Necrobacillosis and lameness in deer

Report from workshops

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August 2023

Funded by

Deer Industry NZ's Industry Capability Fund

DEER INDUSTRY NEW ZEALAND

CONTENTS

Executive Summary 4

Introduction 5

Workshop Attendees Experiences 5

1. Necrobacillosis in weaner deer 5
2. Foot and pastern infection in older deer 5
3. White line disease and abscess in stags 5

Predisposing Factors identified by attendees 7

Increased risk of outbreak 7

Decreased risk 7

In the literature 8

Potential on-farm actions suggested by attendees 9

Knowledge gaps and questions from attendees 11

Suggested areas for further investigation 12

1. Develop a deer lameness investigation protocol and work-sheet 12
2. Epidemiological study 12
3. Foot bathing trial 12
4. Faecal, environmental and foot cultures 12
5. Vaccines 13
6. Antibiotic efficacy 13
7. Environmental modification 13
8. Genetic susceptibility trial 13

Background information and literature review 14

Necrobacillosis 14

Species and strains of Fusobacterium 15

Synergy and other bacteria 15

Persistence and location of F. Necrophorum 16

Zoonotic potential 17

Antibiotic treatment **18**
Penicillins 18
Tetracyclines 18
Macrolides 18
Cephalosporins 18
Florfenicol (Nuflor) 18
Lincomycin/Spectinomycin 18
Clindamycin 19
Flouroquinolones 19
Aminoglycosides 19
Monensin 19
Other causes of lameness 19
References **20**

Executive Summary

Approximately 40 farmers and vets participated across two workshop sessions held in July 2023 to discuss deer hoof lameness.

Outbreaks of infectious lameness resulting in significant production losses, financial losses and farmer distress have occurred on farms over the past 20+ years. The frequency of these outbreaks appears to be increasing in recent years.

Three main presentations were discussed: acute lameness often resulting in death in weaner deer, similar to the well described "necrobacillosis" disease of deer and cattle; a more chronic but severe infectious foot lameness in adult deer (stags and hinds) resulting in weight loss and foot deformity with slow recovery; a white line type disease with foot abscess, primarily in adult stags.

Risk factors identified included: wet weather, weaning, transport, fighting, yarding, new animals coming onto the property, new concrete, mustering conditions, lanes, cutting feet on fencing wire, toe erosion on concrete yards, mud holes.

A list of potential management strategies was developed. These included: managing weaning, managing the environment to reduce the risk of foot injury, rapid and appropriate use of antibiotic treatment.

Several options for further research to fill knowledge gaps and guide better management decision making were proposed. These included an epidemiological study to identify risk factors more clearly and gain an understanding of the disease incidence, bacterial surveys to better understand which bugs are involved, when and how they are shed and where the reservoirs for infection are and work on foot-bathing, vaccines and antibiotic efficacy.

Introduction

Hoof lameness has been an ongoing concern for deer farmers for more than two decades with anecdotal reports of increasing incidence and severity in recent years. Several types of lameness have been described with the more serious being a condition called necrobacillosis which usually affects young deer around the time of weaning. This condition often involves a systemic infection leading to abscess in the lungs and liver of affected deer, resulting in rapid death. There appears also to be an increasing incidence of lameness in older deer with various presentations from severe hoof, coronet and soft tissue infection and damage to white line disease with abscess formation confined to the hoof.

Lameness, by its very nature is a painful condition. It is a serious welfare concern and major contributor to loss of production. Current knowledge and tools for prevention and management of lameness in deer are limited.

Two workshops were held during July 2023, attended by approximately 40 farmers and vets in total. During these workshops, the experiences of attendees were shared, current knowledge was discussed and knowledge gaps and further questions identified. A list of on farm actions that can be taken was developed and also a list of potential areas for future research to help understand the conditions and create more targeted prevention and treatment strategies.

This report summarises the current knowledge about necrobacillosis and other causes of lameness in deer and reports on the details of the workshop discussions.

