.

OVINE INTERDIGITAL DERMATITIS

Figure 9. *Ovine interdigital dermatitis.*

As described briefly in Chapter 3, ovine interdigital dermatitis (OID) occurs following water maceration to the skin between the toes. Bacteria enter the skin and set up an infection.

OID can affect all age groups and up to 90% of the flock may be affected at any one time. The condition may persist for months during prolonged wet weather conditions, especially when sheep are grazing lush green pastures.

CLINICAL SYMPTOMS

In mild cases, the interdigital skin may be reddened and covered with a film of whitish discharge.

In more advanced cases, there may be ulceration and shallow invasion of the skin under the very soft parts of the heels.

There is **NO** under-running of the hoof material in OID.

TREATMENT AND CONTROL

OID heals spontaneously if feet are kept dry, and will only develop into footrot in the presence of D. nodosus and suitable environmental conditions.

Footbathing with 10% zinc sulphate or 5% formalin (refer to Chapter 7) will result in a high cure rate. However, neither treatment has a persistent effect, so repeated footbathing every 2-4 weeks may be required when conditions underfoot remain moist. As long as there is no footrot present, sheep should stand in the footbath solution for 1-2 minutes.

FOOT ABSCESS

Foot abscesses are probably the most common condition that must be differentiated from footrot in a flock. An abscess is an acute infection, usually involving just one foot.

The infection is generally secondary to OID when the bacteria *F. necrophorum* and *Actinomyces pyogenes* are present. Other bacteria may or may not be present. Other forms of damage to the interdigital skin (e.g. physical injury from frosty ground or stones, or excessive use of formalin) may predispose the sheep to foot abscesses.

Figure 10. *Foot abscess.*

Generally the incidence of foot abscess is low (less than 2%), but larger outbreaks do occur, especially in rams around mating time and ewes around lambing time.

CLINICAL SYMPTOMS

A foot abscess is an acute infection, often containing pus, extending from the interdigital skin into the soft tissues of the heel, and into the joint and ligaments above the coronet. Usually only one foot is involved and affected sheep display extreme lameness. In the early stages, the affected foot will be hot and reddened with swelling in the interdigital area and above the coronet.

In more advanced cases, a discharge of pus appears above the coronet. Often the joint above the coronet becomes enlarged and misshapen due to ligament damage. Once the infection becomes established in the joint, it becomes chronic and may take 6-8 weeks to heal. After healing, there may be some permanent damage to the joint.

TREATMENT AND CONTROL

Treatment with a long-acting penicillin antibiotic before there is any sign of discharge can be very effective. Once the infection has broken through the skin, antibiotics will not make much difference to the time taken for the infection to clear up.

Footbathing to prevent or control OID may reduce the risk of foot abscess. However, the risk of new infections from mustering and yarding the sheep in muddy conditions must be considered before footbathing is carried out.

Some commercial vaccines have been available, but there is little evidence to support their use.

TOE ABSCESS

Toe abscesses are an acute infection in the toe, usually in only one foot. There is no association between OID and toe abscess. Front feet tend to be affected more than the back feet. How the infection develops is not well understood, but it is likely that entry is through the damaged white line of the sole. The condition is generally sporadic, but significant outbreaks have been observed after sheep have been held in wet muddy yards, especially ewes during pre-lamb shearing.

Figure 11. *Pus draining from a toe abscess.*

CLINICAL SYMPTOMS

Affected sheep are very lame. The foot appears normal but may feel hot in one digit. Diagnosis can be made by carefully paring back the point of the toe to reveal a black pin sized hole, which often releases pus under pressure.

In advanced cases, there may be an open sinus at the coronet above the toe, where the infection has broken out after moving up the hoof.

TREATMENT AND CONTROL

Careful paring of the toe to release the pressure will provide rapid recovery.

STRAWBERRY FOOTROT

Strawberry footrot is a skin infection, around and above the coronet, that looks like the surface of a strawberry. The primary agent is the scabby mouth virus. The infection may also involve *Dermatophilus congolensis* (which causes lumpy wool) and other bacteria.

Figure 12. *Strawberry footrot (scabby mouth).*

CLINICAL SYMPTOMS

The scabby mouth virus and *Dermatophilus congolensis* may act together to produce large lesions (forming scabs) extending 4 to 8 centimetres above the coronary band (top of the hoof). These lesions bleed profusely when traumatised. Severe lameness can occur, but the condition does not affect the hoof. Affected sheep may not have the typical scabby mouth lesions on the face.

Typically, strawberry footrot only affects one leg and is more commonly seen in weaned lambs recently moved onto stubble. While lesions are severe in individual lambs, the proportion affected is generally low.

TREATMENT AND CONTROL

Protective clothing and gloves must be worn when handling affected sheep because the virus can infect humans.

While treatment with antibiotics is largely unsuccessful, lambs that have secondary bacterial infection of scabs show a good response to either procaine penicillin, or oxytetracycline injections, and topical oxytetracycline spray for three to five consecutive days.

There are several scabby mouth vaccines available that can be used to prevent outbreaks.

SHELLY HOOF

Shelly hoof is a common finding during footrot inspection procedures and can be confused with footrot. The cause of shelly hoof is not understood, but it may be the result of laminitis earlier in the year.

Figure 13. *Shelly hoof.*

CLINICAL SYMPTOMS

The condition is seen as a hole on the outer wall of the claw that tends to be packed with mud. There is no pus or inflammation. Generally, sheep with shelly hoof are not lame.

TREATMENT AND CONTROL

There is no need to treat sheep with shelly hoof.

LAMINITIS

Laminitis is an acute inflammation inside the hoof (similar to "founder" in ponies), where there is separation of the horn from the underlying tissues. As the hoof grows, the horn separation becomes a hole on the side of the hoof and will eventually grow out. Laminitis is usually associated with high energy feeds such as grain, but milder cases may be seen when sheep are grazing high quality autumn or spring pasture.

CLINICAL SYMPTOMS

Sheep appear lame without any obvious signs in the hooves apart from mild heat.

TREATMENT AND CONTROL

Take sheep off pasture and minimise exercise.

CHAPTER 5
FLOCK DIAGNOSIS

DIAGNOSIS OF FOOTROT IN A FLOCK

This chapter discusses the diagnosis of footrot in a mob or flock situation on a property where an outbreak is suspected.

FLOCKS WITH A RECENT HISTORY OF FOOTROT

The "eye ball" test is the usual method of diagnosis and it should be straightforward in flocks where footrot has been present over the past few years.

A representative sample of the mob can be examined for signs of water maceration (score 1), OID (score 2) and early footrot (score 3). If any sheep are found with score 1, 2 or 3 lesions on a property that has had a recent history of footrot, then an immediate diagnosis of footrot in the mob should be made with confidence.

FLOCKS WITH NO RECENT HISTORY OF FOOTROT

Footrot-free flocks can be affected by OID, and the infection may look very similar to early footrot. Rather than just call it "scald", every effort should be made to obtain a confident diagnosis.

In most outbreaks of OID, the diagnosis of OID is straightforward, but making the diagnosis as to whether *D. nodosus* is present or not can be very difficult.

Generally an outbreak of footrot in a flock that has been free for a long time can be explosive and severe on the sheep. The longer it takes to make a diagnosis, the greater the risk of a huge problem.

RECOMMENDED APPROACH

- Immediately isolate the suspect mob(s) from all other mobs.
- Closely examine the feet of a large number of sheep.
- Check other mobs.
- Consider significant risk factors:
  - Occurrence of any outbreaks of footrot on the property over the past five years.
  - Recent footrot on neighbouring properties.
  - Introduction of outside sheep over the past 12 months.
  - Weather patterns over the previous 6 to 12 months.

It is better to be conservative and call it footrot at the outset, and treat it accordingly, than to wait for a laboratory diagnosis.

LABORATORY DIAGNOSIS

Laboratory diagnostic techniques may assist with the diagnosis, but reliance on them may delay the start of a risk-management programme. With both the examination of smears, and the culture of lesions, there is a risk of a false negative result (i.e. a negative result does not necessarily mean that *D. nodosus* is not present in the flock).

- Examination of smears:
  - Smears must be taken from lesions from several feet of a representative sample of sheep.
  - A positive finding means *D. nodosus* is present. However, a negative finding does not necessarily mean that D. nodosus is not present in the flock (there is a possibility of a false negative result).
  - If the laboratory is warned of the urgency of the test, the turnaround time should only be a few hours.
- Culture of lesions:
  - Samples must be taken from the depth of active, moist lesions to avoid contamination with other organic material.
  - It is essential to protect the bacteria from oxygen by using special pre-reduced transport media (*D. nodosus* is an anaerobic bacteria).
  - It takes several days to get results back from the laboratory.
  - A positive finding means *D. nodosus* is present. However, a negative finding does not necessarily mean that *D. nodosus* is not present in the flock (there is a possibility of a false negative result using this technique as well).
- Polymerase Chain Reaction (PCR) technique:[1]
  - Detects very small amounts of bacterial cells in lesion material.
  - This is a precise technique, but it does not differentiate between live and dead bacteria.
  - Available at Lincoln University, upon request.

CHAPTER 6
MANAGEMENT

KEY SUCCESS FACTORS

As discussed in Chapter 1, the principles of a successful management programme are:

- Following careful inspection of all four feet of all sheep, infected sheep should be isolated.
- Infected sheep should be treated. There is a strong tendency for sheep that appear to have recovered to suffer relapses. Hence, infected sheep should remain isolated until they have passed two careful examinations, at least one month apart.
- Healthy sheep should be footbathed and go onto pasture that has not been grazed by sheep for at least two weeks prior.
- Eradication should only be attempted when the prevalence of the disease on the property is less than 5%.

The most critical challenges to a successful footrot management programme are:

- Getting the clean mob clean AND
- Isolation of the clean mob BEFORE the next challenge period.

It has been proven that footrot can be controlled, and even eradicated, on individual properties using the principles outlined above, yet footrot remains a real problem on many properties.[1] A wide range of issues have been identified as potential reasons for failed footrot management programmes. Generally, the mix of issues is specific to each property, and they must be identified and considered before a successful management plan can be implemented.

GROWER ATTITUDE

The most important success factor in footrot management is grower attitude. A positive attitude follows from a comprehensive understanding of the disease and the techniques available to manage it. Some growers prefer to ignore footrot until it becomes a major problem, while others have unrealistic expectations of the various treatments that are available and hope for a "silver bullet".

The perceived stigma of having footrot on the property, and a reluctance to accept that footrot can be managed more successfully, can limit the opportunity to manage the disease effectively. Some old-fashioned myths still exist, and they just confuse the understanding of some of the important aspects of the disease. Some of the more common myths include:

"Footrot survives in the ground for years and years."

"Footrot is spread by birds, vets and stock agents."

"Winter is the worst time for footrot."

"Make the feet bleed because the bacteria is killed by blood."

Successful programmes are always associated with growers who have a strong desire to effectively manage footrot:

- They take a positive attitude and commit to better disease management through investment in facilities, staff and advice.
- They have a plan that involves targets.
- They understand the disease and the limitations to its management on their properties.
- They do not resort to short-cuts.

Grower attitude is the most important success factor in managing footrot on-farm.

PLANNING

In the past, control programmes have tended to be reactionary and poorly planned, or not planned at all. There is a high awareness of the accepted diagnostic, treatment and preventive techniques, but effective management depends on these being incorporated into a well-designed programme.

Successful control programmes are focused on establishing, and then isolating, the clean mob. Commonly, too much emphasis is placed on treatment of the obviously infected sheep after the first whole-flock inspection (without consideration being given to sheep in the "clean mob" that show signs of infection after that first inspection).

Never expect the "clean mob" to be completely clean after the first inspection.

TIMING

The seasonal nature of footrot has a huge impact on the way the disease should be managed at any given time. Good timing is essential for many aspects of the management programme.

Many footrot management programmes tend to start at the height of an outbreak, when the disease is already spreading. However, successful programmes focus on an intensive effort when the incidence of footrot is at its lowest and the disease is not spreading.

Good timing relies on understanding the disease and the issues that can limit the effectiveness of treatment methods (see Chapter 2 – Epidemiology, particularly the section *Interactions between the agent, host and environment*, and Chapter 7 – Treatment).

STAFF

Farm staff should be involved in all aspects of the programme, have ownership of it and, to do it effectively, need to understand what they are doing and why they are doing it. On many properties, footrot inspection is regarded as an annual ritual that will never go away – "no matter what we do now, we know we will be doing it again next year". Many staff see the task as just "tipping up sheep", and are not aware that they play a very important role in a disease management programme.

