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Technical Series

Issue 20

What is Theileriosis?

Theileriosis is a disease usually recognised as anaemia, caused by a species of Theileria (blood-borne parasites). Transmission is by a secondary host, a tick. In New Zealand, this is the cattle tick *Haemaphysalis longicornis*.

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The spread of Theileria orientalis Ikeda

In 2012, strain typing by the Ministry for Primary Industries' Animal Health Laboratory first identified *Theileria orientalis* Ikeda, a strain not previously known in New Zealand. This article describes its spread in New Zealand from the first confirmed diagnosis.

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Tick biology drives infestation

Only one tick affects livestock in New Zealand and this is the New Zealand cattle tick, *Haemaphysalis longicornis*. The tick has been recorded in Northland, Auckland, much of the Waikato, Bay of Plenty, Gisborne and Taranaki.

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Managing Theileriosis on-farm

Overall, the rate of severe Theileria clinical cases has been low (1-2% of the herd). However, a small number of herds have experienced a far greater incidence of the disease and animal losses of up to 15%.

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Ikeda Theileriosis will have future cycles of disease affecting New Zealand cattle, with the impact and severity lessening over time.

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DairyNZ

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What is Theileriosis?

Theileriosis is a disease, caused by a species of Theileria (blood-borne parasites), usually recognised as anaemia. Transmission is by a secondary host and, in New Zealand, this is the cattle tick Haemaphysalis longicornis.

Different species of Theileria cause disease around the world (see map). In the Pacific rim countries, the specific parasite is *Theileria orientalis*. A mild strain of this species, called Chitose, was first identified in New Zealand in 1982.

However, laboratory testing by the Ministry for Primary Industries (MPI) confirmed the presence of a new strain of *T. orientalis* in New Zealand in spring 2012. This strain is called Ikeda and has been associated with anaemia and deaths of cattle in New Zealand. It has previously been, and still is, associated with illness and deaths of cattle in Australia, Indonesia, Japan, Korea and other Pacific rim countries.

The clinical signs of anaemia include lethargy, exercise intolerance and increased respiratory and heart rates. Stresses, such as mustering and yarding of severely affected animals, can lead to collapse and death. While subclinical disease is likely to have an impact on milk production, reproductive performance and susceptibility to other conditions, a case study in Victoria has suggested no measurable impact on milk. It is possible an immunity develops and this will limit recurrence.

There are no human health or food safety risks associated with Theileriosis.

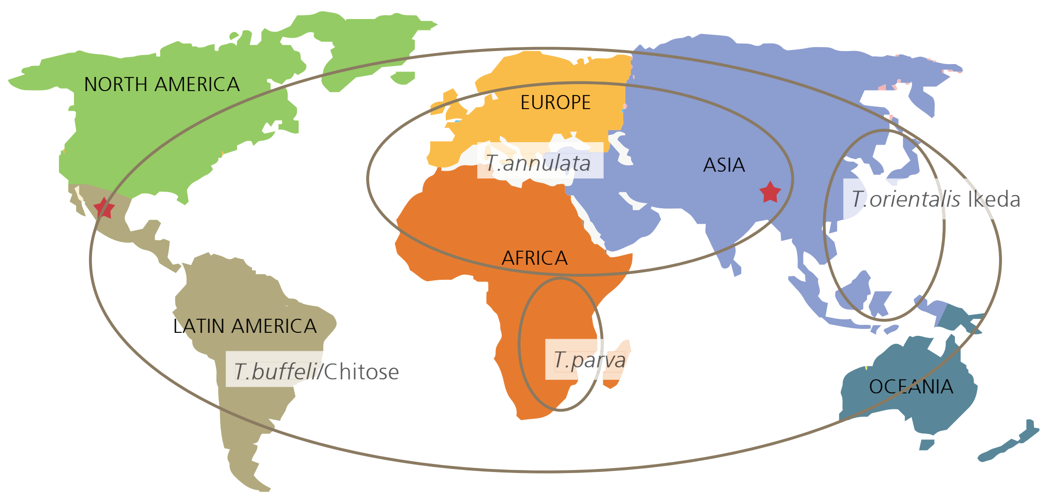
Treatment

The parasitic infection can be treated with a phenolic drug, buparvaquone. This was developed about 40 years ago for treatment of a related, but much more severe, form of Theileriosis in Africa. The drug is only licenced and available in certain countries.

It has been made available in New Zealand in limited and controlled quantities under special permit and has long withholding periods for both milk (35 days) and meat (140 days). Cattle with signs of disease need good care. Supportive therapies, such as blood transfusions, have been helpful for severely affected animals.

This is not necessarily an easy procedure and, as with all such treatments, requires significant veterinary expertise. Prevention and control of Theileriosis is partly achieved by controlling ticks and managing animal movements to ensure infected cattle are not mixed with uninfected cattle and vice versa.

The disease is now considered to be widespread over the northern half of the North Island. It has also been diagnosed as far south as Taranaki, the King Country, Whanganui and Hawke's Bay. Wherever cattle ticks are active, there is a risk of Theileriosis. As of December 2013, 372 cases had been confirmed.



Historic distribution of Theileria species around the world. Ikeda has been known from Australia since 2006 and New Zealand since 2012.

Source: www.theileria.org

Cases greater than reported

Veterinarians have suggested that many more cases have occurred than what has been treated, managed with veterinary advice, had samples submitted for analysis or been reported. Therefore, the incidence of the disease is probably significantly greater than the number of confirmed cases indicates.

The potential impact of this disease on the New Zealand dairy industry is not known. Therefore, DairyNZ is working with farmers, veterinarians and MPI to monitor the disease, provide support and advice for farmers and develop a more robust management programme.

This edition of the *Technical Series* summarises the Theileriosis outbreak to December 2013.

