Kellogg Rural Leaders Programme 2017

Preventing Pinkeye in young cattle.

Executive Summary

Infectious Bovine Keratoconjunctivitis (IBK) commonly known as Pinkeye in cattle is a long established animal health problem in New Zealand. Pinkeye is a painful and debilitating condition that can severely affect animal productivity. It is a bacterial infection of the eye that causes inflammation and in severe cases temporary or permanent blindness. Most cattle producers will be familiar with pinkeye but may not know how to best treat it and minimise its spread within the herd.

The economic impact of the disease is significant due to it being highly contagious. Pinkeye can affect up to 85% of a mob, the disease is painful because the eye becomes sensitive to UV light. Affected weaner calves losing up to 10% of their body weight. In rare cases when both eyes are affected cattle may die from starvation, thirst and accidents. The cost and time used treating infected cattle adds to the economic losses.

Managing an intensive large scale calf rearing farm in the Waikato, Pinkeye can be a challenge for the farm. Two of the three years the farm has vaccinated against the disease and one year we didn't vaccinate at all. In the year we didn't vaccinate against the disease there didn't appear to be any more infected calves than previous years. I wanted to know why?

Piliguard is the only commercial vaccine available in New Zealand. It covers three strains of Moraxella bovis bacteria. This is where the science community is in debate over the number of Moraxella's that exist. 38 strains of Moraxella have been identified by restriction endonuclease DNA analysis 'BRENDA' (R.B Marshall, P.J. Winter, B.S. Cooper, A.J. Robinson.1985) Other literature states there are only 7 strains that exist in New Zealand. What isn't in debate is the only vaccine available does not provide full immunity. Most would conclude that at best it covers half of them.

The use of antibiotics to treat infected animals is common practice. With a worldwide shift to reduce antibiotic use in the food chain and antibiotic resistance increasing, trying to find an alternative to injecting antibiotics is important.

It is a widely held belief by Organic American dairy farmers that supplementing kelp into the diet of cattle reduces the susceptibility to pinkeye due to increased Iodine levels in the tears. It was very difficult to find scientific evidence to support this argument. One study that took place last year at the University of Minnesota stated nothing was known about the Iodine concentration in tears and the conclusion was that cattle fed kelp (*Ascophyllum nodosum*) for 30 days and no effect on *Moraxella bovis (M.bovis)* bacteria, the main agent that causes pinkeye.

Five key findings are:

1. Vitamin A. I believe all farmers should supplement young animals with vitamin A from a young age. Very few currently do this. It appears calves not reared by cows are naturally deficient in vitamin A. It is thought that nutritional deficiencies specifically vitamin A, Selenium and Copper may contribute to Pinkeye. If any vitamin or mineral can be singled out and ranked, vitamin A is the most important. Vitamin A is important in the fight against disease it is extremely important in for vision and protection of the eyes. The immune function against viral, bacterial and parasitic infections. Virtually all immune cells are effected by vitamin A. This is sometimes referred to as the anti-infection vitamin. The younger the animal the sooner the vitamin deficiency with express itself. Young calves have lower body stores of vitamin A. Hot weather, disease, parasites and other stressors are believed to decrease the efficiency with which vitamin A is utilised.

2. Stress and the environment; this is a major contributor to Pinkeye. Dusty yards, heat, flies, thistles, large mobs of animals, lack of shading are all examples of environmental factors that can increase the onset of pinkeye. A good preventative plan should be mindful of these factors. Any stress weakens the immune system. In times of stress animals use up valuable vitamin and mineral reserves which reduce the efficacy of the immune system.

3. Kelp. The main question which drove this report was whether supplementation of kelp could improve the incidence of Pinkeye in calves. Although this is anecdotal I believe supplementing calves' diet with kelp which has over 60 vitamins and minerals would assist greatly in helping to replace valuable vitamins and minerals lost in stressful periods. Because kelp is a plant, it is in a highly absorbable and available form for cattle.

4. There is very little research on Pinkeye in New Zealand. Too little diagnostic testing is done in regards to Pinkeye. Gribbles Veterinary Laboratory who I spoke with said they would get less than ten eye swabs sent to them a year. There are nearly 10 million cattle in NZ, and veterinarians surveyed nationwide said about 10% of cattle develop the disease a year depending on the season. That means approximately that 1 million cattle contract the disease a year and veterinarians are sending in less than ten eye swabs a year. This simply isn't good enough. Until now differentiating between types of *Moraxella* has never been possible. This is about to change with a new qPCR machine which will enable the science community to learn exactly what bacteria's we are dealing with. And hopefully to develop a vaccine to cover all the strains.

5. Antibiotics. These are the only real tool we have in treating the disease. If the current antibiotics we are using to treat Pinkeye have a reduction in efficacy we will be facing a severe animal health challenge, which could possibly be avoided by further widespread diagnostic testing going forward.

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Foreword

I selected this research area for my Kellogg Rural Leadership project because as the manager of a large calf rearing business, animal health is the one of the most important aspects of my job. Being able to vaccinate for diseases is an amazing advance in modern medicine and while most vaccinations are very effective I wondered why when vaccinating for Pinkeye, we still had calves that contracted the disease.

I have managed the farm for three years now, two years the farm has vaccinated, one year the farm hasn't undertaken a vaccination programme. In the one year we didn't vaccinate I didn't see any more calves with Pinkeye than the previous years. This led me to wonder why. Was this just good luck we didn't have a large outbreak or good management - because we isolated the calves with physical signs of the disease and treated them promptly so to be prepared for the future in case we did get a large outbreak.

Also I wanted to know exactly why the vaccine didn't have a 97-98% efficacy like other vaccines. Discovering online that feeding kelp could prevent the disease, I wanted to find out more.

Acknowledgements

Would like to acknowledge my parents Julie and Fraser Moore for the help and support not just for the assignment, but for my education. Mum for driving me to SPELD lessons for all those years so I can actually produce a report.
My neighbours Cathryn Christie, the Otorohanga Vetora practice manager for all of the animal health discussions, your openness and friendship. Her partner Daniel Lund, you keep us amazed.

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1.Introduction

Any producer who has experienced a Pinkeye outbreak will be well aware of the discomfort and loss of performance that can occur. Every year producers can lose thousands of dollars due to: drop in milk production; labour in treating infected animals along with treatment costs; poor weight gains; and reduced prices due to scarring on the eye.

Pinkeye is a highly contagious and infectious disease. At the present time, it is not known if *Morexella bovoculi (M.bovoculi)* plays a primary or secondary role in the pathogenesis of IBK. (Anglelos, 2011). For a long period of time it had been thought the bacterium *M. bovis* was the primary cause of pinkeye. *M. bovoculi* can be isolated with or without *M. bovis* from eyes of cattle with IBK.
M. bovis can live on the legs of a fly for four days but it isn't known how long the bacteria can live on external surfaces. There is still a lot that isn't known about the disease. Infected cattle carry the disease in their eye secretions, nasal and vaginal discharge.

There are a lot of contributing factors involved with the disease Pinkeye. These include environmental factors like bright UV sunlight, conditions in the paddock like thistles, long stalky grass, dust and overhead hay feeders. Nutritional deficiencies also play a role with vitamin A, and the minerals copper and selenium. A high concentration of face flies, breeds of cattle lacking eye pigment and young cattle as well as compromised immunity from other viruses such as BVD.
Coming up with one solution is difficult because of all the contribution factors. At present Pinkeye is not a preventable disease. Isolation and a swift reaction are keys in reducing the spread of the disease.