Workshop Attendees Experiences

Farmers attending the workshops had experienced variable levels of lameness on their properties. Some have been dealing with issues for more than two decades while others have only had issues occurring recently. Where problems have been ongoing or large percentages of the mob have been affected, farmers are experiencing stress, financial loss and frustration at the lack of efficacy of different management and treatment options that have been implemented.

In nearly all cases, lameness occurred in outbreaks and tended to fall into one of three categories:

1. Outbreaks of necrobacilloisis in weaner deer resulting in lameness and death
2. Outbreaks of foot and pastern infection in adult deer, particularly stags but also in hinds
3. High incidence of white line disease and abscess of the hoof in stags

For each of the above presentations, the percent of deer affected in a mob ranged from five to 20 percent. There is more information and knowledge about the first condition, necrobacillosis, in deer than the other causes of lameness in older stags.

There was very little discussion about any other causes of lameness including overgrown feet or traumatic injury. Probably because these are one-off occurrences, easy to identify the cause and result in far less economic and welfare concern at the herd level.

The range of causes of hoof lameness in cattle have been well described. It is likely that a longer list of causes also exists in deer, but the feet are less commonly examined in detail compared to cattle. The author has also observed lameness due to laminitis from grain overload and overgrown and cracked toes in stags.

1. Necrobacillosis in weaner deer

1. Tended to occur around the time of weaning
2. Usually associated with yarding or trucking
3. Worse in wet weather, cases tend to stop with frosts.
4. Most cases autumn and early winter
5. Other risk factors identified were new concrete, exposed mesh, fence wires
6. Rapid spread in a mob and rapid progression to death
7. Good response to antibiotics if treated early, within the first 2 days
8. Poor response to antibiotics if left more than 3-4 days
9. High mortality rate if not treated
10. Foot lesions may be seen as tracking from the bottom of the hoof (often at the toe) or between the claws from moisture damage and injury.
11. Post-mortem abscesses in liver and lungs, sometimes without obvious lameness
12. Some people have had *F. necrophorum* isolated from these cases
13. Some reports that antibiotics are not working as well as they used to
14. Some good results with foot bathing, others found it was not helpful
15. Some good results from rubber matting in sheds, others still having problems despite matting
16. Very frustrating and stressful not being able to reduce losses with various preventative strategies

2. Foot and pastern infection in older deer

1. More common in stags but also in hinds
2. Spreads within a mob
3. Swelling and deformity of the foot and soft tissues often with bleeding and ulceration
4. Weight loss but not usually death
5. Poor response to antibiotics, although one farmer reported very good results with intramammary antibiotics inserted directly into the diseased foot tissues (usually between the toes).
6. Slowly comes right but some need to be euthanised due to severe hoof deformation and welfare concerns
7. Not necessarily associated with yarding or transport, has occurred in the paddock without any recent mustering.
8. Worse in wet weather, can occur at any time of the year

3. White line disease and abscess in stags

1. Under-running of the hoof wall and pockets of dark pus developing
2. One farmer culture negative for *F. necrophorum*
3. There was not very much discussion on this condition and further discussions are warranted.

Predisposing Factors identified by attendees

Several farmers remarked that they had not had any problems until it "came on" to the farm. There is a strong suggestion that necrobacillosis is an infectious condition that is carried by animals and that some virulent strains are not carried by all animals.

There were also strongly correlated environmental factors predisposing to an outbreak although it was often not possible to identify a specific cause. These predisposing factors included:

Increased risk of outbreak

- Wet conditions
- Weaning
- Transport
- New concrete in yards
- Exposed reinforcing mesh
- Cutting feet on fence wires coming into the yards
- Wet and warm
- Indoor wintering
- Fodder beet
- Stones
- Stags during the roar
- Bringing on weaners from certain breeding farms
- Moving weaners from breeding to finishing unit

Some form of breakdown of the skin barrier or hoof barrier is required for entry of bacteria to cause infection. This can be:

- Erosion and wearing off of the toe due to scuffing on concrete with dirt and manure tracking up the point of the toe
- Separation of the hoof wall from the sole and hoof structure due to wetting and sideways pressure on the hoof, potentially from fighting (stags)
- Excessive wetting between the toes
- Loading with faecal material and other bacteria that cause surface damage allowing entry of *Fusobacterium sp*.
- Penetrating wounds from sharp stones, stalky pastures, thistles, wires

Decreased risk of outbreak

The following factors were considered to be associated with reduction in infection:

- Rubber matting
- Footbathing
- Filling in mud holes
- Covering wires on fences leading into the yards
- Frosts
- Dry conditions

In the literature

Examples of predisposing factors identified in published reports.