Types of Theileriosis worldwide

Theileria – a genus of blood-borne parasite of cattle, transmitted by a secondary host tick, similar to malaria.

Theileriosis – the disease that may result from infection by Theileria.

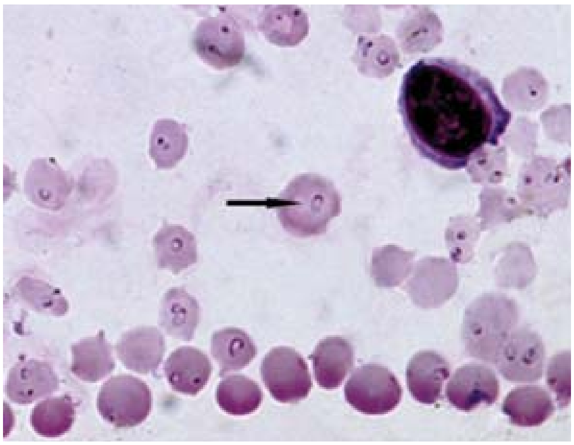
Theileria annulata – a species of Theileria that causes a disease known as Mediterranean Fever, affecting cattle in the Mediterranean (southern Europe and Africa north of the Sahara) and the Middle East.

Theileria parva – a species of Theileria that causes a disease known as East Coast Fever, affecting cattle in sub-Saharan Africa. This is the most severe of the Theilerial infections.

Theileria orientalis – a species of Theileria that causes a mild to moderate disease, principally in the Pacific rim countries, but also known from North and South America and Europe. It has been known as *T. buffeli* and *T. sergenti*. Up to eight different strains have been identified.
Type one – Chitose is a mild strain known worldwide.
Type two – Ikeda is the strain responsible for the disease outbreaks in Australia and New Zealand, and known previously to cause disease in Japan and Korea.
Type three – Buffeli is a mild strain known worldwide.
Types four through to eight are unnamed and not classified taxonomically.

Theileriosis to date

- The disease is now widespread over the northern half of the North Island. It has also been diagnosed as far south as Taranaki, the King Country, Whanganui and Hawke's Bay.
- As of December 2013, 372 clinical cases had been confirmed.
- Veterinarians suggest many more cases have occurred than what has been treated, managed with veterinarian advice, had samples taken or reported. Therefore, the incidence of the disease is probably significantly greater than the number of confirmed cases indicates.
- The main manifestation of the disease is anaemia due to the damage to red blood cells.
- The clinical signs of anaemia include lethargy, exercise intolerance and increased respiratory and heart rates. Stresses such as mustering and yarding of severely affected animals can lead to collapse and death.
- There are no human health or food safety risks associated with Theileriosis.
- The parasitic infection can be treated with a phenolic drug, buparvaquone. It is available in New Zealand in limited and controlled quantities under special permit and has long withholding periods for both milk (35 days) and meat (140 days).



A blood smear with a large dark white blood cell and numerous red blood cells with the piroplasm form of the Theileria parasitising most of the cells.

The spread of Theileria orientalis Ikeda

What happened?

Andy McFadden, Ministry for Primary Industries; Nita Harding, DairyNZ animal husbandry team leader

Theileria disease stats

From late August 2012 until December 5, 2013, 372 farms had confirmed cases of Theileriosis caused by the Ikeda strain (confirmed by PCR [Polymerase Chain Reaction]).

- Over and above the number of cases reported, there is likely to have been a significant number of cattle farms affected that have problems either not observed or not reported.
- The average herd mortality on those farms reported was 0.9%.
- The average prevalence of anaemia in an affected herd was 33%.

In December 2012, strain typing by the Ministry for Primary Industries' (MPI) Animal Health Laboratory made the first identification of *Theileria orientalis* Ikeda, a strain of the parasite not previously identified in New Zealand.

T. orientalis Ikeda has been associated with disease in many Pacific rim countries and recently in Australia. This was significant because only the Chitose strain of *T. orientalis* was known to occur in New Zealand.

So far, only limited studies to investigate the distribution of *T. orientalis* in New Zealand have been undertaken and the Ikeda strain's origin is unknown. It is also not possible to say how long this strain has been present in New Zealand.

However, the Ikeda strain identified from recent outbreaks is different to the mild strain, Chitose, identified from historical testing prior to December 2011.

The parasite is spread between animals by ticks. In New Zealand, only the cattle tick (*Haemaphysalis longicornis*) is capable of acting as a vector for Theileria. The cattle tick is not a native to New Zealand, being widespread around the Pacific rim and introduced into the country in the early 1900s. It is described more fully on pg 10.

Theileria infect the red blood cells of cattle, which results in a transient fever and regenerative anaemia. The clinical signs of Theileriosis are, therefore, those of anaemia, demonstrated by lethargy, lack of appetite, pale udder (observed at milking), exercise intolerance, pale gums and mucous membranes, and occasionally abortion or stillbirth.

Peracute Theileriosis resulting in death is more common around times of stress such as calving or early lactation.

The case definition used by the Ministry for Primary Industries (MPI) for reporting Theileriosis is: *anaemic cow with a red blood cell count of less than 0.24 (that is the proportion of a blood sample that is red blood cells, known as Packed Cell Volume [PCV] less than 0.24) and Theileria in blood observed by microscope in an anaemic cow with Theileria orientalis Ikeda – identified by a novel laboratory test developed by the MPI Animal Health Laboratory for Ikeda strain and now available through commercial animal health laboratories.*

This article describes the spread of *Theileria orientalis* Ikeda in New Zealand from the first confirmed diagnosis until December 5, 2013.

Spring 2012

In spring 2012, veterinarians in Northland reported cases of cattle severely affected by anaemia, including the death of a number of animals. These cases were initially seen in suckling beef calves (two to four months old) and adult dairy cows.