2. Purpose of the research

The aim of the project is to investigate alternative treatment options for Pinkeye. A lot of the research regarding Pinkeye is from the 1970 and 1980s. The current treatment options used today by veterinarians around New Zealand will help producers best treat cases of Pinkeye and reduce its spread.
Are there other options other than the vaccination in trying to prevent the disease? Investigating why the vaccine has such a low efficacy rate compared to other vaccines.
Is prevention better than cure, when trying to reduce the antibiotic use in the food chain. Can cattle be fed a natural supplement to prevent the disease? What animal management practices can be introduced to prevent outbreaks of this highly contagious disease.

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Unfortunately because of the scale of calves reared on the farm- I can't have the calves on the farm looking as cool as these calves, in their protective fly masks! (Google Images, 2017)

1. *Methodology*

Following the literature review, interview questions were developed in order to determine how different farmers have dealt with outbreaks and management techniques used to control outbreaks. Veterinarians were also interviewed from around New Zealand to gauge any new treatment techniques. Five veterinarians in the North Island and five in the South Island took part in the interview process. Semi-structured interviews were carried out mainly by phone and email, with interviews ranging from 15-30 minutes. Interviews were recorded through written notes.

4. Background and Literature Review

4.1 History

Pinkeye was not registered in New Zealand until about 1974 and the first cases were reported in the Gisborne area. Within three more years outbreaks of the disease had been reported further through Poverty Bay and in King Country, Waikato, Wairarapa, Manawatu and Horowhenua. The dramatic spread of the disease and the impact it caused in previously unexposed herds lead to the initial investigatory efforts.
It was considered important to obtain critical information about the disease in the field before infection had spread throughout the susceptible population.

The first survey carried out was confined to members of the New Zealand Hereford Cattle Breeders Association. A body whose members were aware of the importance of the disease elsewhere in the world and were keen to co-operate for the mutual benefit. The estimated incidence for farms being defined as at least one episode of the disease since 1975 was 24%. Pinkeye is a multifactorial disease and although *M. bovis* is considered to be the main definitive cause for it, there are many factors that add to the virulence which allow it to invade the cornea. In addition, other bacteria have been isolated from eyes infected with IBK and been absent of *M. bovis* indicating that other bacteria maybe a primary pathogen in some cases of IBK. These include *M.bovoculi*, *Moraxella branhamella ovis*, *Branhamella catarrhalis*, *Pasteurella multocida* and *Mycoplasma bovoculi*, cannot be discounted (Sarginson, Hunter, West & Gwodz, 1996).

Other environmental factors may be necessary for the development of the disease. *M. bovis* infects the eye and produces a toxin, the toxin attacks the surface of the eye (cornea) and the surrounding membranes (conjuctivae), eroding the surface and causing severe inflammation. One culture of *M. bovis* resulted in 38 strains being identified in New Zealand with some being more damaging than others. (Marshall, Winter, Cooper & Robinson, 1985).

A total of 94 strains of *M. bovis* have been identified by bacterial restriction endonuclease DNA analysis (BRENDA). These strains were made up of isolates from the USA and the UK, in Australia and a number of widely separated areas in New Zealand. The strains are classified into a total of 26 different types on the basis of their BRENDA patterns. Fourteen types were present amongst 34 strains from the USA. Eight types from 17 strains in the UK. Three types from five strains in Australia. (Marshall, Winter, Cooper & Robinson, 1985).

4.2 Occurrence

Pinkeye is mainly a disease of young cattle commonly occurring in their first summer. Severe outbreaks may occur in older cattle if they have never been exposed to the disease. After infection, cattle develop a temporary immunity which lasts up to a year. Exposure to the causative agents in following years gives further immunity, usually without eye changes being obvious. (Walker, 2007).

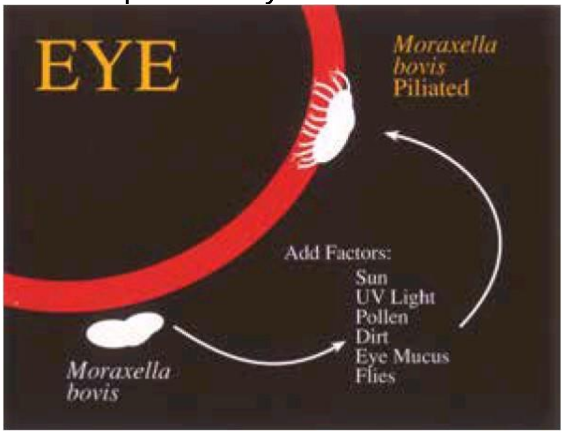
Infection can occasionally persist in a few animals and these are a source of infection in the following summer. The infection rate increases to a peak about 3-4 weeks after the first cases appear, and then gradually decreases. The prevalence of Pinkeye in districts and on individual farms varies from year to year, depending on seasons and weather, the fly population and whether cattle are grazing long grass. On some farms there may be only occasional cases while on others 60-80% of cattle may be affected in very severe outbreaks. In most years the average infection rate is 5-10% in New Zealand (Walker, 2007).

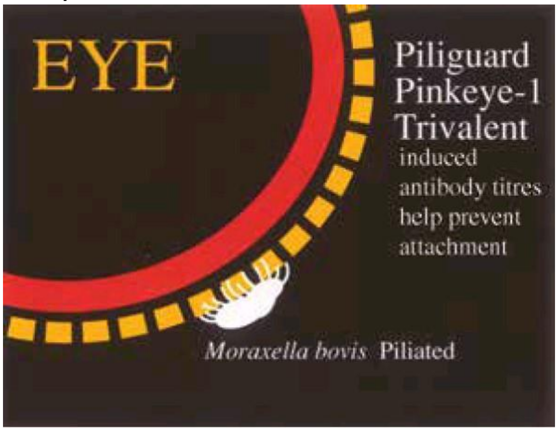
4.3 Vaccine

Piliguard PINKEYE-1 Trivalent Vaccine

This is the only commercially available vaccine against *M. bovis* in New Zealand. This is a single dose vaccine. The vaccine is formulated from three inactivated cultures of *M.bovis* isolates. This is sometimes referred to as a killed vaccine, the *M.bovis* bacteria have been grown in culture and then killed using a method such as heat or formaldehyde. As opposed to live vaccines, which are altered to become less virulent. These vaccines, in contrast to those produced by "killing" the virus (inactivated vaccine), use pathogens that are still alive (but are almost always attenuated, that is, weakened). Pathogens for inactivated vaccines are grown under controlled conditions and are killed as a means to reduce infectivity (virulence) and thus prevent infection from the vaccine.

The vaccine aids in the prevention of pinkeye associated with infection by *M.bovis* strains expressing pili (the hairs by which the bacteria bind to their host). Similar to those expressed by the isolates used in the production of the vaccine.





(Piliguard fact sheet, 2017)

Vaccination with Piliguard, which contains pilus antigen, blocks the attachment of bacteria to the cornea and prevents the establishment of infection.
Vaccines against Pinkeye have been developed but their success on farms has been variable. This is because there are 38 known strains of bacterium in NZ responsible for Pinkeye and they all have the ability to change when exposed to the vaccine developed.