Further, managing footrot is labour intensive. If the inspection procedures are too slow, the working day becomes too long and can lead to frustrated, tired operators and, as a result, more mistakes. Often, by the time the first inspection of the whole flock is finished, there may be a significant number of sheep showing signs of footrot in the so-called "clean mob".[2]

Most staff are given no incentive to perform well in a job that is unpleasant, involving hard work, long hours and dirty, cold conditions. Effective management requires staff who are well trained in all aspects of the disease and its management.

Successful programmes include staff who know:

- What they are doing.
- Why they are doing it.
- What they are expected to achieve.
- What rewards they can expect for success.

Staff training and management is critical.

The best programmes involve all the staff to the point where they take ownership and have a positive attitude, because they see progress being made. Once staff understand the programme, their attitude usually changes dramatically.

PROPERTY CONSTRAINTS

On large, extensive properties, the number of sheep, combined with their location across a wide range of land types, makes it very difficult to manage footrot. Because there is very little that can be done in the face of a large outbreak on a extensive property, proactive footrot management strategies to minimise the impact of the disease (when sheep are already in for another required task), should be the focus. Implementing these strategies will reduce the scale of the outbreak when conditions favourable to the spread of footrot occur.

DIAGNOSTIC TECHNIQUE

The accuracy of the diagnosis is critical to successful management of footrot (see Chapter 3 – Development of footrot and Chapter 4 – Differential diagnosis).

Many growers have wasted time and effort in the past as a result of poor diagnostic technique. Drafting off and treating only the lame sheep is almost a waste of time. On one property, 8% of a mob was drafted off as lame but, on careful inspection of the whole mob, it was found that 34% were infected. Growers who carry out inspection procedures while the sheep are being crutched or shorn should also expect mistakes.

Human error is a huge issue, especially when outside staff are employed. A large amount of the human error can be managed with better training, better facilities, better gear, and better systems.

SHEEP HANDLING FACILITIES

Inefficient sheep handling systems increase the time taken for inspection procedures and can place too much physical stress on the operators. Of growers surveyed in Central Otago, 53% dragged the sheep over the shearing board, 17% worked in open yards and only 30% used some form of a sheep handler.[3] Whereas, with the right set-up, the handling and treatment of sheep is more efficient and less physically demanding.

PREVENTIVE AND TREATMENT TECHNIQUES

There are recognised limitations with all footrot treatments; these limitations must be understood and recognised to maximise the product's effectiveness (see Chapter 7 – Treatment and Chapter 8 – Vaccination). Unreasonable expectations of footrot treatment products can lead to frustration and doubt.

Planning, timing and attention to detail are key components of successful preventive and treatment procedures.

Figure 14. *Back breaking, dirty work.*

Figure 15. *An efficient sheep handling system.*

CHAPTER 7
TREATMENT

TREATMENT OF FOOTROT

Extensive research and development has been directed at producing footrot treatments. Despite a wide range of commercially available products, there is still no single treatment that is 100% effective. Generally too much emphasis is placed on the treatments themselves, at the expense of better planning to prevent an outbreak, and better timing of the application of the treatment.

Many products have entered the market with little information to support what are sometimes miraculous claims. A lack of science-based support for the product can often cause confusion about how effective it may be in the field:

- Trials are performed under laboratory conditions, not under field conditions.
- Trials do not include a proper control group where untreated animals are run together with the treated animals.
- The effect of environmental conditions and spontaneous cure is not considered. The rate of spontaneous cure ranges from 0% to approximately 80%.
- The degree of paring used in conjunction with the treatment is often not reported.
- The method of measuring product performance may not be described.
- The time frame between final treatment and inspection is not reported.

New products may be more effective, but one needs to be cautious about any claims that are made. The claims should be supported by sound trial data that is of a standard that could be published in a scientific publication.

DURING CHALLENGE PERIODS

It is unrealistic to expect any treatment option to significantly reduce the incidence of footrot during a challenge period. Any reduction of incidence during a challenge period is more likely to be attributable to a reduction in environmental moisture and temperature, and the numbers of infected feet in the mob, than to the treatment itself. The treatment regime will cure some infections, but new infections will be developing simultaneously. This can lead to a perception that the treatment option has failed. However, the aim at this stage should be to restrict the potential size of the problem within the mob.

DURING NON-CHALLENGE PERIODS

All sheep should be carefully inspected, with the clean sheep being removed and isolated. Then treatments should be used to cure as many infected sheep as possible, as quickly as possible. The aim is to cure individual animals. Cure rates of 70-90% should be regarded as very satisfactory.

Treatment programmes should be designed for each property to suit the flock, the resources of the property and to fit in with the objectives of the control programme.

CULLING

Culling infected sheep is the only "cure" for footrot that is 100% effective, and must always remain an important "treatment" option. No other treatment will reliably cure all chronic infections, and the longer infected sheep are kept on the property, the greater the risk of a breakdown in the management programme.

Heavy culling of infected sheep provides several advantages:

- Removal of genetically susceptible animals.
- Physical reduction in the numbers of *D. nodosus* and infected feet on the property.
- Removal of a very high risk factor for breakdowns during a management programme.

FOOTBATHING

Formalin and zinc sulphate have stood the test of time as footbath treatments and there is a large amount of science to support their use. Over the years, other products have come and gone, and they have often been accompanied by claims almost too good to be true. They have tended to enter the market when the incidence of footrot is high and growers are clutching at straws.

For formalin and zinc sulphate, research studies have shown cure rates that range from 0% to 80%.[1] The huge variation in responses reported in the scientific literature, and observed at farm level, may be associated with the following factors:

- Incorrect dilution, due to miscalculation of the volume of the footbath and/or dilution rates.
- The feet not being exposed to the chemical for a long enough time (e.g. running the sheep through a trough, rather than standing them in chemical for a period of time).
- The footrot challenge the sheep are exposed to is too high.
- The sheep are not footbathed frequently enough.
- The sheep rest their feet on the ledges of the footbath.
- The sheep's feet get too wet immediately after treatment.

- Overcrowding in the footbath.
- Infected lesions are covered by excess overgrown hoof.

Lack of contact time between the footbath solution and the footrot lesions is a common reason for unsatisfactory results. When growers were asked to estimate the contact time between feet and the treatment chemical, 78% of them indicated that it would be less than one minute.[2] On one property, a dye was put into a commonly used footbath and sheep were run through it "normally", with only 60% of the feet showing satisfactory contact with the dye.

Even if there is sufficient chemical contact during footbathing, allowing sheep to go back onto wet pastures immediately will reduce the effectiveness of the chemical. Ideally, sheep should be stood on a dry surface for 20-30 minutes after the footbath to improve the effect of the chemical. However, when sheep are being treated during a high challenge period, the extra time may be better spent in the footbath. In terms of expectations, it is important to remember that a footbathing programme will never be 100% effective, either in preventing or treating footrot.

Footbathing with formalin or zinc sulphate should never be expected to give 100% cure rates.

FORMALIN

Formalin (40% formaldehyde) is a potent and effective antibacterial chemical, and it has been used extensively as a footrot treatment. Formalin is effective against OID and early footrot, but it does have some limitations:

- Formalin does not penetrate the horn, and it acts as a surface agent only.
- It is not recommended for more advanced footrot, because of the extended time required to expose the infection to the treatment.
- Exposure to solutions stronger than 10%, and prolonged or frequent exposure, can cause inflammation and secondary infection of the interdigital skin, leading to severe lameness. Excessive use of formalin has been reported to cause toe granulomas.
- Formalin left outside in baths becomes more concentrated due to the evaporation of water. Further, it may become ineffective after polymerisation, which can occur at temperatures less than 10ºC and above 35ºC.[3]
- Organic material in the solution / faecal contamination decreases the efficacy of formalin.
- Formalin tends to harden feet, and makes future paring very difficult.
- Formalin is unpleasant to work with.

Recommendations for using formalin:

- Use for the prevention of OID, and for the treatment of OID and early footrot.
- Use as a 5% solution (add 1 part formalin to 20 parts water).
- It is recommended that footbath solutions of formalin should be prepared on the day of use and discarded daily, whether contaminated or not. As there is no method of measuring the concentration of formalin, the addition of water or more formalin to existing solutions should be avoided.
- Contact time should be no longer than 1-2 minutes.
- The results of using formalin can be improved by keeping the sheep's feet dry for up to an hour following treatment.

ZINC SULPHATE

Zinc sulphate (zinc sulphate heptahydrate, or zinc sulphate monohydrate) has a similar level of performance to formalin against OID and early footrot, but tends to provide much better cure rates in more advanced footrot.[4] Cure rates are improved with foot-paring prior to the first footbathing.

The significant advantages of zinc sulphate over formalin include:

- More rapid recovery from footrot, due to deeper penetration of the treatment and its superior healing effects.
- It is a more effective treatment for advanced lesions.
- Increased exposure time is possible, without harmful effects.
- It does not need to be discarded after each use. The concentration of the solution can be measured with a hydrometer, and water or zinc sulphate can be added to correct the concentration (see recommendations below).
- It is effective in the presence of up to 20% organic material.
- Good cure rates are achievable without paring.
- It is more pleasant to work with.

However, treatment with formalin within the 6-8 weeks prior to using zinc sulphate will lower the effectiveness of the zinc sulphate.

Recommendations for using zinc sulphate:

- Use as a 10% solution:
  - Zinc sulphate heptahydrate (ZnSO4.7H20) 10kg per 100L water.
  - Zinc sulphate monohydrate (ZnSO4.H20) 6kg per 100L water.

It is important to add the zinc sulphate to the water, rather than water to the zinc sulphate. In a large footbath, the correct amount of zinc sulphate can be poured into the water and stirred in with a large yard broom.

- Measure concentration with a hydrometer:
  - The specific gravity of a 10% solution should read between 1040 and 1050 in any solution up to 20% faecal contamination (Fig. 16, next page).
  - To increase the specific gravity by 10 units, add 2kg zinc sulphate heptahydrate (ZnSO4.7H20) or 1.5kg zinc sulphate monohydrate (ZnSO4.H20) per 100 litres of solution.
  - To reduce the specific gravity by 10 units, add 20 litres water per 100 litres of solution.
- Faecal contamination will affect the concentration of zinc sulphate in the footbath (Fig. 16). As a rule of thumb, the bath should be emptied and cleaned out after about 50 lots have been through, or when the consistency of the solution becomes thicker than cream after stirring.

- There is no research to give a clear indication of the optimum time in the footbath or frequency of footbathing. The time sheep should stand in the footbath depends on the challenge and the stages of infection within the flock. The frequency required will also depend on the level of the challenge (number of infected feet in the mob and the weather conditions). An assessment of the flock to determine the extent of lesions is essential.
- Keeping the feet dry for a few hours after footbathing may improve the efficacy of zinc sulphate. However, the cost of the extra time involved needs consideration. In practice, very satisfactory results have been observed when sheep are returned to damp pastures soon after footbathing with zinc sulphate.
- Recommendations to reduce spread during a challenge period:
  - OID only (up to score 2) 1-2 minutes.
  - OID and early footrot (scores 2 and 3) 5-10 minutes.
  - Early and advanced footrot (scores 3 and 4) 10-15 minutes.
- To treat footrot:
  - 30 minutes, three times, seven days apart.

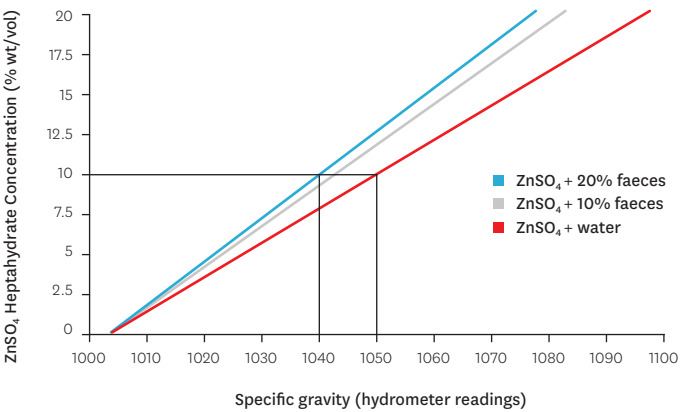


Figure 16. *Specific gravity and concentration of zinc sulphate heptahydrate at different levels of faecal contamination.*

PARING

Extensive paring of infected feet is an age-old tradition and many believe "the harder the paring the better". The rationale for such severe paring may be associated with *D. nodosus* being anaerobic implying that blood will kill it. However, the foot-paring techniques seen on some properties can be more harmful than beneficial. Over-paring, with the aim of physically removing the infected tissues and creating excessive bleeding, is unnecessary, impedes diagnosis and is cruel. It can also cause toe fibromas (Fig. 17).