Testing confirmed the presence of *T. orientalis* in some of these cases. However, the role of Theileria was uncertain and a number of other factors could have contributed to the severity of disease, such as nutritional status and other concurrent health conditions.

Initially, no particular flag was raised, as *T. orientalis* has been in New Zealand since 1982 and has occasionally been associated with some disease and ill-health in cattle, but not to the extent or severity in Northland in spring 2012.

Veterinarians were asked to report cases to MPI. Detailed technical information about Theileriosis and cattle ticks was provided to veterinarians and an advisory note for farmers was distributed by MPI and industry good organisations. DairyNZ discussion groups in Northland had it as an agenda item.

In December 2012, a new laboratory test developed by MPI allowed detection of the Ikeda strain. At this point, disease had been confirmed on 20 farms.

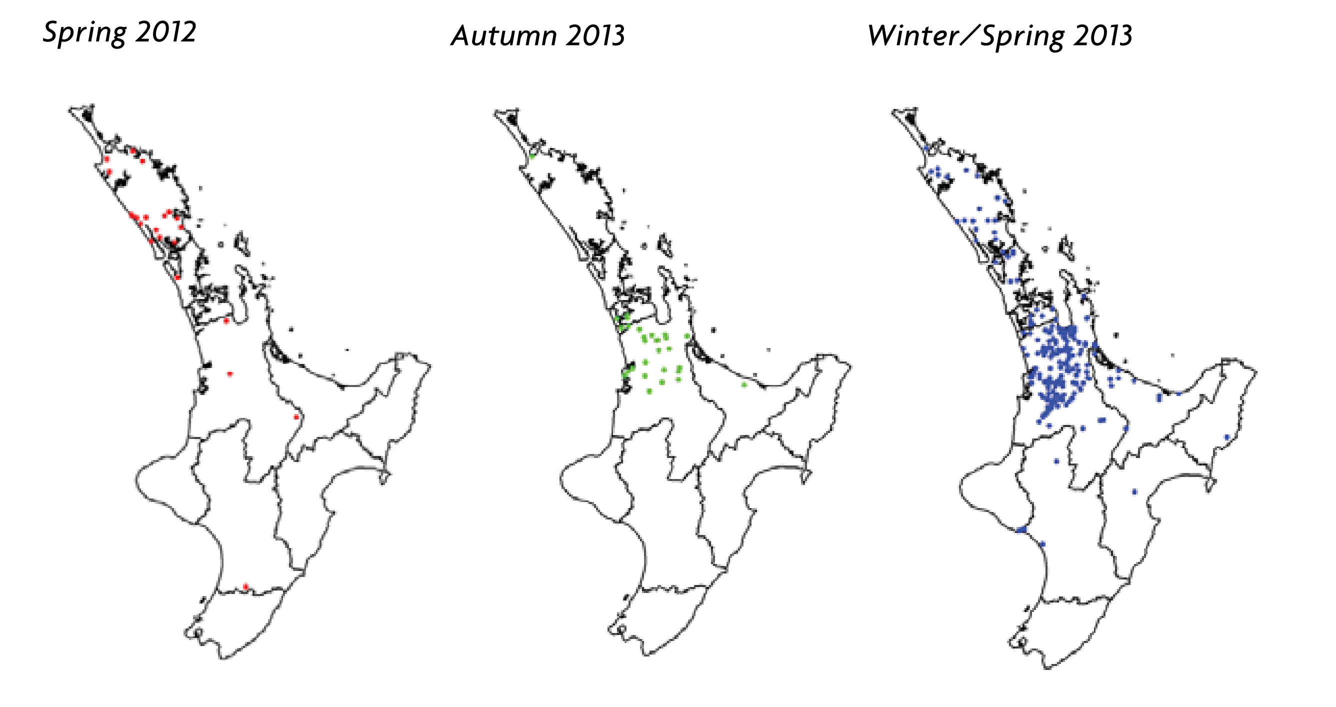
Autumn 2013

A second wave of disease occurred in autumn 2013 and almost exclusively involved mixed age dairy cows in the Auckland and Waikato regions. Both spring and autumn calving cows were affected.

Most cases were associated with cattle movement. For example, cattle from the far north moving to South Auckland, or autumn calving cows moving back to the milking platform and either suffering anaemia or, it is suspected, acting as a source of infection for the previously naive spring calving cows on the home farm. NAIT is proving extremely valuable in tracking the movement of infected animals.

By early June 2013, infection with *T. orientalis* Ikeda had been confirmed on 50 farms. MPI had also begun investigations into the epidemiology of the disease including modelling work, a survey of affected farms and impact assessment studies.

Theileriosis cases



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Winter/Spring 2013

The number of new cases of Theileriosis reported was low during June 2013 and this was expected, considering the lifecycle of the cattle tick. However, by July, new case numbers were increasing, especially in dairy herds.

During the period from August to early October, the number of new cases reported increased each week and by mid-October, Theileriosis had been confirmed on 245 farms. By mid-November, 327 farms were confirmed as having the disease affecting some cattle.

This pattern of disease over winter was unexpected. The tick vector is usually dormant during the winter months, due to low temperatures. However, the 2013 winter was the warmest on record for New Zealand. The 1.2°C higher average national temperature may have contributed to a higher tick survival rate and continued activity throughout winter, certainly locally.