The formulated vaccine focused on the bacterial pili. The different strains of *M. bovis* are identified by differences in their pili. The vaccine developed so far acts by binding to the pili, thus preventing them from binding to the host. If a vaccine is used to protect against only one strain, it is not effective against other strains because their pili are different. A successful vaccine must contain pili from each strain, and to date, pili from all strains have not been produced in quantities that would permit the commercial development of a multivalent pili-based vaccine.

One article states two functionally distinct pili have been identified. The Q pili is responsible for attachment and the I pili allows for local persistence and maintenance of an established infection. It is thought that bacteria possessing Q pilus can convert to I pilus during the course of the infection.
Haemolysins are enzymes produced by Pinkeye bacteria. They cause damage to the eye and are present in all the strains of Pinkeye. The so called haemolysin vaccine which is directed against the bacterial haemolysins rather than pili, has long been considered an alternative vaccine candidate; however, the lack of genetic information about haemolysins has hindered attempts to develop a vaccine based on this protein.

Studies taken out at the CSIRO Livestock Industries' Australian Animal Health Laboratory in Geelong showed that an experimental vaccine containing a partially purified haemolysin preparation protected against infection, whereas the placebo did not (Walker, 2007). Genes and proteins related to the functions of haemolysins have recently been identified in all strains of pinkeye, and a prototype vaccine formulation has been developed using three of these as antigens.

A statement from ***Addison Laboratories in Missouri, USA***, a diagnostic biological laboratory that specialises in vaccines including two different pinkeye vaccines.

1. MAXI/GUARD Pinkeye Bacterin – This product covers the bacterium that has long been the most common cause of pinkeye, *M. bovis*. This product contains eight different isolates of *M. bovis* and is considered the most effective vaccine against *M. bovis* here in the United States. Piliguard is also a *M. bovis* vaccine, but it only contains three isolates of M bovis. The effective rate here in the US for Piliguard is probably similar
to what you are finding in NZ. MAXI/GUARD pinkeye has traditionally achieved over 90% when the causative factor is *M. bovis*. *M. bovis* is a rod shaped organism.

2.*Moraxella bovoculi* Bacterin - This is Addison labs brand new product that was just launched this year. It is the first commercially available product for Moraxella bovoculi. Previously the only way to prevent the problem was through autogenous bacterins. This is where you culture breaking animals and grow a herd specific bacterin from the sample you collect. Addison Labs new product contains 8 different isolates of *M. bovoculi,* which is coccoid shaped (round). They started seeing *M. bovoculi* about 15 years ago through our diagnostic and autogenous work. As time passed, they saw an increase of *M. bovoculi* and its incidence rate has become very prevalent in the United States over the past five years and the bacteria is also present in New Zealand.

Gribbles veterinary diagnostic laboratory with three bases in the North Island and two in the South Island get very few swabs from eyes infected with pinkeye sent in for diagnostic testing. This means there is no current information on the prevalence of *M. bovoculi*. This is the strain not covered in the New Zealand vaccine.

"To date, the results of vaccine studies with *M. bovoculi* antigens have not indicated benefit from the use of such antigens in vaccines to prevent IBK. Vaccination of one at-risk beef herd with an autogenous *M. bovoculi* bacterin did not reduce IBK cumulative incidence. In another study, a recombinant *M. bovoculi* cytotoxin subunit vaccine did not reduce the cumulative proportion of corneal ulcerations associated with IBK. Nevertheless, there are anecdotal reports that vaccination of cattle with *M. bovoculi* bacterin has helped to reduce IBK in herds from which *M. bovoculi* was isolated. Such reports suggest that this organism plays an important, however, as yet undefined, role in the pathogenesis of IBK." (Angelos, John 2011)

4.4 Predisposing Factors:

Important factors that predispose cattle to infection include:

- Age of cattle: younger cattle are more susceptible to pinkeye than older cattle.
- Calves are more likely to develop the disease than adult cattle, as adult cattle appear to develop protective antibodies on the surface of the eye. Bull calves have a higher incidence of disease than heifer calves.

- Ultraviolet radiation (bright sunlight) can lead to conceal colonization of the bacteria. Looking under a microscope the cell shows damage caused by UV burning.
- Physical trauma such as blowing dust and sand, weed seeds and stubble, face flies, tail switching, antibiotic powders can scratch the cornea and allow entry of *M. bovis*.
- Chemical trauma such as fresh nitrogen on the pasture can burn the protective cell layer.
- Stress from weaning, commingling, transport, poor nutrition, parasites, and weather are just a few examples of stressors for cattle. Stress tends to decrease the animal's immune response to disease. (Arnold, M. Lehmkuhler,J, 2012)
- Viral infection (e.g IBR virus) is capable of damaging the protective cells covering the eye. Not only on the cornea but also on the eyelids. Mycoplasma, chlamydia, and *Branhemella ovis* will increase the incidence and severity of disease.

Pinkeye outbreaks are most frequently seen in summer and autumn when flies are more prevalent and ultraviolet radiation is high. This also coincides with the time when mature dry thistles and dusty conditions are more likely. The physical attributes of some cattle make them more susceptible to Pinkeye. For example animals with unpigmented eyelids and protruding eyes that are susceptible to damage are more prone to Pinkeye. Whereas hooded eye conformation which offers some protection from sunlight and physical damage may reduce the susceptibility to Pinkeye. British and European cattle are more susceptible to pinkeye than are Bos ondicus cattle. The white face of Herefords make them more susceptible. Adult cattle appear to develop protective antibodies on the surface of the eye.

4.5 Methods of spread

Pinkeye is present in a herd in the eyes of carrier cattle that do not show any clinical signs of the disease. Eye irritation from dust, bright sunlight, thistles and long grass can cause lachrymation (tear production) which attracts flies. The flies feed on the infected secretions and move from animal to animal spreading bacteria. Carriers may also carry the infection in the nose and vagina so that discharge from this area may also be a source of infection. It is not known how long *M. bovis* can survive in the body secretions or on environmental surfaces, but it has been known to survive for up to four days on the feet of flies and, therefore we should assume that all surfaces infected by contaminated animals (stock yards, clothing, stock trucks) are potential sources of the disease for at least several days. Due to how contagious pinkeye is, stock people need to be aware that contamination on their clothing, hands, drench gun and stock yards may be capable of transferring the infection.

Face flies are the main method of transferring Pinkeye. Cattle sneezing is also a method of spreading as cattle hold a large number of organisms in their nasal passages. Carrier animals can show no clinical signs of the disease, but shed the bacteria in their secretions. Carrier animals can shed the disease for sustained periods of time, they are an important factor in the spread of the disease and this is how the disease survives over the winter. The same strain can remain present on the farm from carrier animals from year to year. When the eyes of a carrier animal start excessive tearing, this is when the disease spreads.

4.6 Antibiotics

Antibiotic therapy is aimed at achieving drug concentrations in tears to meet or exceed the minimum inhibitory concentration for prolonged periods.
There are several methods of treatment. One of the preferred treatments is Orbenin eye ointment which must be purchased from a veterinarian. This is a long acting penicillin, first developed as a mastitis treatment for use into the udders of dairy cows. This has a nil withholding period when used in the eye. Unlike the use of it into the udder for mastitis. Application to the eye lasts about 48 hours. The ointment should be applied in the conjuctival sac- the space between the eyelid and the eye, by pulling the lower lid away from the cornea. If the animal is cooperative, apply the ointment under the upper lid also.