Figure 17. *Toe fibroma.*

ROUTINE PARING

Even routine foot paring may cause more harm than good. A survey of footrot practices used by growers in the United Kingdom indicated that routine foot paring may actually increase the prevalence of footrot.[5]

PARING BEFORE OTHER TREATMENTS

There is confusing evidence about the benefits of paring feet prior to other treatments. One study saw no added advantage to paring the feet before sheep were treated (using Footrite®).[6] While another study achieved better results when feet were pared before footbathing, than when feet were not pared (in this instance, using a solution of 10% zinc sulphate and 0.2% Teepol®.[7]

In further studies, it was concluded that hoof paring prior to footbathing in 10% zinc sulphate resulted in the highest cure rates and, for treating advanced cases, would be the recommended procedure.[8]

The conflicting results may be associated with variable degrees of hoof overgrowth in the trial sheep. It is possible that heavy paring may reduce the reservoir for absorption of zinc from the bath, especially during challenge periods when the hoof horn is soft. However, light paring before the first treatment is advised to increase the contact between the antiseptic and the bacteria.

Paring is a slow and tedious task. When large numbers are to be treated, it may be worthwhile to avoid paring. The disadvantage of moderately decreased cure rates caused by not paring may be offset by the time and effort saved.

Paring on its own is not an effective treatment. However, light paring is recommended to enhance contact between the infection and the antiseptic.

Figure 18. *Before and after paring.*

TOPICAL SPRAY TREATMENTS

A wide range of topical preparations is promoted for the treatment of footrot. Not all of them contain an antibiotic. Their efficacy is limited due to the difficulty of applying a dose high enough to kill the bacteria and getting contact with the deeper parts of the infection.

They are designed for individual treatment, which increases the cost and labour input. If they are used, sheep should be held in a dry area to ensure that the feet are sufficiently dry following treatment before going back onto wet pastures.

ORAL AND INJECTABLE ZINC

There has been long-standing controversy over the use of oral and injectable zinc for the prevention and treatment of footrot.
A Greek study was able to eliminate footrot after daily oral treatment of 0.5g zinc sulphate for 7 weeks,[9] and this finding was supported by a French study.[10] However, both findings conflict with a series of trials in New Zealand,[11] Australia,[12] the USA[13] and Spain,[14] where oral zinc supplementation was ineffective as a preventive or treatment for footrot. A possible explanation for the positive results reported in Greece and France may be that the immune status of the sheep had been decreased by a zinc deficiency. Zinc deficiency is known to reduce the immune response[15] and is a suspected predisposing factor for footrot.[16]

Zinc and other trace elements, administered orally or by injection, are unlikely to provide any significant benefits to footrot control programmes in New Zealand.

One New Zealand study compared three forms of zinc treatment with an untreated control group in Merino ewes run under a significant footrot challenge.[17] The treatments were:

- Two slow-release zinc bullets (the Time Capsule®, Agri-feeds Limited, A 6275), given 6 weeks apart to provide 12 weeks of treatment.
- As above, supplemented with a 5g copper capsule (Copacap 5G, Merial Ancare New Zealand Limited, A 4944 RVM).
- Oral dosing with 135g chelated zinc (Chelafarm, Sulkem Company Limited) every 14 days.

None of the treatments were effective for the prevention or treatment of OID or footrot during the 70-day challenge period.

Oral zinc chelate has been widely promoted by some growers as a control for footrot. However, Sulkem, the New Zealand distributors, do not promote zinc chelate as a footrot remedy and will not recommend a dose rate for its use for this purpose. In a farm situation, where the entire flock is treated (without an untreated control mob), it is impossible to assess whether any positive effect is due to treatment or environmental factors.

A zinc injection has been promoted as a treatment for footrot as well. However, the product is not licensed for use in animals in New Zealand. There have been reports that it was ineffective and caused severe injection site reactions.

ANTIBIOTICS

REQUIREMENTS OF THE AGRICULTURAL COMPOUNDS AND VETERINARY MEDICINES ACT 1997

Several antibiotics have been proven to be effective treatments for footrot. However, their widespread use for the treatment of large numbers of sheep needs to be tempered with the requirements set out in the Agricultural Compounds and Veterinary Medicines Act 1997 (the ACVM Act).

Antibiotics are classified as Prescription Animal Remedies (PAR) Class 1 under the Animal Remedies Act 1967, its Amendments, Regulations and Schedules, and in accordance with section 93 of the ACVM Act.

PAR Class 1 animal remedies may only be administered to an animal:

- by a veterinarian; or
- under, or in accordance with, the authority or prescription of a veterinarian.

A veterinarian may only prescribe or dispense a PAR Class 1 animal remedy for administration to an animal under the immediate care of that veterinarian and following a veterinary consultation in respect of that animal.

"Under the immediate care of the veterinarian" means:

- The veterinarian must have been given and accepted responsibility for the health of that animal.
- The on-going and continuing care of the animal is a reality and not merely nominal.

A "veterinary consultation" means:

- an examination of the animal by the veterinarian; or
- the obtaining by the veterinarian of sufficient information about that animal to enable the veterinarian to make an informed decision with respect to the administration, dispensing, or prescribing of a PAR to or in respect of that animal.

Section 2.1(b), New Zealand Veterinary Association Code of Practice – 27 May 2005. The discretionary use of human and veterinary medicines by veterinarians.

- "The veterinarian must then first assess if there is a registered or exempted veterinary medicine available, which meets the treatment and welfare needs of the animal(s), within the general conditions imposed on that medicine. If such a veterinary medicine is available, then discretionary use is not justified."

Some antibiotics are not licensed as treatments for footrot because the recommendations for footrot are "off-label". Common variations include:

- Route of administration.
- Dose rate.
- Species treated.
- Indications for treatment.

BACKGROUND

Antibiotic treatment does provide some benefits when compared to other forms of treatment, such as the ease of administration, the ability to treat undiagnosed infections, the minimal paring that is required and rapid recovery times. In practice, antibiotics tend to provide limited benefits, because they are commonly used as a "band-aid" when an overall management programme is not being implemented or the programme is not working.

For optimum results, sheep treated with antibiotics should be held on a dry surface for 24 hours after treatment. This is because, following injection of the antibiotic, it diffuses from the bloodstream into the fluid around the footrot lesion inside the hoof (creating a 'topical application' of the antibiotic). Keeping the sheep's feet dry will prevent the antibiotic, which is now coating the lesion, from being washed off, and allows for evaporation at the surface of the lesion to increase the concentration of the antibiotic.[18]

Growers commonly observe a reduction in the number of lame sheep when treated sheep are returned to pastures. This observation is likely to be associated with partial healing. If no other preventive methods are used, it is likely that lameness will reappear in the flock 3-4 weeks after antibiotic treatment.

There is evidence to suggest that paring to remove grossly overgrown hoof, and footbathing at the time of treatment, may enhance the cure rate, especially when sheep return to wet pasture following treatment. However, unless sheep can be held in dry conditions for 24 hours after treatment, it is inadvisable to recommend antibiotics when pastures are wet.

POSSIBLE ANTIBIOTIC TREATMENTS

There are a number of antibiotics that have been shown to be effective treatments for footrot; however, only one has ACVM registration as a treatment against footrot in sheep.

Negative market perceptions regarding residues in meat, as well as the development of antibiotic-resistance in bacteria that infect humans, mean growers should be cautious about the widespread use of antibiotics in food producing animals.

Long-acting oxytetracycline

A single dose of long-acting oxytetracycline, at a rate of 20mg/kg, provided a 94% cure rate in infected sheep under field conditions.[19] However, 23% of the infected feet at the start were still showing active infection 14 days following treatment. Therefore, treated sheep should remain isolated from clean sheep until further inspection 5-6 weeks post-treatment.

Long-acting oxytetracycline can be used according to label recommendations for the treatment of footrot in sheep.

The withholding period is 35 days for milk and 28 days for meat.

Procaine penicillin

A single large dose of procaine penicillin, at a rate of 70,000 IU/kg, provided a high cure rate,[20] but has been superseded as a recommended treatment by long-acting oxytetracycline.

The use of procaine penicillin must be regarded as off-label, due to the high dose rate.

The default withholding period is 35 days for milk and 91 days for meat.

Procaine penicillin / streptomycin

A single large dose, at a rate of 70,000 IU/kg procaine penicillin, and 70mg/kg streptomycin, improved cure rates compared to penicillin on its own.[21]

Penicillin / streptomycin combination products are no longer available in New Zealand. But procaine penicillin and streptomycin are available separately, and could be used as two injections given at the same time.

This use must be regarded as off-label as well, due to the high dose rate.

The default withholding period is 35 days for milk and 91 days for meat.

Lincomycin / spectinomycin

Linco-spectin injection

In a controlled clinical trial, a 92% cure rate was achieved,[22] in both acute and chronic cases of footrot, with a single injection of a mixture of lincomycin (5mg/kg) and spectinomycin (10mg/kg).

In the field, the same authors achieved 100% and 97% cure rates (14-17 days post-treatment) with lincomycin / spectinomycin on two separate farms.

However, a linco-spectin injection is not available in New Zealand.

Linco-spectin soluble powder

Linco-spectin soluble powder[23] is registered as a medication that is added to drinking water, but only for use in poultry and pigs.
It is contraindicated orally for all ruminants.

However, some veterinarians prescribe this product as an injection, after dissolving the powder in sterile water. This is clearly an extreme example of off-label use, which, if not managed according to the NZVA Code, could result in complaints being made before the Veterinary Council of New Zealand for professional misconduct, and / or prosecution under the ACVM Act or the Animal Welfare Act.

There have been reports of sheep deaths following treatment with this product. It is likely that the "stress" situation many of the treated sheep have been under in the few days prior to treatment, combined with the antibiotic itself, predisposes them to intestinal disorders such as salmonellosis. The risk may increase with pregnancy, loss of body condition, or lack of feed and water.

If the product is used, all sheep should have had at least two full days on good pasture with access to drinking water before they are treated, and then immediately returned to pasture after treatment. This product should not be used in heavily pregnant ewes.

The default withholding period is 35 days for milk and 91 days for meat.

CHAPTER 8
VACCINATION

BACKGROUND

Experimental footrot vaccines were developed in the early 1970s. They were either single- or two-strain whole cell vaccines in an alum base. These vaccines reduced the number of sheep that developed footrot during a challenge, lesions were less severe and the duration of the outbreak was shortened.[1]

FOOTVAX®

Footvax®[2] is the only footrot vaccine commercially available in New Zealand at the time of writing. It is a killed, oil-adjuvanted, multi-strain *D. nodosus* vaccine.

Footvax® produces an inflammatory reaction at the site of the infection. The reactions can range from a small lump to a large discharging lesion that may persist for several weeks.[3] Sheep may become depressed and develop a high temperature for several days after vaccination. These sheep may have a reduced appetite, which may increase the risk of pregnancy toxaemia in pregnant ewes or decrease mating performance.

Footvax® should **NOT** be used:

- Within two weeks of mating.
- Within 2-3 weeks of the start of lambing.
- In conjunction with the following licensed animal remedies:
  - Eweguard®.[4]
  - Eweguard Plus Selenium®.[5]
  - Eweguard Plus Se B12®.[6]
  - Cydectin Injection®.[7]

These products should not be used in sheep that have ever been vaccinated with Footvax®. The Footvax® may have sensitised the sheep and subsequent treatment with these products can lead to a hypersensitivity reaction, including death.[8]

A trial by Pfizer showed no adverse side effects when sheep that had been vaccinated with Footvax® were treated with Cydectin Long Acting Injection For Sheep.

Where sheep have been vaccinated with Footvax® previously, Merial Ancare recommends treating a sample of 50-100 sheep with Exodus Long Acting Injection and waiting for 1-2 hours for any untoward reactions before treating the whole flock.

VACCINATION TECHNIQUE

Footvax® is oil-based and causes some sheep to produce a reaction at the vaccination site. The reaction is most severe when the vaccine is injected into muscle tissue instead of just under the skin.[9] Sheep must be injected carefully so that the vaccine goes under the skin as high as possible on the neck. Do not inject in the cheek, because the tissue reaction may prevent the sheep from eating for several days. Sheep should be carefully restrained during vaccination.