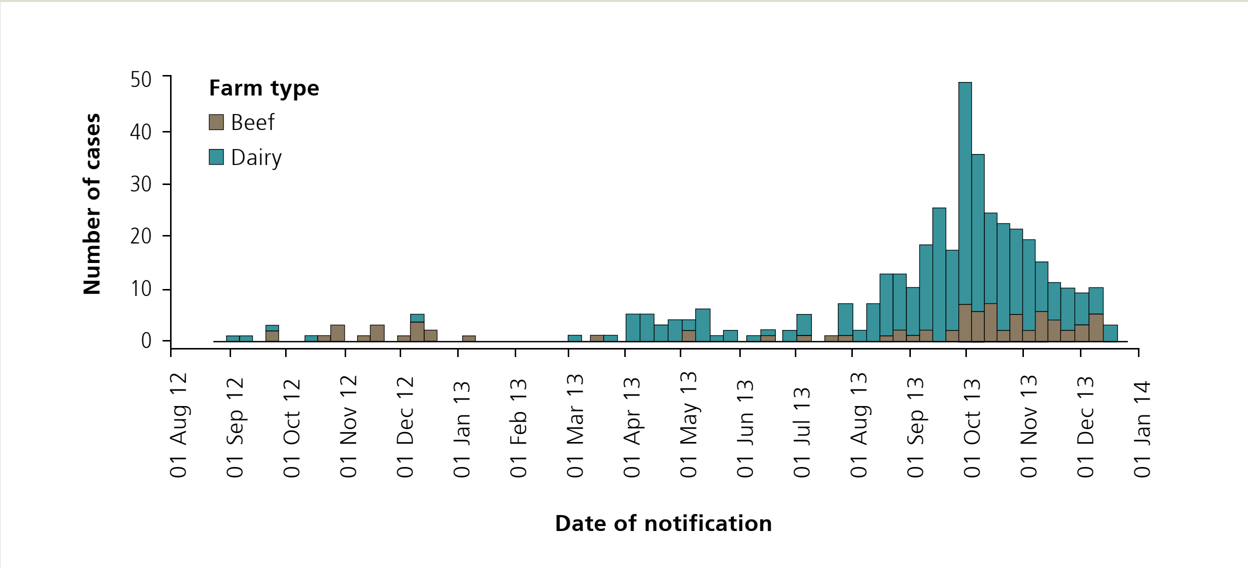
Because late winter/early spring is the main calving period, the physiological stresses from late pregnancy, calving and early lactation probably coincided with enhanced exposure to infected ticks in naive cows. This resulted in many more clinical cases of Theileriosis than what would have occurred at any other time.

Several herds reported a large numbers of cows affected and a resulting number of cow deaths. The mortality range was 0-15% in affected herds.

By the end of October, cases of Theileriosis had also been diagnosed in the Bay of Plenty, Reporoa, Eketahuna, Taumarunui, Whanganui, Gisborne and Napier, as well as over much of the Waikato.

The epidemic curve (Figure 1) shows the waves of peak disease and the split of cases between beef and dairy farms.

Figure 1. *Cases of Theileriosis September 2012-December 2013*



Source: K Lawrence, Ministry for Primary Industries

Understanding the spread of Theileriosis

To get an outbreak of any disease, it is necessary to have a susceptible host and a disease-causing agent. Theileriosis is more complicated because it has a secondary host, the tick, in which vital parts of the parasite's life-cycle must be completed (see life-cycle illustration pg 8).

New diseases or disease new to an area or animal population always have a significant impact, because the host animals are generally naive to it, having acquired no immunity. Also, animal managers are not geared towards preventing and mitigating a new disease.

We still do not have a complete understanding of all the factors involved in the spread of Theileriosis within and between cattle herds in New Zealand. However, the following points are considered to be of most importance.

Animal susceptibility

Many cattle in New Zealand are infected by *T. orientalis* Chitose but this does not appear to provide any defence against infection by the different strain. A Japanese study shows that both strains can be isolated from the same animal.

There was no real immunological defence to the Ikeda strain when it arrived in New Zealand and, in all new areas where it was introduced, the cattle were susceptible to infection.

This lack of immunity combined with stressors at the time of infection, such as late pregnancy, calving and early lactation, probably led to a high rate of infection and subsequent disease in the most exposed and compromised cows.

This can be contrasted with the relatively high rate of infection in otherwise completely healthy animals e.g. 16 Hereford bulls purchased by DairyNZ for 2013 mating were Ikeda positive on tests but have never shown any signs of anaemia.

Herd impact

The impact from Ikeda introduction on cattle farms can be very variable. On many affected farms the impact is very low, while on a small number of farms there may be a significant impact, with a high incidence of animals experiencing clinical anaemia. The factors responsible for variation in impact may relate to a number of environmental stressors, however these have not been defined.

Animal movement

The single most important factor in the geographical spread of Theileriosis is the movement of infected animals into areas without infection. Stock movements are common within the New Zealand farming system.

Dairy farmers regularly send young stock off to graziers to return just prior to their first calving. Late calving cows and dry cows are also frequently grazed off the milking platform for part of the year. In addition to this, the transporting of service bulls between breeders and dairy farms, sales and transfers of lactating stock between properties, and cull cows frequently on-sold to other farmers are all an opportunity for disease spread between properties.

The summer of 2012/13 had further increased transportation between farms, due to the extensive drought. Insufficient feed on-farm meant more farmers sought off-farm grazing and these animals may have gone further afield for grazing, than normal.

Patterns of unusual stock movement may have contributed to a wider spread of Theileriosis during this time, than typically expected under more normal summer conditions.

Theileria is not only carried by infected cattle, but also by infected ticks on animals being transported (including species other than cattle). Nymphal and adult ticks feed on cattle for up to 14 days, so ticks may be transported with cattle if no biosecurity plan is implemented.

Vector transmission

The cattle tick is an integral part of the life-cycle of *T. orientalis*. Without ticks, the parasite cannot complete its life-cycle and spread within the herd (see life-cycle illustration pg 8). This means infection in a herd will not be sustained if ticks are not present.

The cattle tick is widely distributed over the northern half of the North Island. It has been reported in localised areas of the Wairarapa, Manawatu and in the Takaka, Nelson and Marlborough areas. From the location of herds with confirmed Theileriosis cases, it is apparent the cattle tick is probably present in other areas, in quite defined locations. The very mild 2013 winter may have influenced the local distribution and tick population size.