About one-quarter to one third of the tube is sufficient for each treatment. It isn't recommended that the ointment is applied directly to the central ulcer, because if the animal moves the point of the tube could rupture the eyeball. In the early stages, a single treatment maybe enough to halt the course of the disease. The long lasting effect of a single dose of Orbenin is the main reason for its recommended use. Topical application is easy to do, but it is difficult to maintain effective levels of topical antibiotic in the face of heavy tearing.

In a recent study published concerning the efficacy of tulathromycin, the results of treatment are documented. A group of calves with Pinkeye was treated and a group was left untreated as controls. The treated group responded, as evidenced by complete healing of eyes by various time after treatment. For example, over 40% had cured by day seven, over 50% by day 10, over 80% by day 12 and all by day 17. While a few untreated calves had self-cures, only 10% had cured by day 12 and 60% were still affected at day 20. (Whittier, 2007).

Other treatments such as oxytetracycline can also be effective, but these need to be instilled into the eye two to three times a day this is not usually practical. Powders should be avoided as can irritate the eye further. Intramuscular injection of antibiotic such as a long acting tetracycline, has the added advantage of helping to reduce the number of *M. bovis* in other tissues in the body - as well as the eye.

Large scale calf rearers who have experienced pinkeye outbreaks in the past: there is a significant price difference in the price of Orbenin eye ointment and Orbenin Dry Cow Therapy Treatment, both products contain the same antibiotic and some farmers are opting for the latter because of the economic benefits and anecdotal evidence reports that similar efficacy is achieved at a significantly reduced price.
Vitamin A can be injected. Nutritional deficiencies especially copper and selenium should be addressed.

4.7 Vitamin A Deficiency

"Vitamin A is probably the most important of all vitamins if any vitamin can be singled out and ranked." (M.Ensminger, J.Oldfield, W.Heinemann, 1990)
Vitamins like minerals are essential for cattle. There are two general classes of vitamins. These include the water-soluble and fat-soluble vitamins. The water-soluble ones include the B vitamins and vitamin C. Fat-soluble vitamins include A, D, E and K.

Since vitamin A is a fat soluble vitamin, it needs the presence of fat as well as activator ions or minerals for proper absorption through the digestive tract. Cattle can store it in their liver when their daily intake is 3 to 5 times greater than their requirements. Mature cows can store up to 4 months of vitamin A in their livers under plentiful conditions. Therefore under ideal conditions cattle fed good quality hay during the winter will have adequate vitamin A levels from carotene in hay and accumulated liver stores. Vitamin A is found in two forms, one called retinol (found only in foods of animal origin, including butter and fish liver oils) and pro vitamin A, or carotene found in plants.

Vitamin A is essential for the health of the epithelial tissue (cell wall), and is important in its protection, and the fight against disease. It is extremely important for vision and protection of the eyes, immune function against viral bacteria and parasitic infections. Also bone development and is associated with the maintenance of the protective mucus membranes of the respiratory and digestive tracts. Virtually all immune cells are affected by vitamin A. Vitamin A is sometimes referred to as the “Anti infection vitamin”.

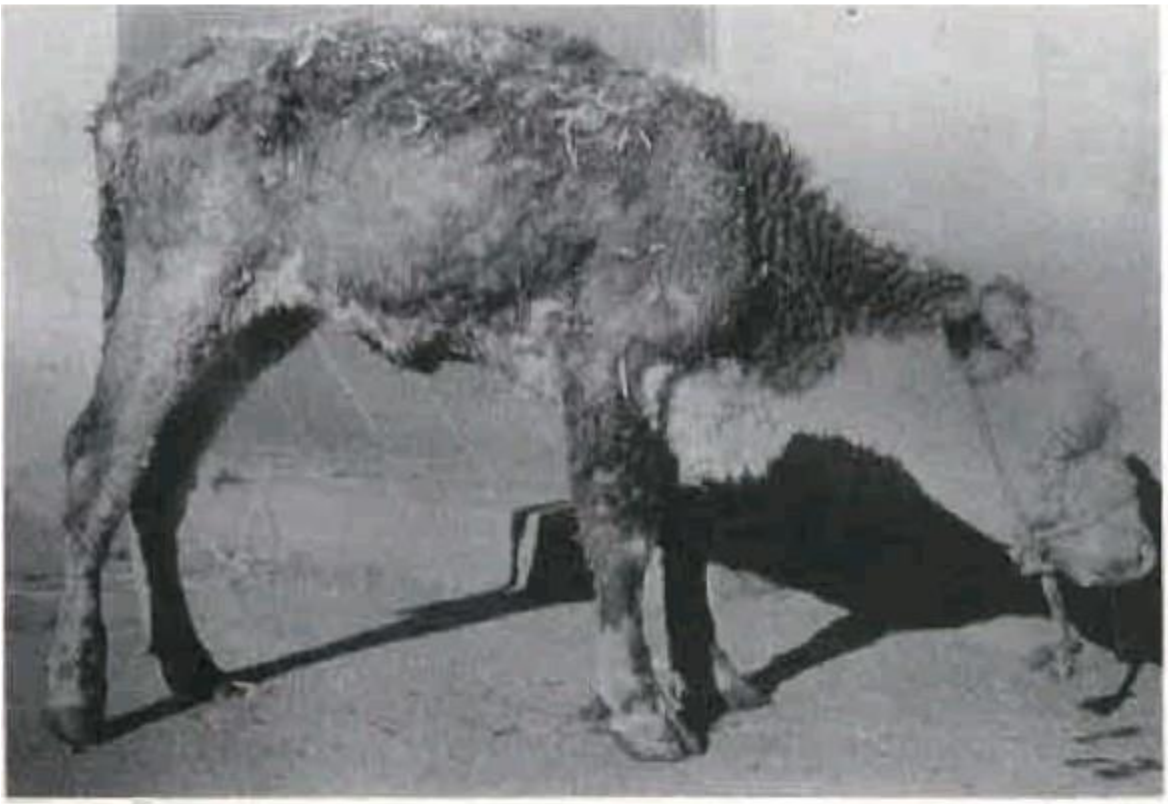


Fig. 4–73. Vitamin A deficiency in a calf. Note excessive watering of the eye (lacrimation), lethargic appearance, diarrhea, and signs of breathing difficulty. (Photo by Chas. Pfizer Co. Print courtesy of D. C. Church)

Photo Source: Feeds and Nutrition, 1990

If cattle become deficient in vitamin A, cells lose their round shape, become brittle and have lowered resistance to infection than normal. In extreme cases of deficiency, the eye forms a dry horny film over the cornea, resulting in a characteristic type of blindness. The younger the animal the sooner the vitamin A deficiency will express itself. Young calves have lower body stores of vitamin A. When deficiencies appear, they can be corrected by either increasing carotene intake, or by administering vitamin A by drench or injection. Vitamin A should always be given with vitamins D and E, and the element selenium. These are synergistic agents which enhance each other's performance.