Self-injection can lead to severe tissue damage, if injected into a muscle or joints. The extensive tissue damage is caused by a chronic inflammatory process associated with the oil component of the vaccine that acts as a slow release depot.

Immediate medical attention should be taken if self-injection occurs (or is even thought to occur). Surgical removal of the injection site is strongly recommended to prevent the development of severe, chronic tissue damage.

FOOTVAX® FOR PREVENTION

The varied reported effects of vaccination are related to unrealistic expectations of the outcome of vaccinating and inappropriate timing of the administration. The purpose of a vaccination programme is to reduce the size of an expected footrot outbreak to a more manageable level.

Best results are achieved when the booster is administered before there is a high incidence of score 3 and score 4 lesions.[10] If vaccination is done too late in the outbreak, while the number of lame sheep may decrease, close inspection will reveal that many of these sheep have healing, but still active, lesions. If the challenge persists longer than 8-10 weeks, the effectiveness of the vaccine will be reduced, and these lesions will become worse, with lame sheep reappearing in the flock.

Immunity develops after the second and subsequent doses of the vaccine. Label recommendations state that the booster should be given six weeks after the sensitiser and that annual vaccination is required. When time is limited (e.g. prior to the start of lambing), satisfactory results can be achieved when the sheep are sensitised four weeks prior to the second booster dose.

Maximum protection levels are short-lived, 4-5 weeks in Merinos and 16-20 weeks in British breeds.[11] The limited length of protection can impact on the outcome of a vaccination programme. Breakdowns can occur when vaccination is too far in advance of the start of the footrot challenge, or when the challenge is longer than the protection period. Often vaccination is planned when the sheep are yarded for some other reason (e.g. pre-lamb shearing), which may be too early to provide maximum protection at the start of the footrot outbreak.

Footvax® can be used:

- Annually, prior to expected challenge periods, on properties with restricted labour and facilities.
- To vaccinate all replacement sheep each year, so the flock is always sensitised and ready for the immediate effect of a booster.
- As an adjunct with other tools, to quickly reduce the prevalence of footrot prior to starting an intensive management programme.

Vaccination should be used strategically to maximise its cost-effectiveness. The higher the numbers of infected sheep at the time of vaccination, the higher the number of sheep that will still develop footrot. These infected sheep will be the source of the next outbreak. Growers who rely on vaccination alone can expect significant breakdowns during severe challenge periods. It must be recognised that the vaccine will, at best, provide only 60-70% protection. However, vaccination is an option on properties with restricted labour, or where there are no adequate footbathing facilities.

Footvax® is NOT 100% effective and provides short term protection only.

FOOTVAX® FOR TREATMENT

Footvax® will give a limited and variable curative or treatment effect, with cure rates ranging from 0% to 71%.[12] Higher cure rates of up to 100% have been reported,[13] but these results may be confused because the method used to calculate the cure rate did not take into account the number of new cases or the number of spontaneous cures. Healing does not become obvious until about 2-4 weeks after the second vaccination.[14] Vaccination should be regarded as a preventive technique, rather than relied upon as an effective treatment.

CHAPTER 9
BREEDING

BACKGROUND

Selecting and breeding for increased tolerance to footrot has been practised in New Zealand for many years. The decreased prevalence of footrot in the New Zealand sheep flock from 61% in 1955 to approximately 6% in the early 1980s was most likely associated with a strict culling programme, supported by traditional treatment procedures.

The Orr Corriedale flock and the Patterson Merino flock are documented examples of successful New Zealand breeding programmes for developing a high level of genetic tolerance.[1] Both flocks relied upon identification and selection of sheep that did not develop clinical footrot when exposed to a challenge.

The heritability estimates for tolerance to footrot vary widely. Estimates vary from 0.15 to 0.30,[2] which is a similar range to the heritability estimates for wool fibre diameter. However, the uptake of genetic selection and breeding programmes to develop footrot-tolerant sheep has been slow, mainly because of the need to maintain footrot on the property to identify tolerant sheep.

Many New Zealand growers say they have bred footrot out of their coarse wool sheep flocks by culling infected ewes and breeding from rams that do not develop footrot. The removal of infected sheep is an important component of a footrot control programme in that the numbers of *D. nodosus* are also being reduced on that property. In many flocks that have "bred" footrot out, the absence of disease may be associated with the removal of the cause rather than increased flock immunity.

GENE MARKER TECHNOLOGY

Researchers at Lincoln University have identified a genetic marker in sheep that is associated with tolerance to footrot. This gene marker technology may provide a practical option for lifting the overall flock tolerance to footrot (refer to the following section).

The New Zealand Merino Company's NZSTX programme is investing in further research into the identification and validation of gene markers for tolerance to footrot (co-funded by Merino New Zealand Incorporated and the Ministry for Primary Industries).

Any benefits of gene marker technology will only evolve from carefully developed breeding programmes, both at the stud and commercial flock levels. The breeding programmes must be based on a sound understanding of the complexity and the potential limitations of the technology.

Breeding for increased footrot tolerance must be regarded as the best option for the future long-term management of footrot in the Merino and mid-micron wool industries.

THE LINCOLN FOOTROT GENE MARKER TEST

Genetics, biological systems, DNA marking, host immunity and environmental impacts are all very complex issues in their own right. When they are put together, the complexity is even greater. The discovery of a gene marker for tolerance to footrot is a classic example of how complex these issues can be. The Lincoln Footrot Gene Marker Test (LFGMT) has been developed at Lincoln University, New Zealand. The LFGMT identifies animals that are more tolerant to footrot, based on their genes, without having to expose the animals to the disease.

Due to commercial sensitivity, the detail of some of the information related to the gene marker technology cannot be made public. However, a summary of the LFGMT is provided below.

HOW DOES THE TEST WORK?

The Major Histocompatibility Complex (MHC) genes are involved in controlling immune response. These genes show great variation between individuals, and it is thought that some gene variants (different forms of the same gene or "alleles") are better at initiating an appropriate immune response than others. Therefore, variation in the MHC genes can be used as a "genetic marker" of tolerance to footrot. The LFGMT involves collecting a small blood sample and analysing the genetic material in it. Depending on the variation seen in the genetic material, sheep can be ranked for their tolerance to footrot.

The Lincoln research has identified 31 different alleles that appear to be associated with immunity to footrot. These alleles may interact to give a wide range of genotypes in the offspring. It is likely that more, as yet unidentified, alleles will also be implicated in the immunity to footrot.

The Lincoln researchers have devised a system to simplify the complex genetic interactions that underpin the immune response. The system is based on relative risk and has been designed to enable easy use of MHC genes in breeding programmes to increase flock tolerance to footrot.

Translating relative risk for alleles into an indication of footrot tolerance for a particular sheep is based on some assumptions:

- The "good" alleles are completely dominant.
- There are no interactions between alleles.
- The relative risk of the "good" alleles is assumed to be the risk for the animal.

Each animal has two alleles reflecting the fact that they inherit one from their sire and one from their dam. The alleles are scored from 1 (most tolerant to footrot) to 5 (least tolerant).

An animal with one allele of score 3 has a relative risk of approximately one for that allele (i.e. in terms of risk, score 3 is an "average" allele), while an animal with one allele of score 1 has a relative risk of approximately one half of the "average" allele (so this is a "good" allele). Scores of 4 and 5 are indicative of much higher relative risks (up to nearly three times more than average) and therefore could be termed "bad" alleles.

Each animal has a particular combination of two allele scores, and its offspring can only inherit one of the scores, so it can be thought of as a gene in the way the genotype is passed on. Lambs sired by a (2,3) ram can only inherit a 2 or a 3 from the ram. A lamb from this mating that is (1,3) must have got the 1 allele from its mother. A (1,2) ram is therefore "better" than a (3,5) ram and will pass on "better" alleles as shown in Table 2.

Ram	Ewe	Progeny
(1,1)	(3,4)	50%(1,3); 50%(1,4)
(1,5)	(3,4)	25%(1,3); 25%(1,4); 25%(3,5); 25%(4,5)
(5,5)	(1,2)	50%(1,5); 50%(2,5)
(2,3)	(3,4)	25%(2,3); 25%(2,4); 25%(3,3); 25%(3,4)

Table 2: *Theoretical genotypes from mating a ram to 200 ewes with different scores.*

** The flock status is based on the alleles, not on the overall tolerance to footrot.*

Individual animals with a score of (1,1) and (1,5) are assumed to have much the same chance of developing footrot when run together because they both carry the 1 allele. The tolerance of their progeny will vary because all progeny from the (1,1) ram and approximately half of the progeny from the (1,5) ram will end up with the "good" alleles. This is not necessarily correct biologically, although the Lincoln data seems to support the argument.[3] This data has been based on progeny test results that have not been published in detail. The information and progeny test results referred to in this chapter must be regarded as a broad summary only and have been provided by Lincoln University.

Published scientific evidence that validates the association between the gene markers and tolerance to footrot is limited. However, Lincoln has provided some information regarding their progeny testing for the validation of the LFGMT. Between 1991 and 1999, over 120 sire lines from 80 typed sires were used to produce 15 to 170 progeny per sire line. Sire breeds included Merino, Corriedale, Awassi, East Friesian, Borderdale, Finnish Landrace and Romney. The progeny were run with one infected animal per 10 test animals, at stocking rates of up to 400 sheep per hectare on irrigated pastures. Footrot susceptible animals were run as controls to verify the challenge.

Rams	% Footrot in offspring under severe challenges
1,1	0–10%
1,2	7–19%
1,3	10–21%
1,4	5–26.5%
2,3	10–26%
2,4	16.5–37.5%
3,3	10–48%
3,4	10–69.5%
4,4	37.5% (single ram, limited progeny testing)
4,5	22–83%

Table 3. *The ranges of incidence of clinical footrot in the progeny of rams with different scores for tolerance to footrot using the Lincoln Footrot Gene Marker Test.*

There is a wide range in the incidence of footrot in the progeny from rams with the same test score (Table 3) and the variability may be associated with the unknown genetic status of the ewes mated and environmental effects. However, this is a recognised limitation for any progeny test and can be minimised by ensuring that high numbers of progeny are produced from each sire being tested.
It appears that for at least one of the sires there were only 15 progeny.

Also, there is some cross-over between rams that have different test scores. For example, the range of results for a (1,2) ram is not much different from a ram with a score of (1,4), supporting the assumption that the "good" alleles are dominant.[4] However, there is a trend showing the incidence of footrot increases with the higher test scores in the rams.

The amount of variation can be reduced by breeding from ewes that have either been gene marker tested or selected as more tolerant (although tolerance (or immunity) to disease is not absolute, because there are often other factors that determine whether the disease will occur or not).

Further, the 1 to 5 relative risk scale is not a simple linear relationship and, in practice, not breeding from sheep with 4s and 5s may be more practical and sensible than trying to find and identify only animals with a (1,1) test result.

Individual animals should not be considered when assessing the usefulness of the LFGMT, as the animals can get footrot for reasons beyond the control of the gene identified by the test. Emphasis should be placed on the effect of the desirable and undesirable alleles on groups of progeny.

The results from the Lincoln progeny tests reinforce the concept that a breeding programme must be regarded as just one more component of an effective footrot risk management programme. There is a wide range in the susceptibility of progeny born to rams that have tested "well" and this range will be compounded by other host and environmental factors.

USING THE LFGMT

Since commercialisation in 2001, the impact of the LFGMT has been investigated only once, using the subjective opinions of Merino and mid-micron growers, including some breeders.[5] The growers participated in a project designed to develop strategies for using the LFGMT, where the costs for using the test were partially funded. Only 29.5% of Merino and 36% of mid-micron growers considered the LFGMT had made a difference during the three years of implementation (Table 4).

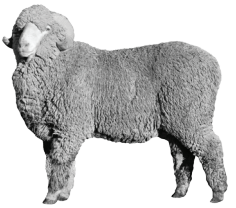
	Merino	Mid-micron
Number of farms	247	634
Number of farms with footrot (%)	161 (65%)	350 (55%)
Number of farms with footrot using LFGMT (%)	61 (38%)	128 (37%)
Number of farms using LFGMT that experienced a difference	18 (29.5%)	46 (36%)

Table 4. *Impact of the LFGMT over 3 years on Merino and mid-micron farms.*[6]

The LFGMT presents an option for the sheep industry to implement programmes for breeding sheep that are more tolerant to footrot. However, a considerable amount of effort and expense will be required to develop and implement breeding programmes that maximise the opportunity afforded by the gene technology and to reduce the impact of footrot on the New Zealand sheep industry.