Spatial temporal modelling by MPI has shown significant local spread of infection for up to 5 km of an infected farm. This occurs within 30 days of a farm becoming infected.

Ticks do not move far on pasture on their own accord. However, the transfer of ticks from one property to another on animals such as rabbits, hares and birds is likely. This local spread has been suggested as the source of infection on farms where there was no movement of cattle onto the property.

It is theoretically possible to transfer Theileria infection from one animal to another by transferring infected blood. Circumstances where this could occur are multi-use needles and biting insects such as biting flies and sucking lice.

Further investigation is required to establish if these are risks under New Zealand conditions. Just what role these forms of iatrogenic spread have in causing disease is unknown; although likely to be minor in comparison to spread by the tick vector. The life-cycle of Theilera is not able to be completed by this form of transmission.

(cont'd pg 8)

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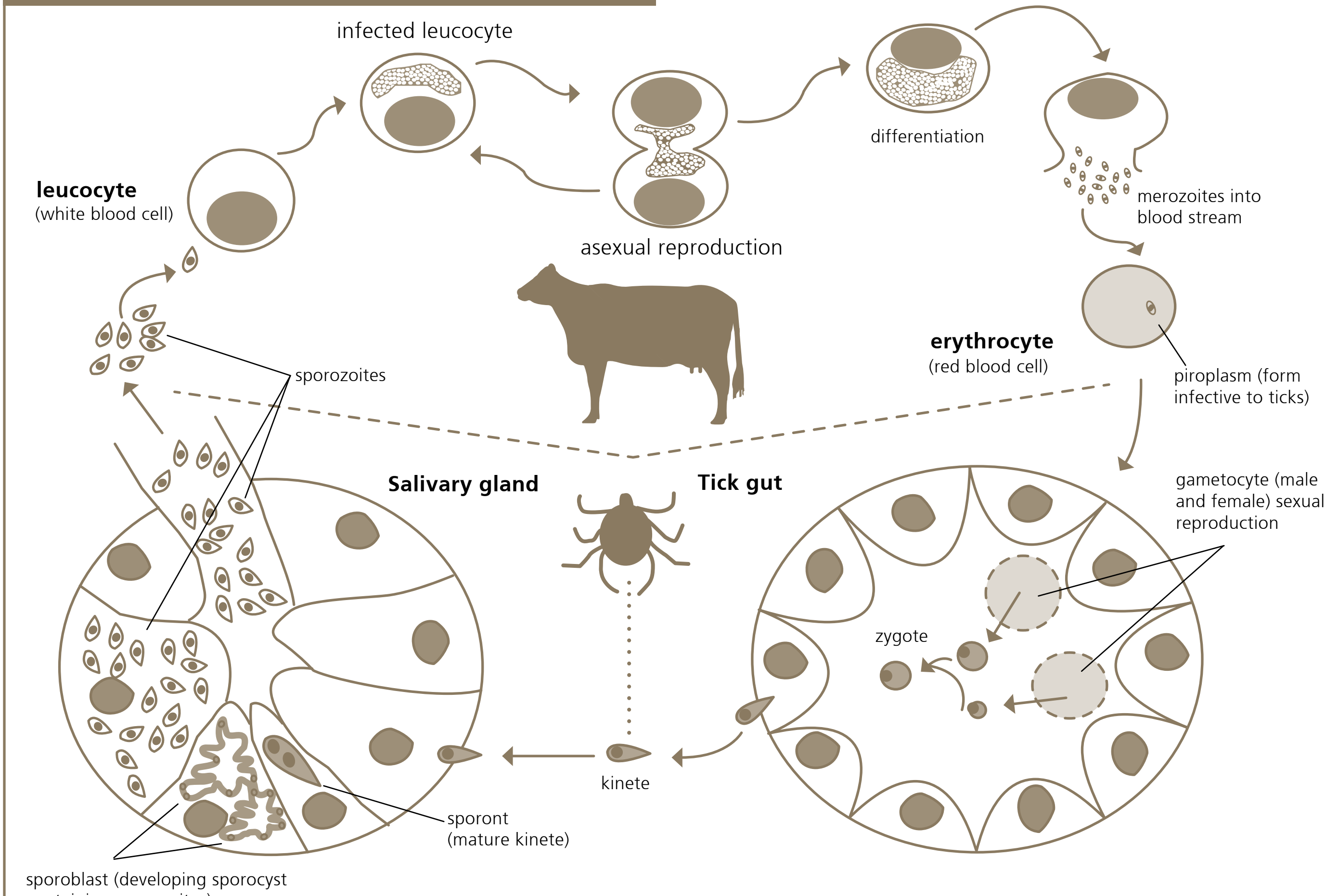
T. orientalis life-cycle

When the tick feeds, it releases sporozoites in the saliva. These invade while blood cells, lymphoid tissue and maybe the spleen in the new cattle host. They reproduce asexually, eventually producing merozoites which invade red blood cells and become piroplasms infecting red blood cells.

The piroplasm is the form of parasite in a cow's red blood cells that causes the damage that leads to anaemia.

Ticks ingest the infected red blood cells. In the tick gut, a form of sexual reproduction occurs and the resulting kinete migrates through the tick to its salivary glands and multiplies.

The life-cycle of Theileria annulata *(as an example)*



Source: Redrawn from Mehlhorn 1996

Further reading

Anonymous (2013). Anaemia in cattle caused by *Theileria orientalis* Ikeda, Response update to Stakeholders (15 November 2013). Ministry for Primary Industries, Wellington.

Lawrence, K., McFadden, A. and Pulford, D. (2013). *Theileria orientalis* (Ikeda) associated bovine anaemia: The epidemic to date. Vetscript 26, 12-13.