Hot weather, disease, parasites and other stresses are believed to interfere with the animal's ability to convert carotene to vitamin A and to depress the efficiency with which vitamin A can be used to meet needs. Also, these and other factors may increase the animal's requirements for vitamin A. Inflammation and damage of the intestinal wall by diarrhoea or parasites undoubtedly interfere with the absorption of carotene and vitamin A and the conversion of carotene to vitamin A. (Sowell,H.B 1993). There is no scientific evidence supporting feeding excessive levels of any vitamin or mineral, including Vitamin A, to prevent diseases of the eye.(Arnold, M. Lehmkuhler,J. (2012, Sept)

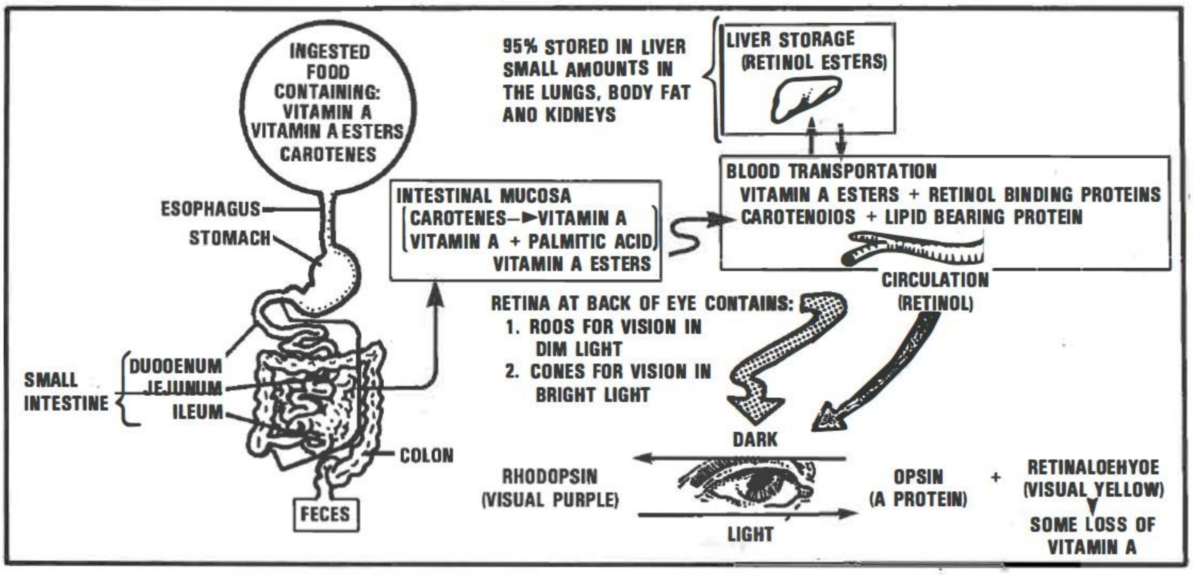


Fig. 4–72. Metabolism of vitamin A and its role in vision in dim light.

Metabolism of Vitamin A and its role in vision and dim light.
Diagram Source: Feeds and Nutrition, 1990

4.8 Selenium Deficiency

Selenium (Se) is an essential trace mineral for cattle, they take up selenium from the plants they eat. It is involved in proper immune function, acts as an antioxidant, and helps activate thyroid hormones. Cattle store selenium in their body but only for short periods, mainly the liver. This means a continual supply in the diet for cattle must be made available for optimum absorption of the mineral.

Selenium forms part of a number of enzymes and other proteins in animal tissues. In particular it is a component of the enzyme glutathione peroxidase (GSH-PX). This enzyme inhibits and destroys naturally occurring peroxides that cause cell damage. It acts in conjunction with vitamin E to protect cell membranes including cell walls. This protection is particularly important in muscle cells that work hard and consume large quantities of energy and oxygen. (Government of Western Australia, Department of Agriculture and Food, 2017). Selenium and Vitamin E are concentrated in colostrum, therefore cattle need a good supply in their diet in late pregnancy to make sure the calf gets an adequate amount. Selenium and Vitamin E can cross the placenta.

Deficiency

In the presence of a Vitamin A deficiency stillborn calves are born frequently, or calves that are weak and unable to suck from their mothers unaided. They usually die within a few days from starvation or a secondary bacterial infection.
A later form in calves typically shows up 1-3 months, the clinical appearance varies - depending on which muscles are affected. Skeletal - there is a rapid onset of stiffness and the calf may suddenly be unable to stand. They may still be bright and alert with a normal appetite. Cardiac -there is sudden death without other signs of illness. Respiratory - the calf displays distressed breathing.

One of the most extreme signs of a selenium deficiency that producers notice, is white muscle disease. This debilitating disease causes calves to become stiff and damage their muscles, especially the hind legs. In addition sudden death from heart failure can result. Sudden death can result a few days after birth or a few weeks after birth.

When there is a selenium deficiency, toxic free radicals are formed which damage muscle tissues particular; skeletal, cardiac and respiratory muscles. These muscles are the most susceptible to damage. Selenium deficiencies are most comment in young calves and calving cows. But are also observed in adult cattle. A selenium deficiency usually shows up in calves 1-3 months of age.

Soil Analysis for Selenium: Selenium is found in the soil and taken up by plants. The level of selenium can vary depending on the initial amount of selenium in the soil, the type of plant, rainfall and fertiliser application.
Soil drainage - there is a decrease in animal blood selenium levels with increasingly poor drainage (Fraser and Kirk, 1981). This is mainly due to conditions in soils of a high water table reducing and decreasing the availability of selenium to plants (Watkinson, 1996).

"Recent selenium status of cattle can be assessed by testing blood samples from some of the herd or liver samples from an affected animal. These are the most accurate ways to assess selenium status. Soil samples are not suitable for determining risk of selenium deficiency in animals as the total soil selenium level includes elemental selenium and selenite, both of which are relatively unavailable to pasture plants and selenium uptake by plants is inconsistent". (Government of Western Australia, Department of Agriculture and Food, 2017).

In some situations a trace element deficiency may only be subclinical or marginal and therefore can only be detected by collecting blood, liver and tissue samples for trace element and enzyme determination.

4.9 Copper Deficiency

Copper (Cu) is an essential trace element for animals and is needed for body and bone growth, pigmentation, healthy nerve fibres and white blood cell function.
There are two main causes of copper deficiency in cattle:
1. Low copper levels in the grass due to lack of copper fertilizer in naturally copper-deficient soils.
2 The other form of deficiency is induced when dietary levels are adequate but copper absorption is impaired by the interference of other minerals. Ingestion of excessive levels of molybdenum and sulphur in pasture or feed supplements. These can form insoluble complex salts in the rumen, reducing copper absorption.

Clinical signs of copper deficiency are poor growth rates, discoloration of the coat especially around the ears and eyes, giving cattle the 'spectacle' look. Non-functioning keratinisation can lead to a sparse, thin coat - not to be confused with natural shedding of the winter coat. Diarrhoea is classically seen after turnout onto pastures with high molybdenum concentrations - so called "teart pastures".

Copper deficiency is directly related to reduced fertility in heifers. Impaired fertility can also be related to secondary copper deficiency due to high molybdenum intakes rather than a lack of copper in the diet.
"Dairy cows are most likely to be deficient in early winter/spring when their need for copper is at its highest for pregnancy and early lactation. Fast growing calves over six months of age are likely to be deficient." (DairyNZ, 2017).