There are some important issues that need to be considered:

- The impact of this new gene marker test on successful breeding programmes is based on three assumptions that, to date, have not been validated by peer review in a scientific publication:
  1. The "good" alleles are dominant.
  2. There is no interaction between the alleles.
  3. The relative risk of the "good" alleles is the risk for the animal.
- The test is only an indicator of the potential level of tolerance of that animal to footrot – genetic tolerance to diseases is not absolute. The test should be regarded as an indication of how much more tolerant the progeny of a mating programme may be. The Lincoln data shows that sheep can still get footrot when bred from tolerant rams.
- The ability to be more tolerant to footrot appears to be associated with an immune response. The general "well-being" of the individual animal affects the level of any immune response. Anything that reduces the effectiveness of the immune system (e.g. other diseases, underfeeding, pregnancy and lactation) can diminish an animal's tolerance to disease.
- Footrot is a disease of the environment, so the ability of an individual animal to tolerate the disease will be a factor of its own level of immunity, as well as the degree of challenge from the environment. Growers will need to continue to take environmental factors into consideration when managing footrot.
- Genetic selection for tolerance to footrot may decrease the selection pressure applied to other traits. It is not yet known if selection for the footrot tolerance gene marker will be associated with indirect selection for other (less desirable) genetic traits.
- In any breeding programme, the primary focus should be on driving up the proportion of the flock that has "good" alleles. This will be achieved by breeding from rams with "good" alleles (1, 2 and possibly 3) and not breeding from the animals with "bad" alleles (4 and 5).



CHAPTER 10
GENERAL GUIDELINES

GENERAL GUIDELINES FOR THE MANAGEMENT OF FOOTROT

INTRODUCTION

There are a number of options for the management of footrot, and the choice should only be made after a very careful risk analysis. Not all growers have the need, ability or the desire to take on an intensive footrot control programme. The level of control will vary between properties, depending on the attitude of the grower, the nature of the property, the breed of sheep, and seasonal rainfall and temperature.

Many growers are content to keep the incidence of footrot down to an acceptable level, with footbathing and / or vaccination, and other less intensive control options. However, these growers must expect to face seasonal variations in the incidence of OID and footrot. In the case of most Merino and mid-micron flocks, these seasonal variations can be extreme.

IMPACT OF THE WEATHER

The weather patterns from year to year have a huge impact on the incidence of both footrot and lame sheep. During prolonged dry periods, the incidence of footrot will decrease to a level where there may be no lame sheep in the flock. Once the rains come, the incidence will slowly build up over the next few months, leading to a significant outbreak of lame sheep due to footrot.

REACTIVE VERSUS PROACTIVE GROWER ATTITUDE

Traditionally, most work against footrot occurs during and immediately following an outbreak. Paring, footbathing, vaccination and antibiotics are all used to deal with the problem reactively. If there is any planning at all, it tends to be short-term in nature. The incidence of footrot will eventually decrease with dry or cool weather, regardless of whether control programmes are in place or not.

Once the incidence of lame sheep returns to a "normal" level, the focus on footrot management tends to decrease and other farm business takes priority until the next outbreak.

Any grower who is serious about managing footrot must be prepared to focus on the disease every year, whether there is a challenge or not. The opportunity to incorporate genetic tolerance into the flock will also improve the outcome of any of the management options taken.

KEY PRINCIPLES

There are three key principles that underpin successful footrot management programmes:

1. There are no "magic cures", and the basic concepts of diagnosis, isolation, prevention of reinfection and treatment need to be used.
2. The reasons for failure need to be considered and addressed by the grower.
3. Success will only be achieved and sustained with good professional advice, careful planning and a commitment to the plan.

MAKE THE DECISION TO DO IT BETTER AND GET GOOD PROFESSIONAL ADVICE

The decision to improve the management of footrot is generally made during the height of the problem, when the current programme is not working. However, the reasons for unsuccessful control programmes are not always easy to recognise for those who have been intimately involved, often for a long time. It is important to stand back and reassess the problem.

An outsider who has an excellent understanding of footot should be incorporated into any footrot control programme at the outset.

UNDERSTANDING THE PROBLEM

Commit to learning more about the disease and its management, and be prepared to change the way things have traditionally been done on the property.

Identify and understand the reasons the programme has not been successful, and fix them wherever possible.

Understand and accept the limitations of all the treatment and prevention options, and enter the programme with reasonable expectations.

STAFF

All staff must be involved in all aspects of the programme. Staff should have a good understanding of the epidemiology of footrot, learn how to do diagnostic paring safely, and have a good knowledge of the differential diagnosis of lame sheep (especially foot scoring). The staff should be involved in the development of the plan and the setting of targets.

The staff must develop a positive attitude towards, and have ownership of, the programme. They need motivation and involvement, and real incentives to achieve agreed targets.

WORKING RULES

The following working rules will help the grower and staff to achieve the programme's targets:

- Each person should be responsible for his / her own gear.
- Set standard terminology for the different classes of sheep, so everyone is talking about the same things (e.g. the difference between clean and cured mobs).
- Set a rigid daily timetable during the inspection process, to ensure that staff have reasonable breaks.

FACILITIES

Good sheep handling facilities are essential for any footrot control programme. They are necessary to handle large numbers of sheep effectively and efficiently, and to provide a better working environment for those using them.

PILOT FARM STUDY

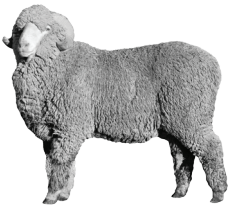
In 1984, a pilot footrot control programme on an intensive, irrigated property was undertaken.[1] The property carried 3,000 Halfbred (Romney-Merino cross) ewes, 3,000 Perendale ewes and 500 stud Poll Dorset ewes. The property had experienced severe footrot problems for at least 20 years. Between 1977 and 1983 there had been a massive footrot outbreak associated with a huge development programme.

SUMMARY OF STUDY

- Early 1984: Facilities built, plan developed, and staff trained.
- April 1984: Inspected 500 ewes to establish the prevalence of footrot:
  - 70% of the Halfbreds and 30% of the Perendales had footrot (i.e. 3,000 infected sheep).
  - Reduce the prevalence with vaccination and footbathing (footbathed four times, seven days apart).
- May 1984: First inspection of the whole flock:
  - Prevalence of footrot was reduced to 19% in the Halfbreds and 5% in the Perendales (i.e. 720 infected sheep).
  - The Clean Mob was isolated and monitored.
  - The Treatment Mob was isolated and treated.
- Late May 1984: Second inspection of the Clean Mob.
  - 5% prevalence in Clean Mob.
- June 1984:
  - The Treatment Mob was treated – 30 minutes in 10% zinc sulphate, three times, seven days apart.
- July 1984: Third inspection of the Clean Mob:
  - No sheep from the Clean Mob were infected.
  - Clean Mob isolated and footbathed through lambing until weaning.
- July 1984: Second inspection of the Treatment Mob:
  - 20 sheep (non-responders) identified and culled immediately.
- January 1985: Post-weaning inspection:
  - No clinical cases of footrot could be found.

KEY FINDINGS

1. Footrot is manageable when there is a commitment to learning more about the disease, and investment in facilities, people and planning.
2. Despite very careful diagnostic techniques, 4-5% of the Clean Mob was found to be infected four weeks after the first inspection process. This is now recognised as a normal expectation following the first inspection.
3. Direct veterinary involvement led to a higher awareness of footrot as a disease and improved management techniques for all the people involved.



CHAPTER 11
FOOTROT MANAGEMENT ON LOW RISK PROPERTIES

OPTIONS FOR FOOTROT MANAGEMENT ON LOW RISK PROPERTIES

DO NOTHING

Fine and mid-micron wool growers taking this option must expect, at some time, a significant footrot outbreak, which will be difficult to manage due to lack of planning and facilities. Culling of lame sheep throughout the year can help to keep the risk of an outbreak to a low level. However, if an outbreak does occur, it is likely that the incidence and severity will be significant due to lack of immunity.

This option is appropriate for many crossbred flocks, where the occasional outbreak of footrot is not associated with any significant costs to production.

There are many crossbred flocks that harbour a continuous low-grade footrot infection without any serious impact on performance. However, there is anecdotal evidence that the incidence of OID, and possibly footrot, is greater in flocks with Finn and East Friesian genetics. The most common time for lameness seems to occur between docking and weaning, with acute lameness in both ewes and lambs.

STRATEGIC FOOTBATHING ONLY

Many crossbred properties have successfully maintained a very low incidence of footrot by footbathing strategically when the sheep are yarded for other events, such as shearing, crutching, drenching etc. This procedure has been very effective when carried out in the challenge periods, mostly during spring and autumn.

The sheep should stand in a 10% zinc sulphate solution held in a large footbath prior to leaving the yards. As discussed in Chapter 7, the amount of time sheep should stand in the footbath depends on the challenge and the stages of infection within the flock. The frequency required will also depend on the level of the challenge (number of infected feet in the mob and the weather conditions). An assessment of the flock to determine the extent of lesions is essential. Recommendations are:

- To reduce spread during a challenge period:
  - OID only (up to score 2) 1-2 minutes.
  - OID and early footrot (scores 2 and 3) 5-10 minutes.
  - Early and advanced footrot (scores 3 and 4) 10-15 minutes.
- To treat footrot:
  - 30 minutes, three times, seven days apart.

Conversion of the concrete base of an old shower dip has been a cost-effective way of building a footbath on many properties. If the footbath is large enough and has a central division, the extra time required to treat the sheep, over and above the time required for the main task, can be minimal.

For best results, strategic footbathing should be started in the early stages of an outbreak. It has been demonstrated that weight loss tends to be greatest when footrot is actively spreading.[1] Unless the sheep are treated, the weight loss is not recovered during the non-active period.

VACCINATION ONLY

Refer to Chapter 8 for further information. Generally, sole reliance on vaccination is unlikely to be cost-effective. Significant outbreaks should still be expected in fine wool flocks where there is a reasonable probability of a challenge. On properties that do not experience significant outbreaks, the benefits of vaccination alone may be overstated. It is likely

that the lack of outbreaks is associated with other factors, such as breed, weather, stocking rates and grazing policies.

Vaccination is a wasted expense if used during non-challenge seasons. Vaccination is best used only when the risk of an outbreak is high, not as a routine preventive measure. Annual sensitisation of all replacement two-tooths ensures that the whole flock has been sensitised, so the booster vaccination can be delayed until as close to the expected outbreak as possible.

STRATEGIC FOOTBATHING AND VACCINATION

Combining strategic footbathing with vaccination will improve the level of risk management on low risk properties, and on properties where more intensive programmes cannot be implemented.

CHAPTER 12
FOOTROT MANAGEMENT ON HIGH RISK PROPERTIES

A FOOTROT MANAGEMENT PROGRAMME FOR HIGH RISK PROPERTIES

The objective of a footrot management programme on a high risk property is to have no clinical footrot in the flock. The management programme set out in this chapter is also a prerequisite for an eradication programme (see Chapter 13).

The two essential components of the management programme are suitable sheep handling **facilities** and a comprehensive **action plan**. The first section of this chapter addresses what facilities are required, and the second section provides a detailed action plan.

FACILITIES

Handling facilities (Fig. 19) can be designed to fit in with existing structures, so that they are workable, do not hinder other stock work and are multi-use. Good sheep flow is the most important design aspect.

NOTE: For right-handed operators, it is recommended that the facilities are designed so that sheep enter from the right-hand side, flowing to the left.