An outbreak resulting in the death or euthanasia of the entire mob of 40 wild caught pronghorns occurred seven-days after **heavy rain**. Initially two animals died and were necropsied.

Two outbreaks in reindeer in Norway were preceded by **rain** and **warm weather** in late summer and autumn. (Handeland et al, 2010).

Gut upset (stress, change in diet) resulting in increased excretion of *F. necrophorum*, *F varium* and other gut micro-organisms. Alteration to the gut microflora increased fecal shedding of *F. Necrophorum* biovar A in mice (Smith and Thornton, 1993). The authors suggested that a similar situation could occur in cattle whereby disturbance of the normal gut microflora could result in increased shedding of *F. necrophorum*.

Increased rate of lumpy jaw caused by *F. Necrophorum* in white-tailed deer and mule deer in Western Canada was associated with **high stocking density**, **moving and handling animals**. **Lack of basic hygiene** measures and **bottle feeding of fawns** (Mainar-Jaime et al, 2006)

Hilson (2004) identified the following risk factors: Recently concreted holding yards (weaner deer x two farms), newly concreted yards (hinds), New rocks in forcing pens, running through frozen creeks on the way to the yards, potential for leg injury on netting as deer were running down straight lanes to the yards and pressure points occurring.

Potential on-farm actions suggested by attendees

- Rubber matting in sheds
  - Whole shed or at pressure points, especially exit from the shed, in crush
  - May get dirt and manure built up under mats. Either solid matting or material that can be lifted and washed underneath.

- Clean the shed
  - Reduce manure and bacteria load
  - Especially avoid boggy areas or standing water on yards

- Physical and visual barriers on fences leading into the yards
  - At pressure points
  - Stops wires going between the toes
  - Boards at eye level and lower down
  - Heavy fabric/scrim
  - Electrics on paddock fences
  - Move animals regularly to prevent fence-pacing

- Fill in mud holes
  - Could be an area where bugs are transferred from one animal to another and also cause wetting and hoof damage
  - They will dig new holes
  - Blood and bone in holes can deter deer from going into them

- Reduce weaning stress
  - Manage diet so that it is as consistent as possible
  - Maize grain or PKE pre- and post-rut
  - Wean onto familiar pastures
  - Probiotics, magnesium
  - Smaller mobs, reduce time in shed
  - Don't try to do multiple things at weaning (vaccination)
  - First vaccination on mum prior to weaning. Through shed with mothers

- Check paddocks for sources of injury
  - Hard stalky pastures, chicory stalk, thistles, stones, wires
  - Especially check around feeders

- Reduce pressure during the roar
  - Plenty of space
  - Not sparring on rough, hard, stony ground
  - Feed for distraction, eg lifted fodder beet
  - Branches/scrub to attack rather than other deer

- <u>Foot bathing</u>
  - Zinc sulphate every time they come into the shed
  - Long enough and deep enough to go over coronet of the hoof

- <u>Zinc sulphate around troughs</u>
  - There was no personal experience with this or trials

- <u>Antibiotics</u>
  - Early treatment is critical
  - Tetracyclines have traditionally worked if given early but some people report that they have been less effective recently
  - Ceftiofur (excede), Tilmicosin (TilmoVet) and licomycin/spectinomycin (Lincospectin) are also options that have worked
  - Intralesional (into the infected tissue between the toes) cloxacillin intramammary has been effective
  - Challenge for stags during the roar - dart guns

- <u>Isolate affected animals</u>
  - Outbreaks often occur in mobs and don't affect other mobs on the same farm even under the same conditions
  - Separating affected animals and avoiding yarding healthy mobs after infected mobs have been through the shed could help prevent spread of infection

- <u>Vaccines</u>
  - No current vaccines available in NZ
  - Can get import licence for Fusogard, which is a vaccine for Fusobacterium