Elements interfering with *Cu* absorption: Zinc *(Zn),* Molybdenum *(Mo),* Iron *(Fe),* Sulphur *(S)*

Factors that can decrease Copper absorption:

- Prolonged Zinc treatment for Facial Eczema
- Clover contains higher concentrations of Copper than grasses. In winter/early spring clover content in pasture is less than at other times of the year
- Fertiliser additions (Nitrogen and Lime) increase the uptake of Mo by plants
- Winter rationing limits cow intakes making less plant Cu available
- Wet muddy conditions increase the amount of soil (therefore Iron) eaten
- Internal parasites increase the loss of Cu in dung
- Rapid new plant growth has low Cu levels and higher Mo content
- Winter feeding of brassica (eg swedes and choumoellier), which can have higher levels of Sulphur

4.10 Pinkeye treatment

Previously covered is antibiotic treatment. Cases detected and treated early are less likely to develop complications (such as deep ulceration and scarring, “bubble eye,” and permanent damage), but it is still important to treat advanced cases of pinkeye. Administering a topical fly repellent may be a useful course of action to reduce the spread of Pinkeye in the herd. Protecting the eye from sunlight and further irritants may accelerate healing. Sutures, eye patches, isolation and being moved to a shady paddock because the eye becomes extremely sensitive to light.
Photo source: Google images

4.11 Prevention

Many approaches have been tried over the years to prevent Pinkeye. The random nature of Pinkeye outbreaks and the numerous factors that contribute to the disease have led to many myths and misconceptions regarding Pinkeye prevention. Management practices that reduce the risk factors associated with Pinkeye are the most effective tools in decreasing the incidence of the disease.
Topping pastures can be a good way to reduce seed heads, and thistles which can irritate the eye.

Good quality nutrition and minerals available at all times, will improve the overall condition of the cattle and decrease the incidence of this disease. Overhead hay feeders should be lowered and round bales should be rolled out. Clean drinking water (instead of stagnant pond water) is critical because intake is greater with clean water and this helps provide plenty of fluid in the eye, especially in dry, dusty, and/or windy conditions.

The pre-corneal tear film is essential in eye defence mechanisms as tears wash away pathogens and tear proteins are an important part of protecting the eye. With a lower incidence rate of the disease, the overall concentration of the bacteria on the farm will be lowered, reducing the risk of a large outbreak.
Reducing flies and isolation is an incredibly important factor in reducing the spread of the disease. Shaded areas need to be provided to so cattle can get out of bright UV light when it is most intense. Breeding for Herefords with pigmented eyelids as this is a heritable trait.

4.12 Feeding kelp to prevent pinkeye

The only study found that directly addresses supplementing kelp and pinkeye is, “A short communication: Iodine concentrations in serum, milk, and tears after feeding *Ascophyllum nodosum* to dairy cows". (Sorge, 2016)
It is thought that the increased iodine levels in the tears of Holstein Friesians fed 56 grams of kelp a day for 30 days would improve the animal’s ability to cope with the eye infection from *M. bovis*. It increased iodine levels in the upper airways contributing to antiviral defences. Although a previous study had shown some antibacterial activities of *Ascophyllum nodosum* extracts, tears from study cows did not prevent the in vitro growth of any of *M. bovis* bacteria regardless of their iodine levels.

"In contrast, 1% and 7.5% iodine positive controls did show inhibition of bacterial growth. Therefore, the hypothesis that the iodine concentration of tears has a direct effect on the growth of, for example, *M. bovis* could not be confirmed. It remains unclear how or if the previously demonstrated antibacterial properties (Vacca and Walsh, 1954) translate to kelp fed to and digested by ruminants." (U.S. Sorge 2016)

Other studies into supplementing kelp have had positive outcomes. Examples of this are: decreasing the incidence of foot rot and decreasing the severity of Respiratory syncytial virus in lambs. Supplementing with iodine from kelp is thought to potentially improve immune function against infectious bacteria. Therefore the conclusion is, a prevention of infectious bovine keratoconjunctivitis would probably not be based solely on increased iodine concentrations in tears. A repeat of the study is not planned.

4.13 Kelp

Seaweed grows in abundance all around the coastline of New Zealand. The information on feeding seaweed to cattle as a probiotic seems promising. Macroalgae marine seaweeds are rich in bioactive compounds. Because seaweed is literally a plant that grows in the sea, it is very bio-available to humans and animals. Seaweed has a long fossil history and belong to the heterogeneous group of plants. It has a low fat content, high concentration of polysaccharides, high mineral content. Brown algae is known as (*phaeophyta*), green algae (*chlorophyta*) and red algae (*rhodophyta*) and is differentiated on the basis of chemical composition. They are an excellent source of vitamins such as A,B1,B12,C,D and E, riboflavin, niacin, pantothanic acid and folic acid as well as minerals such as Ca, P, Na, K (Dhargalkar & Pereira, 2005).

The red and green species are rich in carbohydrates, whereas the brown seaweeds are rich in soluble fibre and iodine. The highest iodine content is found in brown algae, with dry kelp (*Laminaria*) ranging from 1500 to 8000 ppm and dry rockweed (Fucus) from 500 to 1000 ppm (Dharmananda, 2002). Seaweeds are able to generate the essential compounds to protect themselves from external factors like UV light radiation, stress and pollution. This suggests, like photosynthesizing plants, they have an antioxative effect.

The bioactive compounds which are most extensively researched, include sulphated polysaccharides, phlorotanninsand diterpenes. These compounds have been reported to possess strong anti-viral, anti-tumour, anti-cancer and antibacterial activity, anti-inflammatory properties and antioxidant. Not all seaweeds are the same, they vary between geographic locations, the time of year it is harvested, and species. Bioactive potential and possible health effects of edible brown seaweeds.

4.14 Prebiotics

One specialised area of seaweed research has focused on the concept of dietary “prebiotics” as functional ingredients for gut health, both for humans and animals. A recent definition of a probiotic is “a selectively fermented ingredient that allows specific changes, both in the composition and/or activity of the gastrointestinal microflora that confers benefits upon the host wellbeing and health” (Roberfroid, 2008).

Mode of action of prebiotics and proposed health benefits in humans and animals.