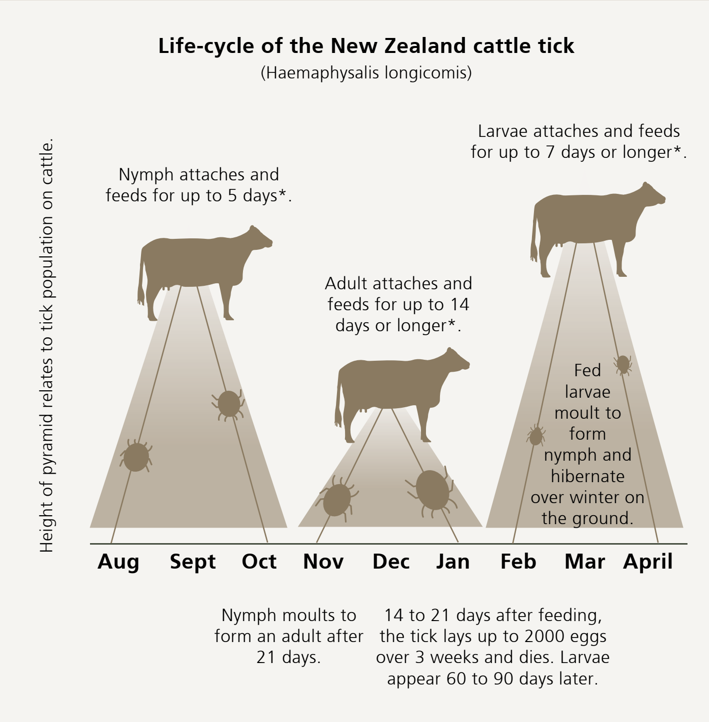
Hickey, K. (2013). Questions and answers surrounding the 2012-2013 outbreak of cattle anaemia associated with *Theileria orientalis*. Sourced from http://www.mpi.govt.nz/biosecurity-animal-welfare/pests-diseases/theileria-and-anaemia-in-cattle.

Kamau, J., Salim, B., Yokoyama, N., Kinyanjui, P. and Sugimoto, C. (2011) Rapid discrimination and quantification of *Theileria orientalis* types using ribosomal DNA internal transcribed space. Infection, Genetics and Evolution, 11, 407-4.

Tick life-cycle

* This graph indicates the periods when the tick population can be seen in relation to each life-cycle stage. Occasionally the life-cycle stages will not be obvious, as ticks do have the ability to cycle several times within one year if conditions are suitable.

Reproduced with permission from Bayer Animal Health NZ



Tick biology drives infestation

Nita Harding, DairyNZ animal husbandry team leader; Eric Hillerton, DairyNZ chief scientist

Only one tick affects livestock in New Zealand and this is the New Zealand cattle tick, Haemaphysalis longicornis. This tick originates from eastern Asia and was introduced into New Zealand more than a century ago, most probably on imported cattle.

The tick will feed on all ruminants and has also been reported on other animals and birds. As with all ectoparasites (parasites that live on the surface of the host), a heavy infestation can cause anaemia, considerable local skin irritation, some loss of body condition and, very occasionally, death (particularly in young animals).

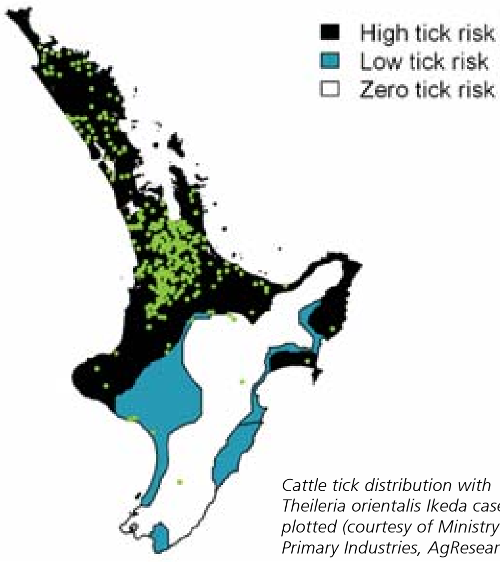
In dairy cows, heavy tick infestations have been suggested to cause a reduction in milk production. Sheep with heavy tick infestations will rub due to irritation from ticks, reducing the quantity and quality of the wool clip.

The tick is distributed in the warmer northern areas of New Zealand and has been recorded in Northland, Auckland, much of the Waikato, Bay of Plenty, Gisborne and Taranaki. Distribution in the South Island is limited, with the tick present in Marlborough, Nelson and Takaka.

However, reports are limited by how close observations have been. The juvenile ticks, especially the larvae, are very small and therefore not obvious. Ticks feed where they can get access to blood vessels just under the skin surface, so small numbers are easily overlooked.

Tick distribution

Ticks are found mostly in the North Island and top of the South Island but they can be present on animals in other parts of the country that have been moved from areas where ticks are present. All cattle in areas where ticks are present are at risk of being infected with Theileria.



Cattle tick distribution with Theileria orientalis Ikeda cases plotted (courtesy of Ministry for Primary Industries, AgResearch).

Tick activity

The cattle tick has four developmental stages – egg, six-legged larvae, eight-legged nymph and eight-legged adult. Generally, the tick completes one life-cycle per year. However, in warm and moist conditions more than one life-cycle may occur (see life-cycle illustration, pg 9).

The New Zealand strain is parthenogenetic (reproduces asexually), so only adult female ticks are present.

Tick populations show a distinct seasonal pattern. Eggs are usually laid from late November to early February. These hatch into larvae after about 90 days. The larvae feed for up to seven days from late summer into the autumn. Fed larvae drop into the sward base and moult to become nymphs.