- <u>Second set of eyes</u>
  - Vet or farmer with knowledge and experience to have an outside critical look at the whole situation to help identify risk areas that may have been overlooked

Knowledge gaps and questions from attendees

The following is a list of further questions asked by the workshop attendees:

- Why do we get outbreaks?
- What are the actual bugs we are dealing with in the different cases?
- Do all deer carry and shed the bacteria?
- What is the faecal excretion rate from healthy and stressed deer?
- What causes increased shedding?
- How long does it last in the soil?
- Is Fuso a secondary or primary invader?
- What is the involvement of other bacteria?

- Why does it seem to stop when the frosts start?
- Is there antibiotic resistance developing?
- Is there a genetic resistance or susceptibility to disease?
- Can other forms of antibiotic be injected directly into the foot lesions?
- Do feral deer carry it?
- What is causing foot injury in adult stags?
- Can we use different classes of stock to mop it up?
- Would probiotics reduce shedding?
- Do foot-baths work?
- Is using antibiotics in velvet stags an issue for velvet WHT?
- Does using single deck only on trucks during transport make a difference?
- Are there other factors with trucking that increase risk?
- Is the muck that accumulates under rubber matting an issue?
- Do Californian thistles injure the foot enough to create a point of entry?

Suggested areas for further investigation

1. Develop a deer lameness investigation protocol and worksheet

- Workshop with vets and experienced farmers to develop a deer lameness investigation protocol and worksheet. Trial it on farms and train vets on how to investigate lameness outbreaks on deer farms.
- This could help farmers identify potential sources of entry and risk mitigation options.
- This could also include foot scoring training whereby lame deer are sedated and the feet thoroughly examined by defects, points of entry of infection and the nature of the lesions. This should be done in older animals and young deer to identify the differences in the nature of the lesions.

2. Epidemiological study

- Use a combination of survey data and farm visits to collect data on the factors that may increase or reduce the risk of disease.
- This information would help develop better understanding of the risk factors and useful mitigations and help develop better lameness investigation protocols and management strategies. It could be used to rule out and rule in different options.
- This study would be best done alongside a bacterial survey study.
- A large amount of data would be required for statistical validity and to correct for confounding variables.
- This would be a good study for a PhD or masters student.

3. Foot bathing trial

- Foot-bathing is a common and effective method for reducing footrot in sheep and goats.
- There has been a single trial done using formalin foot-baths at a single time point. This trial did not show any benefit of the footbath in reducing the rate of subsequent infection.
- At least one farmer has reported excellent results with regular foot-bathing in zinc sulphate although others have not had similar success.
- A controlled trial using multiple and strategically timed foot-bathing with zinc or copper sulphate would help to determine whether the practice dies or does not add benefit.

4. Faecal, environmental and foot cultures

- A survey of bacterial shedding (*Fusobacterium* and potentially *Trueperella*) from faeces and on feet on diseased and healthy animals and in the environment would help to understand the pattern of shedding and sources of contamination.
- It would also give a better understanding of which bacteria are actually involved in the different presentations of disease.
- This study would be best done in combination with an epidemiological study that would also identify environmental and management changes, weather and outbreaks of disease and how these correlated with bacterial shedding and survival.

5. Vaccines

- A vaccine (Volar) was developed in New Zealand for use in cattle and deer but is no longer available. Trial data for the registration of this vaccine appears to be unavailable.
- Fusoguard is available oversees and can be imported under a special licence from MPI. This is not too difficult to get.
- The literature suggests that farm specific autogenous vaccines may be more effective due to the wide range of serovas that may be present.
- Woodbury and Chirino-Taylor reported variable results using Volar and Fusogard in white-tailed deer. They suggest that variable results may be seen where *A. Pyogenes* is the initial organism setting up conditions for establishment of *F. necrophorum*. They also suggest that autogenous vaccines may have better efficacy.
- The trial would involve working with a vaccine company and conducting a controlled experiment on farms with known issues.