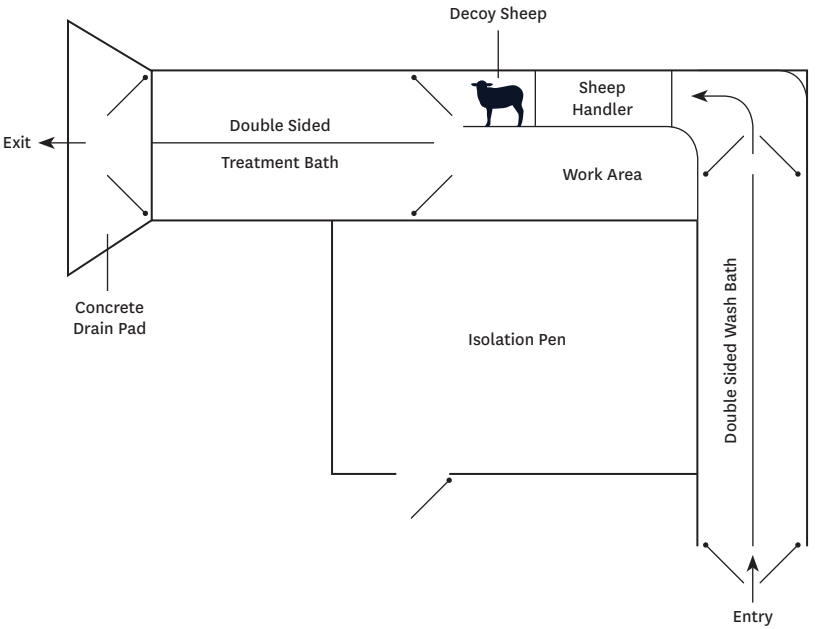


Figure 19. *Suggested layout of facilities for the management of footrot.*

WASH BATH TO CLEAN AND SOFTEN HOOVES

- Cleaning and softening the feet prior to inspection saves time and enables a faster, more accurate diagnosis. (Fig. 20).
- When the bath is full of sheep, the water level should be just above the coronet. If the water is too deep, the sheep take out too much water, making the working area too wet and slippery.
- Using two oblong baths side by side (Fig. 21) provides a decoy system for more efficient sheep flow. One side holds the sheep while the other empties into the handler.
- A continuous flow of water is important (Fig. 22). Standing sheep in a pool may soften the feet but will not remove enough dirt, especially from between the toes. Sheep should move against the water flow.
- Sheep should pass over a raised metal grill as they move from the wash bath into the handler (Fig. 23). Allowing sheep to stand on a concrete drainage area between the wash bath and handler allows the feet to become dirty again.

Figure 20. *Hoof before and after going through the wash bath.*

Figure 21. *Wash bath with split race.*

Figure 22. *Inlet into wash bath with running water.*

Figure 23. *Entry into handler from wash bath.*

SHEEP HANDLER

- Significant savings in time efficiency and physical effort can be achieved with a handler that is well-designed and enables several people to work at the same time.
- The handler should be set up in an "all-weather" area with adequate lighting (both natural and artificial).
- Wooden handlers (Fig. 24) can be constructed as permanent or temporary structures. See the appendix for a suggested plan.
- Handlers should include a rack or shelf above the handler to hold knives and footrot shears while they are not being used.

Figure 24. *Working on a sheep handler.*

- Conveyor-belt handlers can be used, where one person lies underneath and inspects the feet as the sheep pass over the top. The conveyor system ensures good flow of the sheep and requires only one person to make the diagnosis, but it is almost impossible to accurately examine all feet without some hands-on inspection.
- More modern conveyors have a system to turn the sheep on its back to allow hands-on inspection. The time taken to examine each sheep is quite variable so there are problems with sheep flow when more than one person is working on the handler.
- Some contractors provide a foot inspection and trimming service that includes the handler and people. This new service offers considerable advantages to many growers, but must include some form of accountability for performance if the service is to be used in a control programme.

NOTE: There are some safety issues when groups of people are using sharp instruments while working with sheep on a handler.

Hazards include:

- Self-inflicted wounds from sharp gear.
- Sharp instruments kicked out of the hand or kicked off the handler.
- Sheep running around the work area after removal from the handler.

Risk management is based on staff training and leadership:

- Sheep must be comfortable in the handler – they are more comfortable when their head is raised on the operator's knee.
- General behaviour – create a quiet working environment and keep to the rules.
- Place all gear not in use on a rack or shelf above the handler.
- Provide and use a first-aid kit.
- Wear protective gear – footwear, long trousers and consider facemasks.
- Do not leave sheep wandering around in the work area.

WORK AREA

- The work area should be concrete that is smooth enough to enable washing, but not so smooth so as to become slippery when wet.
- The distance between the handler and the isolation pen should be close enough to carry a sheep from the handler into the isolation pen without too much effort.
- There needs to be a good water supply for washing down the work area during the day. Hoof trimmings can build up on the concrete and are slippery to walk on, especially when sheep are being carried into the isolation pen.
- The area should be designed to allow sheep to flow from the wash bath, past the handler, into the footbath during routine footbathing.

FOOT-PARING GEAR

- Each person should have his / her own pair of footrot shears and a knife, and they should be responsible for maintaining the gear all year round. Commonly, foot-paring gear is ignored between footrot challenges and becomes blunt, broken or lost.
- Allowing the staff to purchase and maintain their own gear is a good incentive to look after it. Often the “cheap” gear is cumbersome to use, becomes blunt quickly and breaks. Investment in more expensive, better quality gear is common sense.
- Suitable sharpening tools should always be available during inspection procedures for both footrot shears and knives. All staff should know how to sharpen the gear.

ISOLATION PEN

- Only marking the Not Clean sheep, and drafting them out at the end of the day, presents a risk for a mix-up between Clean and Not Clean sheep during the day. A system that removes the Not Clean sheep immediately after diagnosis minimises this risk and ensures strict adherence to the isolation principle.
- The isolation pen is a small yard behind the work area. It should be designed so that the Not Clean sheep can be removed from the handler without contamination of the work area and without too much effort. Removing the top rail reduces the effort required to lift the sheep into the isolation pen.
- The Not Clean sheep should stay in the isolation pen until they can be shifted to the isolation paddock (done as the last task for the day).

TREATMENT FOOTBATH

- The most expensive aspect of an ongoing management programme is the time and chemical spent on footbathing. A large, well-designed footbath is very important for reducing the time factor. A roof over the bath will reduce the need to add more chemical after rain.
- Footbaths should be centrally divided into two independent baths with a connecting bung in the centre ledge (Fig. 25). One bath can be used when smaller numbers are to be treated. For whole flock treatment, the bung is taken out so that the solution is common to both baths.

Figure 25. *Footbath built into the sheep handling facilities.*

- The size of the bath will depend on the number of sheep on the property. As a guide, one square metre will hold 3-4 adult sheep with 3-4 month's wool. Footbaths that can hold 150-200 sheep are common on large properties.
- As with the wash bath, when the sheep are in the bath, the level of the solution should be just over the top of the coronet. If it is too deep, the wool gets wet and removes too much of the solution.
- The floor of the bath should be gently sloped towards a large outlet to allow drainage and cleaning.
- The entry and exit gates should be the same width as the bath to make sheep movement easier.

- At the exit, a sloping concrete pad approximately two metres long will reduce chemical wastage by draining run-off back into the bath (Fig. 26).

Figure 26. *A covered footbath outside the yards. Note the concrete exit pad.*

- It is very important to ensure that the sides and gates are below and inside the raised edges of the bath to prevent sheep resting their feet outside the solution. If corrugated iron is used for the sides, make sure that the edges will not cause injury.

Figure 27. *A large footbath for preventive footbathing on an extensive Merino property, located in the middle of the property to reduce mustering time.*

ISOLATION PADDOCK

- This paddock should be near the yards. No other sheep should pass through the isolation paddock during inspection, or for at least 14 days after completion of the inspection process. A dry paddock will help to reduce the severity of lesions in the sheep while they wait for their treatment process.

THE ACTION PLAN

The action plan is based on a systematic strategy to address specific priorities. Adherence to the timeframes, and focusing on the priorities, will determine the success of the programme.

CONTROL PHASE

ASSESS THE CURRENT SITUATION

IS FOOTROT ACTIVELY SPREADING?

YES

CONTROL/REDUCE THE INCIDENCE

- Footbathing.
- Vaccination.

NO

NO

INCIDENCE LESS THAN 20%

YES

MANAGEMENT PHASE

1ST INSPECTION **DATE:** _____

CLEAN MOB

- High priority.
- Put the Clean Mob onto pastures that have not been grazed by sheep for at least 14 days.
- Do NOT use prevention measures (footbathing or vaccination).
- Focus is on exposing hidden infections.
- Observe every 2-3 days.
- Remove any affected sheep (OID or footrot) and place in the Treatment Mob.

TREATMENT MOB

- Lowest priority.
- Keep the Treatment Mob isolated from the Clean Mob.
- Do not treat the Treatment Mob until the Clean Mob is clean.
- Cull as many infected sheep as possible.

INSPECTION OF CLEAN MOB

- Within 4 weeks of the 1st inspection.
- High priority.

DATE: _____

TREATMENT

- Footbathing:

DATE 1: _____

DATE 2: _____

DATE 3: _____

- Antibiotics

KEEP THE CLEAN MOB CLEAN

- High priority.
- Put the Clean Mob onto pastures that have not been grazed by sheep for at least 14 days.
- Surveillance.
- Preventive footbathing (with or without vaccination).
- Keep isolated until the next annual inspection.

INSPECTION OF TREATMENT MOB

- 30 days following treatment.

DATE: _____

ANNUAL INSPECTION AT WEANING

DATE: _____

CURED MOB

- Keep the Cured Mob isolated from the Clean Mob until the next annual inspection.
- Preventive footbathing (with or without vaccination).

CULL NON-RESPONDERS

ASSESS THE CURRENT SITUATION

The programme can start at any time of the year and the approach will be determined by the situation at that time. Generally, most programmes begin during or near the end of a challenge period, when the incidence of footrot is high.

The feet of a representative sample of 10% of the mob should be carefully inspected and all lesions scored. If lesions with scores 0, 1, 2, and 3, as well as score 4 are present, then the disease is still actively spreading. If lesions with only scores 0 and 5 are found, without scores 1, 2, 3 or 4 then the disease is not actively spreading.

To estimate the incidence of footrot, use the following formula:

$$\%\ \text{of sheep affected} = \frac{(\text{Number of sheep with at least one foot-score of score 2 or greater}) \times 100}{(\text{Number of sheep examined})}$$

THE CONTROL PHASE

The control phase has two different but important aspects:

WHEN THE DISEASE IS ACTIVELY SPREADING

It is unrealistic to expect a significant reduction in the number of infected sheep during a challenge period. When footrot is actively spreading (sheep with scores 1, 2, 3 and 4 are present), the objective is to stop the outbreak getting any bigger.

Regular footbathing in 10% zinc sulphate, with or without vaccination, should be implemented. The key objective is to reduce the number of new infections. Time spent in the zinc sulphate solution will depend on the numbers of infected sheep and the range of lesions (refer to Chapter 7 and the section regarding footbathing).

Vaccination combined with footbathing is a good option when the challenge period is likely to persist for more than four weeks. However, unless the sheep have already been sensitised there will be a 4-6 week delay before any advantage is gained from the booster vaccination. The benefits of vaccines are limited if the challenge is high and a large proportion of the lesions are score 3 and 4.

WHEN THE DISEASE IS NOT ACTIVELY SPREADING

When footrot is not actively spreading (sheep with only scores 0 and 5 are found – no sheep with scores 1, 2, 3 or 4), the objective is to reduce the incidence of footrot to 20% or less before the inspection process is started.

Inspecting feet and separating sheep into clean and infected mobs should not be considered when the disease is actively spreading or when the incidence is greater than 20%.

If the incidence is greater than 20%, footbath the whole mob in 10% zinc sulphate three times, at 7 day intervals. Note that this incidence is greater than that recommended by Beveridge.Paring the feet is not warranted. The aim is to quickly reduce the number of infected animals to a more manageable level, so that the first inspection can start as early as possible, ensuring that there is time to do the second inspection before the onset of the next challenge period. Time is better spent footbathing than paring feet. A cure rate of 60-70% is a reasonable expectation, as long as feet are not too overgrown.

THE MANAGEMENT PHASE

The objective of the management phase is to have the Clean Mob clean and isolated from the Treatment Mob before the onset of the next challenge.

It is important to set realistic and achievable objectives. Achievement of the first objective will remove the source of re-infection from the Clean Mob. There may still be infected sheep on the property but, as long as they remain isolated, they will not re-infect the Clean Mob.

FIRST INSPECTION

When the disease has stopped spreading (usually mid-winter and early summer) and the incidence is less than 20%, the inspection process can begin. The objective of the first inspection is to find the sheep that have four clean feet (these sheep will become the Clean Mob), and to isolate them from the Not Clean sheep as soon as possible. The inspection procedure must be regarded as a diagnostic process and the key is to make a diagnosis of a clean foot. By definition, that means any sheep that does not have four clean feet is regarded as Not Clean. A number of the Not Clean sheep will, in fact, not be infected, but it is a more effective risk management strategy to take out all the doubtful sheep and deal with them during the treatment process.

The inspection procedure is all about finding the sheep with four clean, normal feet.

The concept of diagnostic paring is important. There is absolutely no advantage in making the hoof bleed. Diagnostic paring is an art and requires training, sharp gear and practice!

During the inspection process, paring of each hoof must be restricted to no more than 4-5 actions with the footrot shears and knife.