Nymphs first appear in late autumn and into winter. Unless the winter is very mild, nymphs have a period of dormancy and become active again in September and October. Adults first appear in early November, with their peak period of activity in late November to early January.

The tick spends most its life at the bottom of vegetation. Each stage, apart from the egg, must feed on blood from an animal host, but only once, before development into the next stage. The period of time spent on the host animal is short – larvae feed for around seven days, and nymphs and adults for 5-14 days each. After feeding, the tick falls to the ground and develops into the next stage weeks or months later, depending on temperature. Unfed ticks can survive for up to 12 months.

When hungry, the larva, nymph or adult climbs up a plant stem to wait for a passing host. They sense the presence of a host by warmth, movement, change in light and carbon dioxide gradients. This is called "questing". They grasp onto the host as it walks past, using their front legs. Once on the host, they seek softer skinned and better protected areas to start feeding, such as around the udder, under the tail and in the ears.

Tick behaviour is controlled by hunger and weather. Ticks do not like hot, dry conditions, being most active when the temperature is between 10-20°C and humidity is above 60%. Longevity is controlled by fat reserves and desiccation. In hot, dry conditions ticks have a short life if they do not encounter a host.

In cool and moist conditions, a tick will survive many months waiting for a host. Thus this tick is found in cold and snowy winter environments such as Hokkaido, Japan's large northern island and home of their dairy industry, where winter snowfall can easily be a metre deep.

Larvae are small and not easily seen on cattle. Measuring up to 1.5 mm, nymphs are bigger and brown in colour. Unfed adult ticks are about 3 mm long, thin and red-brown in colour. Fully fed adults can be up to 6 mm in diameter and large numbers on cattle are obvious.

(cont'd pg 12)

Nymph (1.5 mm)

Unfed adult tick (3 mm)

Fully fed adult tick (6 mm)

(cont'd from pg 11)

Managing ticks within the farm system

Heavy tick burdens can have a severe impact on young animals. Deaths of fawns within a few days of birth, as a result of anaemia, was a particular problem for the deer industry in the 1980s.

Because ticks spend most of their life off animals, controlling ticks by treating animals has a limited impact on the total population of ticks on a farm.

It may be important to deal with large infestations on animals and a new and immediate threat by chemical control. Understanding the conditions that favour ticks, and managing pastures and grazing to reduce tick survival in the pasture, will be more effective long-term.

Control of ticks on animals

Inspecting animals for ticks is recommended as part of general biosecurity precautions when animals arrive on a farm. Even if no ticks are found, all animals should be quarantined for 7-28 days, depending on the disease threat. If ticks are present, the risk of Theileriosis can be assessed and precautions taken to protect the resident herd, if necessary.

Currently, two tick treatments are licenced in New Zealand. When used according to the manufacturers' recommendations, especially frequency and quantity of use, the products have a nil milk and meat withholding period.

As pyrethroids is the only ectoparasiticide suitable for such use, overuse is discouraged, as this could hasten a resistance to the chemicals and leave farmers with no suitable products for treating lactating dairy cows.

Control of ticks by pasture management

Ticks require adequate cover for survival. Long, rank pasture, fern, scrub, rushes and sheltered areas along hedges favour tick survival. Newly developed or closely grazed pastures are unlikely to offer much protection for the various stages of the tick life-cycle.

Well-managed dairy pastures will have little in the way of suitable tick habitat. Pasture at runoffs may be of more concern, as it may not be grazed as intensively and may have rougher areas that are difficult to graze closely.

The longer grass around the paddock's edge after a crop has been harvested (silage, hay or maize) can be an area where favourable tick habitats exist. After not being grazed for some time, this may contain large numbers of ticks awaiting hosts.

Warm, moist conditions enhance tick survival and development. When seasons are unusually warm (winter 2013) or when paddock conditions remain moist, more ticks will survive. Farmers in areas of the country where ticks occur may find it useful to evaluate the tick risk of their paddocks, based on how favourable conditions at the base of the pasture are for ticks.

Longer grass and sheltered paddocks are likely to be higher risk and the first grazing of these paddocks may be best done by older stock, rather than more susceptible younger stock such as calves.

Estimating tick abundance and activity is best done by a blanket drag.

A white woollen blanket or piece of corduroy, about 50 cm wide, stiffened by a pole or cane, and up to 1 m long, is dragged by a string along a series of 5 m strips of vegetation until ticks are found.

Adult ticks that attach to the blanket can be counted. Larvae are best counted and removed at the end of the series of drags because they are not easily dislodged from the blanket during sampling, and are easily overlooked at the end of each sample drag when scarce and because of their size.

Blanket dragging over different paddocks will give an indication of the numbers of ticks and relative risk of different parts of the farm.

Once ticks are established in an area, it is unlikely they can be eradicated, unless extremes of temperature and drought are experienced. Though ticks do not move far once they fall from a host to the base of the pasture, other animals, including birds, can transfer ticks from one property to another. It is considered that local spread of up to 5 km can occur this way.

Pasture management to reduce tick numbers

1. Plan ahead.
2. Prepare pastures for susceptible stock one year in advance, by grazing to low residuals during December to March.
3. Have paddocks/breaks a suitable size for the mobs of animals, so they are grazed evenly and to the desired residual (1500-1600 kg DM/ha).
4. Avoid putting young stock in paddocks where tick populations are likely to be high (rougher, longer pasture or pasture that has not been grazed for some time).

Further reading

DairyNZ farmer fact sheet 5. www.dairynz.co.nz/theileria.

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Managing Theileriosis on-farm

Nita Harding, DairyNZ animal husbandry team leader

Theileriosis is a disease that can have a significant on-farm impact. Overall, the rate of severe clinical cases on affected farms has been low (1-2% of the herd). However, a small number of herds have experienced a far greater incidence of the disease and animal losses of up to 15%.