6. Antibiotic efficacy

- Very little is known about the in vivo efficacy and distribution (pharmacokinetics and pharmacodynamics) in deer and no antibiotics are registered for use in deer in New Zealand. Thus they are all used off-label, usually at cattle dose rates.
- Culture and sensitivity testing in the lab would be a good place to start to ensure appropriate antibiotic selection. This would involve taking samples from infected animals and submitting for antibiotic sensitivity testing.
- In vivo testing would involve a controlled trial treating infected animals on the same farm with different antibiotics and monitoring for clinical cure rates.
- Intralesional antibiotic treatment should be included in this trial.
- As farmers would be treating with antibiotic under veterinary prescription anyway, this trial could be jointly-funded.

7. Environmental modification

- This work would require epidemiological data and bacterial reservoir data first.
- The bacteria are gut inhabitants that transfer between animals during the period that the bacteria exist outside the animal. Internal and external factors may be able to be modified through the use of probiotic or other biological agents that would decrease the excretion or environmental transmission of infection.

8. Genetic susceptibility trial

- Initially a survey study tracking the genetics of animals that do and do not develop disease within a mob. This could be part of the larger epidemiological study above.
- If a genetic trend is identified, further work could be done in conjunction with stud breeders to breed lines of deer that are genetically resistant to infection.

Background information and literature review

Necrobacillosis

Fusobacterium is a gram-negative rod-shaped obligate anaerobic bacteria that is a normal gut commensal and an opportunistic pathogen. This means that while it is present in the gut in the right location and in balance with other gut microbiology it does not cause disease. When it establishes in abnormal areas of the body through disturbance of normal barriers and immune system responses, it can cause severe disease. In these location, *F. necrophorum* is able to produce certain virulence factors (strategies for enhancing tissue damage and causing disease) which impede the immune response and cause cell death. (Necro = death).

Synergy has been demonstrated between Fusobacterium and other bacteria such that one can enhance the survival and replication of the other (Smith et al, 1991). For example, infection with *Staphylococcus areus* can cause tissue changes that decrease the number of *F. necrophorum* organisms required to establish infection and then the tissue damage done by the *F. necrophorum* can allow the establishment of other bacteria. It is probable that most infections are in-fact mixed infections and that control should be targeted at more than one bacterial species.

F. necrophorum has been associated with the following conditions and is considered a zoonotic disease risk (can be transferred from animals to humans).

- Liver abscess in cattle (particularly feedlot cattle) and deer
- Lung abscess in cattle and deer
- Necrotic stomatitis in calves
- Foot abscess in deer and cattle
- Foot scald in sheep and goats
- Thrush (infection around the frog of the hoof) in horses
- Lumpy jaw in white-tailed Deer
- Sudden death in a range of species, particularly deer
- Abscess in the rumen and intestines
- Abscess in joints and other organs
- Throat infections in people

Wild and farmed deer populations around the world seem to be especially susceptible to necrobacillosis.

Examples include foot infections in reindeer in Norway (Handeland et al, 2010), necrobacillosis in white-tailed deer in Peru (Elias et al, 2021), lumpy jaw in white-tailed deer and mule deer in Western Canada (Mainer-Jaime et al, 2007) and necrobacillosis in white-tailed deer in Canada (Woodbury and Chirino-Trejo, 2004). Necrobacillosis was the second most common cause of death after parasitism in farmed, mostly fallow, deer in Switzerland (Sieber et al, 2010). A severe case of foot abscess, lung, liver, rumen and cecum abscess and death was reported in 38/40 captive wild-caught pronghorn with the remaining two euthanised. (Edwards et al, 2001).

Species and strains of *Fusobacterium*

There are different strains of *Fusobacterium necrophorum* with biovar A the pathogenic strain (Smith and Thornton, 1993). Smith and Thornton (1993) found that only a small proportion of cattle excreted biovar A in the faeces whereas a large proportion had the organism present in the rumen contents. Biovar B however was often present in the faeces and bedding but is not thought to be associated with disease. On the cattle farm with animals excreting Biovar A, there was a history of necrobacillosis in calves and it was also found in bedding, whereas Biovar A was not found in the bedding on farms with no history of necrobacillosis or when it was not being excreted in manure.