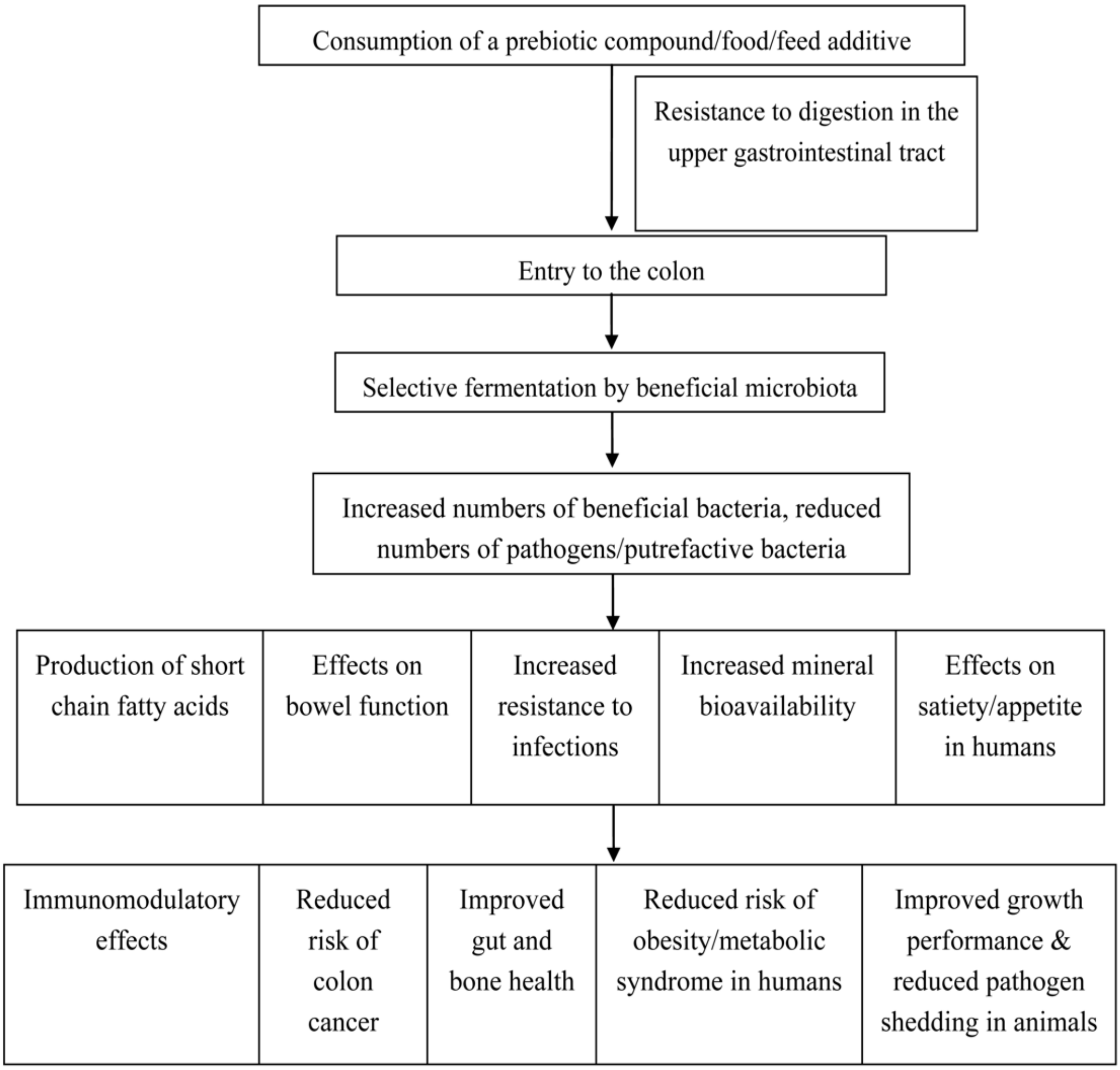


Diagram source: Prebiotics from marine and macro algae for human and animal health applications.(2010)

Prebiotics can be consumed as dietary supplements or in functional foods. A functional food is defined as a food which provides a health benefit beyond basic nutrition. Prebiotics can be added to cattle feed as an alternative to antibiotics. Seaweeds are rich in polysaccharides that are resistant to digestion and absorption in the small intestine, although they are completely or partially fermented in the large intestine by the microbiota present. (Deville et al.2004)
"Although the exact mode of action of antibiotic growth promoters is unknown, they most likely act via modulation of intestinal microbial populations, including reduction of pathogenic microorganisms. Prebiotic compounds therefore offer potential as an alternative to in-feed antibiotic growth promoters." (O'Sullivan, Murphy, McLoughlin, Duggan, Lawlor, Hughes & Gardiner, 2010)

5.Claims

5.1 Thorvin a USA company in Virginia sells certified organic kelp. Thorvin recommend feeding a dried, flaked kelp. Mix in feed at 1% to 2% of grain ration or 0.1% to 0.5% of Dry Matter Intake (DMI), depending on the species. Thorvin can also be fed free choice, alone or with salt, or top dressed.
Thorvin claim cattle self-regulate but in some cases animals will consume larger than normal quantities, adding this typically usually only lasts 30-60 days depending on the animal's mineral status. If higher consumption continues longer than 60 days Thorvin suggest mixing it with salt 1:1 to reduce intake and to consult a nutritionalist. Thorvin sell Icelandic Geothermal Kelp which they claim delivers a complex array of minerals, vitamins, and beneficial phytonutrients. They use this product in formulations as a source of 100% naturally occurring iodine, and to promote mineral balancing and immune response. When questioned for scientific evidence that kelp was an effective supplement in preventing pinkeye, they were unaware of any studies that showed feeding kelp prevented pinkeye. Adding that what they did have is numerous reports from producers who attribute the use of Thorvin to the reduction of pinkeye in their herds.

5.2 Dr. Paul Detloff

Dr Paul Detloff is a big advocate in the supplementing of kelp to prevent pinkeye. Paul graduated from veterinary school in 1967, practicing for 21 years before ever learning what kelp even was. This is when Organics hit the USA. He changed tack in 1989 and took on an organic holistic approach to veterinary medicine. He claims to have "seen every mouse trap type of product you could imagine." In the last 25 years, in his mind kelp is the winner of the entire crowd.

When asked for scientific evidence his response is, 'Personal observation is the most reliable source of the truth.' He went on to say that kelp is a plant loaded with highly absorbable trace minerals, the two big ones being iodine and manganese. Iodine for basic metabolism in the thyroid gland and Manganese for reproduction. 90% of manganese is in the ovaries and testes. Trace elements which are found in every enzyme. Enzymes do the work for hormones from the endocrine system.

Kelp trace minerals are over 90% absorbable because they come from a live plant. The positive effects he consistently sees in cattle that are fed a kelp supplement are; increased breeding efficiency, better feet and legs from the zinc, copper and selenium, better hair coat, better quality colostrum, less calf scours. Parasites don't like the iodine levels in kelp. Less pinkeye, less lice. Adult cows after being on kelp for 18-24 months will have less internal parasites. In conclusion Paul recommends starting adult cattle on 56 grams a day as they will gorge on it, and young calves should have it free choice, adding 'they'll know when they need it'.

5.3 Bradley J. Heins,

Associate Professor of Organic Dairy Management at the University of Minnesota. Heins has been studying the effects of kelp on cattle. Bradley ran a trial feeding kelp to 115 organic Holstein and crossbred dairy heifer calves. Heifer calves were assigned to 1 of 3 treatment groups which were (1) control calf starter (No Kelp), (2) calf starter plus 56 grams of kelp per calf daily, or (3) calf starter plus 112 grams of kelp per calf daily.
Although kelp is promoted in the organic dairy industry to improve animal health, there were no differences in calf groups. Heins states that quite possibly, calves fed kelp did not consume enough calf starter because of their dislike of the taste of kelp. Based on the results of this study, including kelp in dairy calf starter rations may not be economically justified because of the high cost of kelp and reduced performance of calves.

5.4 André Brito

Assistant professor of Organic Dairy Management at the University of New Hampshire. Dr. Brito found while speaking with organic dairy farmers and nutritionists across New England, he found that many farmers have noted the benefits of feeding kelp meal, particularly regarding its effectiveness reducing the incidence of pinkeye in dairy animals.

Whenever organic dairy farmers are using feed supplements they believe to work but do not have scientific information, as a scientist, he wanted to know why. When he started to look into the scientific literature, he was surprised that there wasn't much research to back up farmers' claims and experiences, so he decided to begin looking at how kelp affects dairy cattle health and performance.

In 2016 Dr.Brito took on the task of looking into and unravelling challenges and opportunities of kelp meal supplementation in North-eastern organic dairies. With the research to take place over three years and a grant just shy of $US200,000, he surveyed more than half of the organic milk producers in the Northeast of New Hampshire, USA, who are using kelp as a supplement to enhance herd health. There is a risk of kelp leading to high iodine levels in milk, which is potentially toxic to children.