With the footrot shears:

- Remove excess lateral wall.
- Remove excess heel.
- Remove excess toe.

With the knife:

- Check for lifting and infection at the axial grooves and heels (see Figure 7, Chapter 3).

Feet that require more paring than outlined above are Not Clean. These sheep present an unacceptable risk to the Clean Mob. Further paring, to determine whether infection is present or not, becomes part of the treatment process of the Not Clean sheep (the Treatment Mob).

NOTE: The first inspection should not proceed unless the second inspection will take place:

- within the next four weeks; AND
- before the onset of the next challenge period.

If the second inspection cannot be completed by the start of the next challenge, it is better to remain in the control phase (see previous section). One of the most common reasons for programme failure is that there are too many infected sheep in the Clean Mob at the time of the next challenge.

Staff must be reminded frequently that they are NOT looking for footrot during this process, they are looking for four clean, normal feel. "If in doubt – OUT!"

ISOLATION

As soon as a foot is diagnosed as Not Clean, stop work on that sheep and place it in the isolation area. Do NOT continue to pare the sheep.

During the mob inspection process, the Not Clean sheep must stay in the isolation pen. At the end of the day, they can be moved to the hospital paddock area (becoming the Treatment Mob).

The Treatment Mob should be regarded as a low priority, at least until the second inspection of the Clean Mob has been completed.

MANAGEMENT OF THE CLEAN MOB

- After inspection, move the clean sheep from the handler to stand in 10% zinc sulphate for 30 minutes.
- Following footbathing, move these Clean sheep (the Clean Mob) onto pasture that has not been grazed by sheep in the previous 14 days.
- The Clean Mob should not be footbathed again for the next 3-4 weeks – any infected sheep must be given the chance for the infection to become more obvious (if OID or footrot become apparent, the affected sheep must be removed from the Clean Mob and placed in the Treatment Mob). If possible, run the sheep on lush, green grass, which may help to expose undetected lesions.
- Once the inspection process is finished, the number one priority is regular surveillance of the Clean Mob, at least every 2-3 days. Any lame sheep must be caught and the feet carefully inspected. If OID (score 2) or footrot (score 3 or 4) is present, the mob needs to be re-inspected immediately, and all sheep with OID or footrot removed from the Clean Mob and placed in the Treatment Mob. If possible, continue to run the sheep on lush, green grass, to expose undetected lesions.
- It is normal to expect 4-5% of the Clean Mob to still have footrot, despite rigorous inspection.

SECOND INSPECTION OF THE CLEAN MOB

The Clean Mob must be re-inspected 3-4 weeks after the first inspection, even if there have been no apparent breakdowns. This second inspection is a high priority. If more than 4-5% of the mob is Not Clean at this inspection, a third inspection may be necessary. Any sheep diagnosed as being Not Clean at this inspection need to be held in the isolation pen and added to the Treatment Mob from the first inspection.

MAINTENANCE OF THE CLEAN MOB

Following the second inspection, the objective is to keep the Clean Mob clean.

- Regular observation of the Clean Mob following the second inspection process must take priority over the Treatment Mob.
- Preventive footbathing, with or without vaccination, will help manage any risk of a breakdown, especially if too many Not Clean sheep were found during the second inspection (and a third inspection was not done).
- The Clean Mob must remain isolated until the annual inspection at weaning.

MANAGEMENT OF THE TREATMENT MOB

When managing the Treatment Mob, the objective is to have a Cured Mob after four weeks (culling any non-responders). The Treatment Mob must take second priority to the correct timing of the processes required to keep the Clean Mob clean. As long as the Treatment Mob is kept isolated, there will be no risk to the Clean Mob. Always try to cull as many infected sheep as possible.

TREATMENT

- Zinc sulphate footbath
  - Run the Treatment Mob through the wash bath and over the handler to pare excessively overgrown feet (the purpose is to improve access of the zinc sulphate to the infected area).
  - Footbath three times (at seven day intervals) in 10% zinc sulphate solution for 30 minutes each time. The treatment interval is critical – there is no need to treat more frequently, but intervals of more than seven days may compromise the cure rate.
- Antibiotics
  - Treatment with antibiotics may be an option, with or without footbathing.

INSPECTION

The sheep in the Treatment Mob should be inspected no sooner than 30 days after treatment, to provide enough time for cures to occur. The inspection of treated sheep is a difficult and tedious process. The objective is to look for cured feet, which after careful paring have no abnormal hoof tissue or pockets of active infection. Since these sheep are the potential source of the next footrot outbreak, accuracy of diagnosis is critical to success. Cull as many infected sheep as possible.

Figure 28. *Overgrown foot, shown after going through the wash bath.*

Figure 29. *The same foot pared with footrot shears.*

The importance of this inspection process is often undervalued, because too much reliance is placed on the treatment. However, no treatment will be 100% effective, which means that there will always be some sheep that are still infected.

At this inspection, every sheep that cannot confidently be called cured should be isolated and culled as soon as possible. These sheep present a risk for a breakdown in the programme and, if they are retained, then three separate mobs will have to be managed. This will increase the chances for mistakes.

The longer an infected sheep remains on the property, the greater the chance of a breakdown in the footrot management programme.

Following inspection, the cured sheep should stand in 10% zinc sulphate for 30 minutes and go onto pasture that has not been grazed for 14 days. This is the Cured Mob.

MANAGEMENT OF THE CURED MOB

Once the Cured Mob has been identified, the objective is to keep this mob isolated from the Clean Mob.

The Cured Mob is now the greatest risk for a breakdown in the management programme. It should be assumed that the infection is still present in the mob, despite treatment. Research has shown that relapses four to seven weeks after footbathing, in either formalin[1] or zinc sulphate,[2] can occur in what were regarded as cured sheep. *D. nodosus* has been found in the interdigital skin of what appeared to be completely cured feet several weeks following treatment.[3]

The Cured Mob should remain isolated from the Clean Mob until it has successfully passed through a significant challenge period without breakdown, or until the next annual inspection. Careful planning and attention to detail become important over the ensuing months. All staff must recognise the importance of the Cured Mob as a risk for breakdown and understand the consequences of any mistakes.

Regular surveillance and preventive footbathing of the Cured Mob is important. However, this must take second priority to keeping the Clean Mob clean.

Lambing can present some challenges with regards to keeping the two mobs separated. Ewes that are mothered-on must be returned to their respective mobs without cross-contamination. If there is any doubt, the ewes should always be returned to the Cured Mob. Every effort has to be made to get things right before lambing. If a severe spring challenge is expected and / or there is doubt that the Clean Mob is still clean, this may include the judicious use of flock vaccination.

ANNUAL INSPECTION

The annual inspection is a fundamental part of the overall footrot management programme. All the feet of all the sheep must be inspected as soon as possible after weaning. The objective of the annual inspection process is to go into the autumn with the situation under control. This means having the Clean Mob clean and isolated from the Treatment Mob or the Cured Mob before the next challenge.

The timing of the annual inspection is critical. If weaning is delayed it is likely that the inspection process will still be going on when the autumn challenge starts. This will interfere significantly with an effective footrot control programme.

Many control programmes break down after a few years. The incidence of lame sheep will have become consistently low and it becomes too easy to believe that footrot is no longer a problem. Footrot management takes a lower priority, shortcuts are taken, and the first omission from the programme is the annual inspection. Over the next 2-3 years, the prevalence builds up again until there is a significant outbreak during the next severe challenge period.

Even with a very successful intensive programme, *D. nodosus* is likely to always be present, so there will always be a risk of a breakdown.

The length of time the intensive control programme is followed depends on the number of infected sheep, the environmental conditions and the commitment to eradicate. Where the initial level of infection is high, it may take several years to achieve the objective – no sheep with clinical footrot on the property.

CHAPTER 13
ERADICATION

AN ERADICATION PROGRAMME

The objective of an eradication programme is to completely eliminate *D. nodosus* from the flock and property. A new set of management and risk factors must be carefully considered before the decision is made to commit to eradication.

There are two options for an eradication programme:

- Total destocking of the property and waiting at least 21 days before restocking the property.
- Eradication of footrot from the existing sheep on the property.

OPTION 1

If the property is to be completely destocked, and then restocked with sheep that are footrot-free, the following factors need to be considered:

- What is the cost of the destocking option in terms of genetics?
- What is the probability of restocking with sheep guaranteed to be free of *D. nodosus*?
- Destocking includes both goats and sheep.
- The property should not be restocked for a period of at least 21 days.

OPTION 2

Eradication of footrot from the existing flock should never be considered until:

- the incidence of footrot in the flock has been sustained at less than 5% for at least one year (including a reasonable challenge period);

AND

- all the risk factors for re-introduction of infected sheep and goats have been addressed (see below).

No routine measures (for example, footbathing or vaccination) can be used leading up to, or after eradication has been achieved, as they may mask potential breakdowns. Any infected sheep must be removed from the property immediately – treatment is not an option in an eradication programme.

Adequate control of footrot means having no clinical cases of disease within the flock, or getting rid of 99.5% of the problem.

Eradication means eliminating the last 0.5%

ERADICATION RISK FACTORS

Eradication presents a range of new risk factors, because the source of reinfection becomes external instead of internal, and all on-farm preventive measures (such as footbathing and vaccination) have ceased.

Risk factors to be addressed include:

- The footrot status of the property's immediate neighbours.
- Uncontrolled goats on the property (or on neighbouring properties).
- Are the property's boundaries sheep and goat proof?
- Whether staff can be trained to recognise the importance of, and abide by, the risk management procedures.
- Whether neighbours can be trusted to abide by the risk management procedures.
- The consequences of a breakdown.
- Whether a breakdown can be managed immediately, at any time of the year.

ERADICATION PROCESS

The focus of the eradication process is on exposing any hidden footrot infections, and removing the infected sheep from the property immediately. For eradication to be successful, footrot infection cannot be treated, but must be eliminated completely.

DURING A NON-CHALLENGE PERIOD

The eradication process depends on careful inspection of the Clean Mob, and at least one or two re-inspections, during a non-challenge period. After each inspection, the Clean Mob must NOT be treated with any preventive measures. Every opportunity must be taken to promote the progression of any hidden infections. Regular surveillance is extremely important to detect any new cases. As long as there is no active challenge, there will be little risk of the disease spreading to other sheep.

Absolutely no preventive methods can be used, as they may mask potential breakdowns.

THE NEXT CHALLENGE PERIOD

Before the next challenge period a very important decision must be made:

Is the property in a position to stop all routine preventive procedures, without risk of a serious breakdown during an active challenge?

The eradication programme has been successful when the flock has gone through at least two challenge periods without a breakdown. At this point, a new set of factors need to be addressed to ensure the property remains footrot-free.

Eradication means taking every opportunity to promote the progression of hidden footrot infections.

All infected sheep must be removed from the property immediately. Treatment is not an option.

MAINTENANCE OF FOOTROT-FREE STATUS

The risk of a breakdown in a footrot-free flock is associated with *D. nodosus*-infected sheep or goats entering the property. These animals may not necessarily be lame.

The consequence of a breakdown can sometimes be catastrophic, due to a low level of natural immunity to footrot in the flock.

RISK MANAGEMENT STRATEGIES

- Regular staff training and updating staff on risk management procedures.
- Breeding for increased footrot resistance / tolerance.
- Not bringing any sheep onto the property from external sources. If rams must be purchased from a property that is not footrot-fee, then a quarantine paddock needs to be set up for the rams. On arrival, all new rams must be carefully inspected. Any rams that are not absolutely clean must be disposed of immediately. All the clean rams should be moved into the quarantine paddock and must remain isolated until they have gone through a significant challenge without developing footrot. The quarantine paddock should present a high challenge environment by ensuring that the feet are kept moist for at least 4-6 weeks at temperatures around 20ºC.
- Ensuring that no other sheep enter the quarantine paddock at any time of the year.
- Regularly inspecting and maintaining all boundary fences, especially before the onset of a challenge period.
- Regularly looking for, and promptly removing, any other sheep or goats. Staff must know that nothing is more important than catching any “straggler” as soon as it is seen.

- Maintaining an excellent relationship with all neighbours, asking them to deliver all "stragglers" directly into the shed.

RESPONSE PROCEDURE TO A SUSPECTED OUTBREAK

Ensure that the suspect mob is completely isolated from all other sheep on the property, and examine 10-20% of the mob (preferably in the paddock they are in). For diagnosis, refer to chapters 3 to 5.