Another Fusobacterium species, *F. varium* may also be an important consideration. Quantitive PCR methods used on samples to rumen contents of cattle with and without liver lesions was able to identify *F. necrophorum* subsp. *necrophorum* and also *F. varium* as having a higher prevalence in animals with liver abscess compared to another *Fusobacterium necrophorum* subsp, *funduliforme* (Deters et al ,2022). Liver abscess in feedlot cattle (Schwarz et al, 2023) found F. varium may be more important than thought. *F. varium* is commonly isolated from necrobacillosis cases in white-tailed deer in Canada (Woodbury and Chirino-Trejo, 2003; Chirino-Trejo et al, 2003). The latter authors also identified *T.pyogenes* in white-tailed deer with necrobacillosis.

F. varium has been found to be less responsive to antibiotics.

Diagnosis
Fusobacterium is more difficult to culture because it is an obligate anaerobe and need special transport and culture conditions. DNA tests have been developed using PCR and quantitative PCR and these have identified many different strains on Fusobacterium from animals on the same properties (Deters et al, 2022; Brooks et al, 2014)

Synergy and other bacteria

In most of the reported cases there has been mixed infection found in lesions involving both lameness and systemic abscess. The common bacteria found in association with Fusobacterium in cattle and deer include:

Trueperella pyogenes (formerly Arcanobacterium pyogenes)
Actinomyces bovis
Actinobacillus
Fusobacterium varium
Dichylobacter nodosus

There has been some discussion around which is the primary infectious organism, and which is secondary, however the relationship may not be so clearly differentiated.

Co-infection with *Actinomyces (Trueperella) pyogenens* or Staphylococcus aureus was found to greatly enhance the infectivity of *F. necrophorum* and reduce the infective dose required to cause lesions in mice (Smith et al, 1991). This is likely because the initial bacteria create tissue damage and anaerobic conditions allowing the entry and growth of the Fusobacterium. The strong necrotising (cell killing) factors and suppression of the immune cells exhibited by the Fusobacterium in turn allows other bacteria to establish deeper and larger purulent lesions.

While it has been believed that Fusobacterium which causes scald between the toes of sheep creates an environment for the establishment of virulent footrot caused by *Dichylobacter nodosus*, Whitcomb et al (2014) demonstrated that in fact it was the other way around and that primary infection with *D. nodosus* creates the conditions to allow *F. necrophorum* to establish.

The exact synergistic nature of the different bacterial genera is not well understood in deer and control should probably be targeted at more than one organism.

Trueperella pyogenes (formerly *Arcobacterium pyogenes*, *Actinomyces pyogenes*, *Corynebacterium pyogenes*)

This bacterium is also a common inhabitant of the gastrointestinal and respiratory tract of normal healthy animals that causes opportunistic infection when it establishes in abnormal parts of the animal or under certain conditions. It is often found in mixed infections with *F. necrophorum*. In cattle *T. pyogenes* is associated with metritis, mastitis, liver abscess and pneumonia (Rzewuska et al, 2019). *T.pyogenes* has been associated with meningitis, brain abscess, keratoconjunctivitis and foot abscess in several species of deer (Rzewuska et al, 2019) Fifty percent of mixed infection cases of necrobacillosis in white-tailed deer in Canada involved *Arcanobacterium* (*Trueperella*) *pyogenes* (Woodbury and Chirino-Trejo, 2004).

Antibiotic treatment of *T. pyogenes* is becoming more difficult due to developing resistance and while work has been done on developing a vaccine (Galán-Relaño et al, 2020), there no vaccine currently available.

The presence of *T.pyogenes* and *E.coli* can enhance the establishment of *F. necrophorum* allowing infection to establish with relatively fewer initial bacterial organisms.

Skerman TM (1983) isolated *Bacteroides (Dichylobacter) nodosus* from the feet of mature hinds and stags newly introduced to a property near Taupo. Lesions reported were similar to those often described with other foot abscesses.

Persistence and location of *F. necrophorum*

While it has been stated that Fusobacterium is present in soil and survives for long periods in the environment, the literature does not support this. It is likely that the primary reservoir for *F. necrophorum* is animals that are shedding the bacterium in the faeces or on diseased feet and not the environment, soil or pastures.