5.5 Don Field

Owns Fertile Fields in Taranaki who sells kelp *Ascophyllum Nodosum* seaweed, commonly known as Norwegian Kelp, Common Wrack or Rockweed. This is a brown seaweed which grows along the North Atlantic shorelines of Canada and Europe. The seaweed is harvested off the cold, clean coast of Nova Scotia, Canada. Because the waters in this part of the world are so cold, the seaweed grows very slowly and is therefore more nutrient dense. Don says his sales of kelp meal are continually increasing, and he now sells 5 tonnes a year. He says farmers are putting it in the milk for young calves, also farmers are feeding it after calving to replace vitamins and minerals lost.

5.6 Raymond Burr

Consulting director of Q Labs, a Hawkes Bay based company focused on soil management, plant production and animal performance. Raymond has had success injecting Vitamins A, D and E in the prevention and cure of pinkeye in both cattle and sheep throughout NZ for many years.
"Our theory is that the initial weepy eye stage is caused by a Vitamin A deficiency. This in turn creates the ideal environment for the proliferation of *M. bovis* and given extra favourable environmental and management factors outbreaks can rapidly escalate." Raymond says, that vitamin A deficiency is not well investigated under New Zealand pastoral grazing systems. "Through observation pinkeye in calves is more prevalent in later born calves than first round calves. The first calves often have good volumes of grass to eat through the rearing process. Good calf rearing practices including rumen development, but feeding insufficient volumes of good quality green grass early enough in the transition period can inhibit the calves ability to produce its own Vitamin A when milk is withheld. Calves are often weaned off milk and onto a concentrated feeding programme in the absence of green leafy grass. I must also point out at this stage that processing animal feeds with heat and dehydration also destroys carotene. Thus leaving the animal exposed to a lack of carotene right at a critical time in the calves transition. Vitamin A is also known as the stress vitamin. Animals reserves are quickly "burnt" up through any stress period, administering Vitamins A,D and E will settle them down and get them back eating."

Findings and Discussion

Pinkeye outbreaks varied a lot depending on geographic location with it appearing to be less of a problem in the South Island. One Rotorua based vet said his practice had a low presence of the disease generally, but one area near Kawarau frequently had bad outbreaks. He thought this was due to the different soil type that is more of a pumice base, translating to more dust in the summer months. Also that area was known to be deficient in selenium and he thought this was a contributing factor. This is where the environmental factor had played a major role.

Another South Island vet suspected about one in 200 farms would get an outbreak so the incident rate was low. Most thought the incidence rate of pinkeye was static. No vets noticed any trends regarding the severity of the reactions.
Cattle under one year of age appeared more susceptible, but nearly all veterinarians mentioned that it occurred equally in mixed aged cattle.

Outbreak patterns developed on seasonal weather conditions of that year. Equinox winds being a contributor as too were hot dry summers. Reducing the severity of a pinkeye outbreak was largely to do with the reaction time it took farmers to identify the problem.

Isolation was the next key factor. Most veterinarians thought the severity of the disease hadn't changed a lot over the years, but individual animal’s responses still varied widely. One Northland based veterinarian where the disease is prevalent said, 'the vaccine was taken off the market a couple of years ago because the effect was no better than 50% protection. But it was reintroduced as farmers complained they had nothing else to try and prevent the disease". He added, "routine vaccination does limit the severity of the disease".

More than one veterinarian used an off label treatment of mixing an antibiotic with saline solution and running in though a pump to topically treat both eyes of an infected mob that had spread through large numbers to try and bring the disease back under control. Orbenin Eye ointment was the most widely prescribed topical treatment. Stitching the third eyelid closed and scraping the back of the eyelid with a scalpel to encourage an increased blood supply to the area was sometimes used.

Intramuscular antibiotic injections such as oxytetracycline were also commonly prescribed as well as conjunctival sac which is the space between the eyelid and the eye. One South Island based veterinarian used a powdered antibiotic Tetravet, mixed with water and glycerine. This encouraged the antibiotic to stick not only to the eye but the face also where the bacteria was active.
No veterinarians interviewed were familiar with feeding kelp to prevent pinkeye.

6. Conclusions

Pinkeye is a complex disease that is unpreventable. Measures can be taken to try and reduce an outbreak. Swift action in the form of antibiotic intervention whether this be by intramuscular or topical is up to the individual. The advantage of intramuscular antibiotic treatment is that this method reduces the shedding of the disease when it is in a high contagious form. Eye patches are a relatively new product on the market here in NZ. These protect the eye from any further irritation from dust, flies and UV light which is painful. Eye patches have the added value of keeping the contagious tears covered so flies cannot access the weep. Environmental controls such as topping paddocks are also beneficial in reducing topical irritation to the eye. Fly traps may also help keep the fly population to a minimum.

Supplementing animal's diets with kelp seems unlikely to inhibit *M. bovis* growth but may have a place in supporting the young animal's immune system. There is some support for nutritional support in terms of vitamins helping reduce the severity of the disease however there is no sound science to support this anecdotal opinion. Certainly in NZ particularly in large scale rearing operations the reduction of stress for animals must go some way to mitigating the incidence of diseases like pinkeye in young calves.

In my opinion stress uses up valuable vitamin and mineral reserves which reduce the efficacy of the immune system. Further research in the New Zealand farming environment is required for us to learn more about this disease affecting productivity. More swabs need to be taken from infected animals' eyes and submitted to veterinary laboratories for us to gain a better understanding of the real bacterial picture we are exposed to, thus providing valuable information going forward. If the current antibiotics we are using for pinkeye have a reduction in efficacy we will be facing a severe animal health challenge, which could possibly be avoided by further widespread diagnostic work undertaken now on infected herds and flocks

7. Recommendations

7.1 Shade trees

The farm should have a number of shaded paddocks so stock can get out of the bright summer midday sun when the UV light is at its most damaging. Having shade is also very important for infected animals as their eye becomes more sensitive to light.

7.2 Maintenance of farm tracks

Maintenance of farm tracks needs to be completed regularly so that dust in the summer months is kept to a minimum. The stock yards should also be watered down if they are very dusty and only bringing cattle to the yards when absolutely necessary to keep exposure to dust at a minimum.

7.3 Reducing stress

As previously mentioned stress uses up valuable reserves of vitamins and minerals. Avoid unnecessarily bringing stock to the yards or any double handling.

7.4 Replacing vitamins and minerals

Injecting with vitamins A,D and E may help to boost the immune system. Also feeding kelp to replace important vitamins and minerals lost in times of stress. Kelp is known as a prebiotic which is highly bioavailable and contains over 60 vitamins and minerals.

7.5 Diagnostic testing

Farmers need to insist on eyes swabs being taken from infected animals during an outbreak, this will help scientist to understand specifically what *Moraxella* bacteria we are dealing with here in NZ.

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Appendix 1

Questions asked of NZ veterinarians interviewed:

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1. How prevalent is pinkeye on your client's farms?
2. Have you noticed any trends in the incidence rate of pinkeye outbreaks?
3. Have you noticed the severity of the reactions to pinkeye reducing?
4. What age group of cattle seem most susceptible?
5. Do you think there is a link between pinkeye and a vitamin and mineral deficiency?
6. Have you noticed any breed susceptibility?
7. What treatment do you prescribe?
8. What are your thoughts on the vaccine?
9. Do you know of any successful alternative treatments?
10. Have you heard of feeding kelp as a preventative measure?