If signs of footrot are obvious:

- Ideally, arrange for immediate removal of the mob from the farm.
- If immediate removal of the mob is not possible:
  - Yard the sheep, ensuring that they do not move over ground where other sheep will move within the next 21 days.
  - Carefully inspect all sheep. Clearly identify all suspect sheep and keep them in the yards. Take samples to confirm the diagnosis, if required.
  - Remove all suspect sheep from the property immediately.
  - Treat all other sheep with antibiotic or footbath in 10% zinc sulphate for 30 minutes.
  - Return treated sheep to the paddock they came from.
  - Observe daily for signs of lameness.
  - Re-inspect the mob before the next challenge period to ensure that no suspect sheep remain.
  - Continue complete isolation of the suspect mob until it has gone through a challenge period without a breakdown.

If signs of footrot are not obvious:

- Keep the suspect mob completely isolated from other sheep on the property.
- Maintain a strict regime of observing the sheep for signs of lameness.
- Inspect all sheep in the mob, preferably in the paddock, before the next challenge period.
- Do not mix the suspect mob with other sheep until the mob has gone through a challenge period without a breakdown.

CHAPTER 14
NEW ENTRANTS

MANAGEMENT OPTIONS FOR NEW ENTRANTS INTO THE FINE WOOL INDUSTRY

Growers who are considering entering the fine wool industry are strongly advised to prepare for footrot management before the introduction of Merino or mid-micron sheep onto their properties.

OPTION 1: AIM TO MINIMISE THE INCIDENCE OF FOOTROT

This is the most practical option for new entrants, unless the entire farm can be destocked of all sheep. It must be assumed that footrot exists in the sheep that are currently on the property, and that these sheep present a significant risk to the new, fine wool sheep.

Assuming that footrot will already be present on the farm, the overall aim is to minimise an outbreak in the fine wool sheep, by planning before they arrive. It is very important that the necessary planning and infrastructure is already in place, so that any outbreaks of OID or footrot can be efficiently and effectively handled.

PRIOR TO ARRIVAL

- Build a footbath (for details, refer to Chapter 12).
- Ensure that the pastures available for the new sheep have not been grazed by sheep for the previous three weeks.

ON ARRIVAL

- Inspect sheep and cull / isolate infected animals.
- Footbath all sheep in 10% zinc sulphate for 30 minutes.
- Put the sheep onto pasture that has not been grazed by sheep for the previous three weeks.

MAINTENANCE

- Regular observation of all fine wool mobs. At the first sign of lameness, follow the guidelines set out in the action plan in Chapter 12.
- Plan for the fine wool sheep to always go onto pastures that have not been grazed by other sheep for at least one, preferably two weeks.
- Regular footbathing, especially during the challenge seasons.
- For breeding ewes, consider sensitising with Footvax® on arrival (for more information, refer to Chapter 8), and annually sensitising replacement two-tooths. Be prepared to give a booster vaccination prior to an expected outbreak.

OPTION 2: AIM TO STAY FOOTROT FREE

If no sheep are currently being farmed on the property, the following guidelines will assist in ensuring that the property remains footrot free.

PRIOR TO ARRIVAL

- Ensure that the property is destocked of all sheep and goats four weeks before the sheep arrive.
- Ensure that all boundary fences are stock proof against sheep and goats.
- Prior to transport from the source property, footbath sheep in 10% zinc sulphate for 30 minutes.

ON ARRIVAL

Inspect all sheep on arrival, BEFORE they go onto pastures.

If footrot is detected:

- Isolate any infected sheep (and preferably cull).
- Put the clean sheep into a quarantine area, preferably where there will be a footrot challenge.
- After 3-4 weeks, re-inspect the mob.
- If there are no new cases, sheep can be put into a new area. Avoid re-grazing the quarantine area for at least three weeks.

If footrot is not detected:

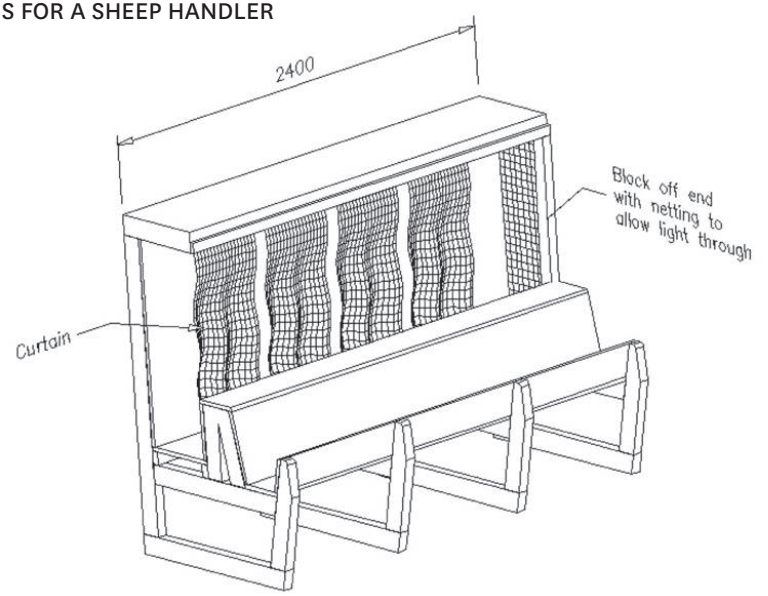
- Put the sheep into a quarantine area, preferably where there will be a footrot challenge.
- After 3-4 weeks, re-inspect the mob.
- If there are no new cases, sheep can be put into a new area. Avoid re-grazing the quarantine area for at least three weeks.

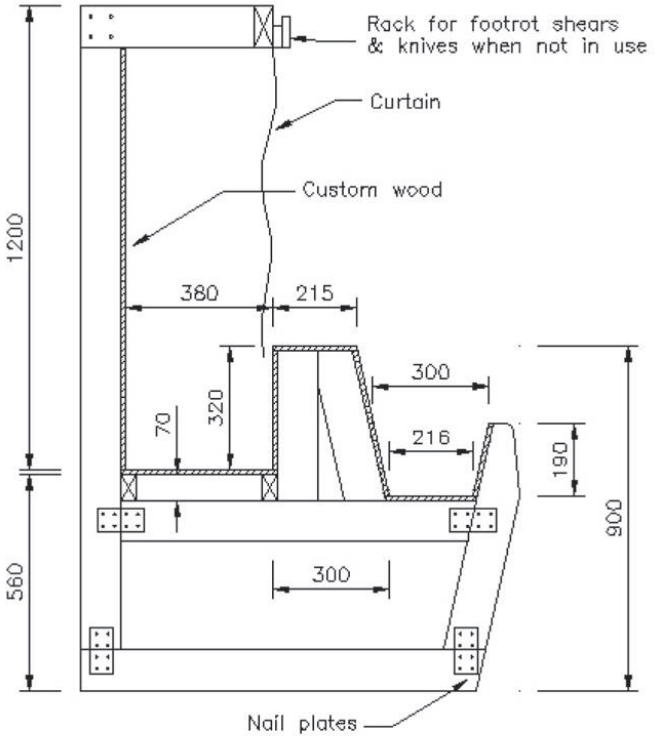
MAINTENANCE

- Refer to Chapter 13 – Eradication.
- Ensure that your neighbours do not return your stragglers directly to any of your pastures. Get them to contact you, so that the stragglers can be isolated and inspected (and treated or culled, if necessary).

APPENDIX

PLANS FOR A SHEEP HANDLER





NOTES

ENDNOTES

CHAPTER 1

[1] Beveridge (1941).

[2] Anon. (a) (1955).

[3] Anon. (b) (1983).

[4] Davies (2001).

[5] *Ibid.*

[6] Zhou (2001).

[7] Claxton & O'Grady (1986).

[8] Egerton & Parsonson (1966).

[9] Alexander (1962).

[10] Egerton & Parsonson (1966).

[11] Laing & Egerton (1978).

[12] Allworth (1995).

[13] Mulvaney (unpublished).

[14] Skerman (1983).

CHAPTER 2

[1] Beveridge (1941).

[2] Egerton *et al.* (1969).

[3] Beveridge (1941).

[4] Whittington (1995).

[5] Stewart *et al.* (1986).

[6] Schmitz & Gradin (1980), Claxton *et al.* (1983), Hindmarsh & Fraser (1985), Thorley & Day (1986), Kingsley *et al.* (1986), and Zhou & Hickford (2000).

[7] Schmitz & Gradin (1980).

[8] Egerton & Raadsma (1991).

[9] Emery et al. (1984).

[10] Parker (1985).

[11] Patterson (personal communication).

[12] Zhou (2001).

[13] Skerman & Moorhouse (1987).

[14] In Australia, it was found that there is some seasonal variation in the amount of monthly rainfall required for a footrot outbreak – at least 50mm during winter, 125mm during summer and 60mm during autumn. (Graham & Egerton (1968).

[15] Egerton *et al.* (1969).

[16] Graham & Egerton (1968), Beveridge (1941).

[17] Anon. (b) (1983).

[18] Beveridge (1941).

[19] Graham & Egerton (1968).

[20] Whittington (1995).

[21] Anon. (b) (1983).

[22] Scott & Henderson (1991), Anon. (b) (1983).

[23] Mulvaney *et al.* (1984).

[24] Malecki and Coffey (1987).

CHAPTER 3

[1] Winter (2004).

[2] Green & George (2008).

CHAPTER 4

[1] Most of the common conditions causing lameness in sheep are described in this chapter. For further reading, refer to Bruere & West (1993).

CHAPTER 5

[1] Zhou & Hickford (2000).

CHAPTER 6

[1] Jopp *et al.* (1984), Davies (2001).

[2] On Central Otago properties, the number of stock units per person used to range from 1666 to 1999 (Jopp *et al.* 1984). The trend towards fewer permanent farm staff numbers has limited the ability to manage footrot on many properties.

[3] Jopp *et al.* (1984).

CHAPTER 7

[1] Allworth (1995).

[2] Jopp *et al.* (1984).

[3] Ross (1983).

[4] Skerman *et al.* (1983b).

[5] Wassink *et al.* (2003), Green *et al.* (2007).

[6] Malecki & Coffey (1987).

[7] Skerman *et al.* (1983a).

[8] Skerman *et al.* (1983b).

[9] Demertzis *et al.* (1978).

[10] Banting (1979).

[11] Skerman *et al.* (1983c), Mulvaney (1999).

[12] Egerton *et al.* (1985).

[13] Cross *et al.* (1981).

[14] Rejas Lopez *et al.* (1999).

[15] Fraker *et al.* (1977).

[16] Banting (1979).

[17] Mulvaney (1999, unpublished).

[18] Egerton *et al.* (1968).

[19] Grogono-Thomas *et al,* (1994).

[20] Egerton *et al.* (1968).

[21] *Ibid.*

[22] Venning *et al.* (1990).

[23] Pfizer Animal Health, A2098 RVM.

CHAPTER 8

[1] Egerton (1970), Egerton & Burrell (1970), Egerton & Morgan (1972).

[2] MSD Animal Health Limited (ACVM Representation No. A1992)

[3] Mulvaney *et al.* (1984).

[4] Pfizer Animal Health (ACVM Representation No. A7302).

[5] Pfizer Animal Health (ACVM Representation No. A9122).

[6] Pfizer Animal Health (ACVM Representation No. A9659).

[7] Pfizer Animal Health (ACVM Representation No. A5979).

[8] MSD Animal Health advises that Eweguard vaccines and Cydectin Injection® should not be used in sheep that have previously been treated with Footvax®. MSD are not aware of any interactions when Footvax® is administered to sheep that have previously been treated with Eweguard vaccines or Cydectin Injection®.

[9] Meat processing companies may significantly discount carcass values that have been damaged following vaccination with oil-based vaccines.

[10] Reed (1986).

[11] Skerman *et al.* (1982).

[12] Mulvaney *et al.* (1984), Plant & Claxton (1986), Malecki & Coffey (1987).

[13] Liardet *et al.* (1986).

[14] Malecki & Coffey (1987), Mulvaney *et al.* (1984).

CHAPTER 9

[1] Skerman & Moorhouse (1987), Patterson & Patterson (1991).

[2] Zhou (2001).

[3] Hickford (personal communication).

[4] *Ibid.*

[5] Greer (2005).

[6] *Ibid.*

CHAPTER 10

[1] Mulvaney (1984).

CHAPTER 11

[1] Marshall *et al.* (1991).

CHAPTER 12

[1] Plant & Claxton (1986).

[2] Atkins *et al.* (1986).

[3] Glynn (1993).

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UNLOCKING THE
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