A detailed study that involved taking samples from the feet, mouths, faces and soil associated with sheep with footrot found that *F. necrophorum* was much more likely to be found in animals that in the soil (Cilfton et al, 2019). Sheep with diseased feet were more likely to have *F. necrophorum* on the feet than animals with healthy feet. Isolates in the mouth were commonly found but these were genetically different from the ones found on the feet. In this study *F. necrophorum* was rarely isolated from soil and when it was, it was in the surface layer from high stock traffic areas only.

Clifton et al (2017) also concluded that the environment was not a significant reservoir for *F. necrophorum* for infection of sheep and that it was instead primarily detected in and on the sheep.

Zoonotic potential

F. necrophorum and *F. varium* can cause disease in people. *F. necrophorum* is commonly found in throat infections however there is little information about direct transmission form animals to humans and this is unlikely to be a common route of infection.

Antibiotic treatment

Workshop attendees had tried a range of different antibiotics with variable success.

Penicillins

Penicillins are theoretically effective against *F. necrophorum* but may not achieve high enough concentrations for long enough at the site of infection after systemic (intravenous or intramuscular) administration. Ampicillin was highly effective against all strains of *F. necrophorum* and *F. varium* but penicillin was not effective against *F. varium* (Brooks et al, 2014). Two farmers have reported good efficacy with intra-lesional administration of the intramammary cloxicillin antibiotic "DryClox".

Tetracyclines

Oxytetracycline such as "Bivatop" have been the most commonly used antibiotic as a first choice for lameness and necrobacillosis. When used early in weaner deer at the first signs of infection, this antibiotic has been effective. Blanket mob treatment has been effective at preventing further cases in the mob.

Generally, oxytetracycline has been demonstrated to be effective against *F. necrophorum* but less so or variable efficacy against *F. varium.*

Macrolides

The macrolides are effective against *F. necrophorum* and concentrate in lung tissue. None of the macrolides were effective against *F. varium* in white-tailed deer in Pennsylvania (Brooks et al, 2014).

<u>Tylosin (TyloVet)</u>

Used in feedlot cattle as a prophylactic to reduce incidence of liver abscess caused by *F. necrophorum.* Prophylactic antibiotic use is discouraged in this country.

<u>Tilmicosin (TilmoVet)</u>

Some attendees reported good success with TilmoVet.

Tulathromicin (Draxxin)

Cephalosporins

<u>Ceftiofur (Excede LA)</u>

Several farmers had tried excede for the purpose of using a novel antibiotic when tetracyclines were not effective and also to take advantage of the persistent action (4 days) and low dose volume. This is particularly useful in velvet stags.

Florfenicol (Nuflor)

Florfenicol was effective in vitro in all 23 isolates of F, varium (n=18), F. n. necrophorum (n=2) and F.n. fundiliforme (n=3) in white-tailed deer in Pennsylvania (Brooks et al, 2014)
There are no florfenicol products for use in large animals registered in New Zealand

Lincomycin/Spectinomycin

A farm with 900 hinds, with up to 700 becoming lame after pregnancy testing had good results treating chronic cases with this antibiotic combination (Hilson, 2004)

Clindamycin
Not effective (resistance was present) against *A. Pyogenes* (Chirino-Trejo et al (2003)

Flouroquinolones

Enrofloxacin
Chirino-Trejo et al (2003) identified resistance to enrofloxicin and clindamycin in gram negative anaerobic bacteria isolated from white-tailed deer with necrobacillosis. They found antibiotic resistance in A. pyogenes to these antibiotics.
Twenty two out of 23 isolates of Fusobacterium from white-tailed deer in Pennsylvania were resistant to enrofloxacin (Brooks et al, 2014)

Aminoglycosides

Gentamycin
Not effective

Monensin

In feed additive (ionophor) Inhibits growth of Fusobacterium species. Could be considered during times of high risk. A long-acting bolus is available.

Other causes of lameness

Copper deficiency can cause osteochondrosis leading to lameness and limb deformity. (Thomspon et al, 1994; Audige et al, 1995)

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