Economic impacts from Theileriosis are not restricted to costs associated with managing clinical disease, such as treatment and the time required to provide extra nursing care to affected animals.

The potential impact on-farm could be significant. Losses could arise from:

- reduced milk production – milk withhold after drug treatment and lower production from not eating (Australian data suggest the latter is minimal with mild cases)
- increased feed costs, including changing grazing routines and paddock use, and cost of supplementary feed
- stock losses
- cost of preventative treatment
- cost of therapy and veterinary attention
- possible longer-term effects of lower growth rates in young stock.

Understanding contributing factors and taking a pro-active approach to diseases such as Theileriosis is part of an animal health plan. When the problem is a new disease, its management is also part of a biosecurity plan.

Theileriosis is a timely reminder that New Zealand dairy farming is lucky in the limited range of biosecurity problems it faces but the industry remains at constant threat from the new, the different and the unexpected. Adopting best practice in biosecurity is the first line of defence.

Managing the risk of introducing Ikeda Theileriosis

It is important to understand how the risk of Theileriosis varies by region and individual farm. This includes:

- if the region is a known or potential tick area
- if local herds are already affected by Ikeda Theileriosis,
- if animals have been introduced to the farm from an affected area or been on a higher risk part of the farm (e.g. purchased animals, animals returning from a grazier or run-off).

Theileriosis is spread from animal to animal via ticks (see pg 10). Ticks move little locally.

They move up plant stems from the plant base to find a host. They then drop off the host after feeding and, as that will be several days later, they drop into a different paddock maybe some distance away. If they cannot find a bovine host, they feed from other mammals or birds, and this may move them outside the farm boundary.

This may be why farms up to 5 km from an infected herd have experienced Theileriosis when they have not moved animals and have no direct contact with an infected farm.

There is little that can be done to control this type of spread. However, understanding this process and the likelihood of infection shows that vigilance is necessary in monitoring a herd for ticks.

Although wild animals can contribute to Theileriosis spreading, the main source of farm infection is from livestock. This can be by introducing infected cattle and/or by transported stock hosting infected ticks. Infected ticks may arrive with animals other than cattle, such as sheep, deer and dogs.

It is important to understand the health status of incoming animals to be able to take precautions to protect the health of the resident herd. Incoming animals should be kept separate from resident animals for at least seven days and checked for ticks.

Where control of ticks is advised (e.g. an area that does not have ticks, a resident herd not yet exposed to Theileriosis or in a high risk season), animals can be treated prior to mixing with resident animals.

It may be useful to insist that cattle are treated before transport, rather than after arrival, because the risk of introducing infection will be lowered and the risk of animals becoming tick infested or infected during transport will be reduced.

It is very important that animals returning to the home farm from grazing-off are regarded as incoming animals, to be quarantined and treated as necessary.

Farmer case reports

Signs of Theileriosis in cattle are generally subtle because the disease is mostly mild.

Farmer comments have usually been along the lines of "the animals were just not right, but I couldn't put my finger on why".

One Waikato farmer reported the first sign of Theileriosis in his cows as the sight of hollow-sided animals that were not interested in eating. Affected animals were also slow to walk to the shed and some cows had lower than expected milk production (based on a timely herd test).

The observation of change in an animal's movement is one made by the experienced stock person and may have been missed by less experienced or unengaged staff or a relief milker.

The farmer believed that infection began the previous autumn at a run-off block. Yearling growth rates were lower than normal, despite plenty of feed available. When weighed in May, heifers were 30 kg lighter than expected. The later calving cows were also grazed at the run-off during winter and these were the first cows to show signs of anaemia.

For other farmers, unexplained deaths at calving and lethargic cows were the first signs of disease. Affected cows spent much of the day sitting or standing with their heads down. Sudden death when these cows were moved was common. The incidence of Theileriosis may have been higher than reported as one or two 'extra' perinatal deaths may only be recognised after calving has been completed.

Higher than expected numbers of abortions were occasionally reported by farmers, some occurring within a few weeks of expected calving dates, and the cows were often slow to recover. Some calves were born dead, even when close to full-term.

In general, the mortality has been quite low (0-2% of animals in affected herds). A few herds have had much higher numbers of animals affected, and in some cases, significant numbers of deaths (up to 15% of the herd).

The prevalence of anaemia, the frequency of infection/subclinical disease with no observable signs without blood testing, has ranged from 10-88% of cows in affected herds, with an average prevalence of 33%[1].

(cont'd pg 16)

(cont'd from pg 15)

Limiting the disease's impact

Once some cows have Theileriosis, and ticks are present, it is common for infection to spread gradually through the remainder of the herd. If Ikeda behaves like Chitose, then a level of infection without disease will become 'normal'. It will always be necessary to minimise stress on animals at times of risk of new infection or vulnerability, such as at calving.

Cattle are less able to cope with a new infection and show more severe clinical signs during stressful events. This was probably a factor in the large number of cases over the calving period in 2013.

Other stressful events that could reduce an animal's ability to cope with infection are weaning, transport and mixing groups of animals. Making these events as stress-free as possible should reduce the impact of Theileriosis.

Most animals showing signs of severe anaemia resulting from Theileriosis can be treated and will recover. However, prompt identification, good nursing care and, in some cases, supportive therapy such as blood transfusions will be required.

The drug buparvaquone is used to treat the much more severe *Theileria parva* infections in Africa but is not licenced elsewhere.

It has been available for restricted use in New Zealand under a special permit, but has long withholding periods (35 days for milk and 140 days for meat) and specific animal identification and management requirements. Its use is, therefore, a drastic action. So far, little evidence is available on its effectiveness.

A summary of on-farm management

It is now considered that Ikeda Theileriosis has joined Chitose Theileriosis as an endemic infection in areas of New Zealand where ticks are present, and farmers need to adopt measures to minimise its impact.

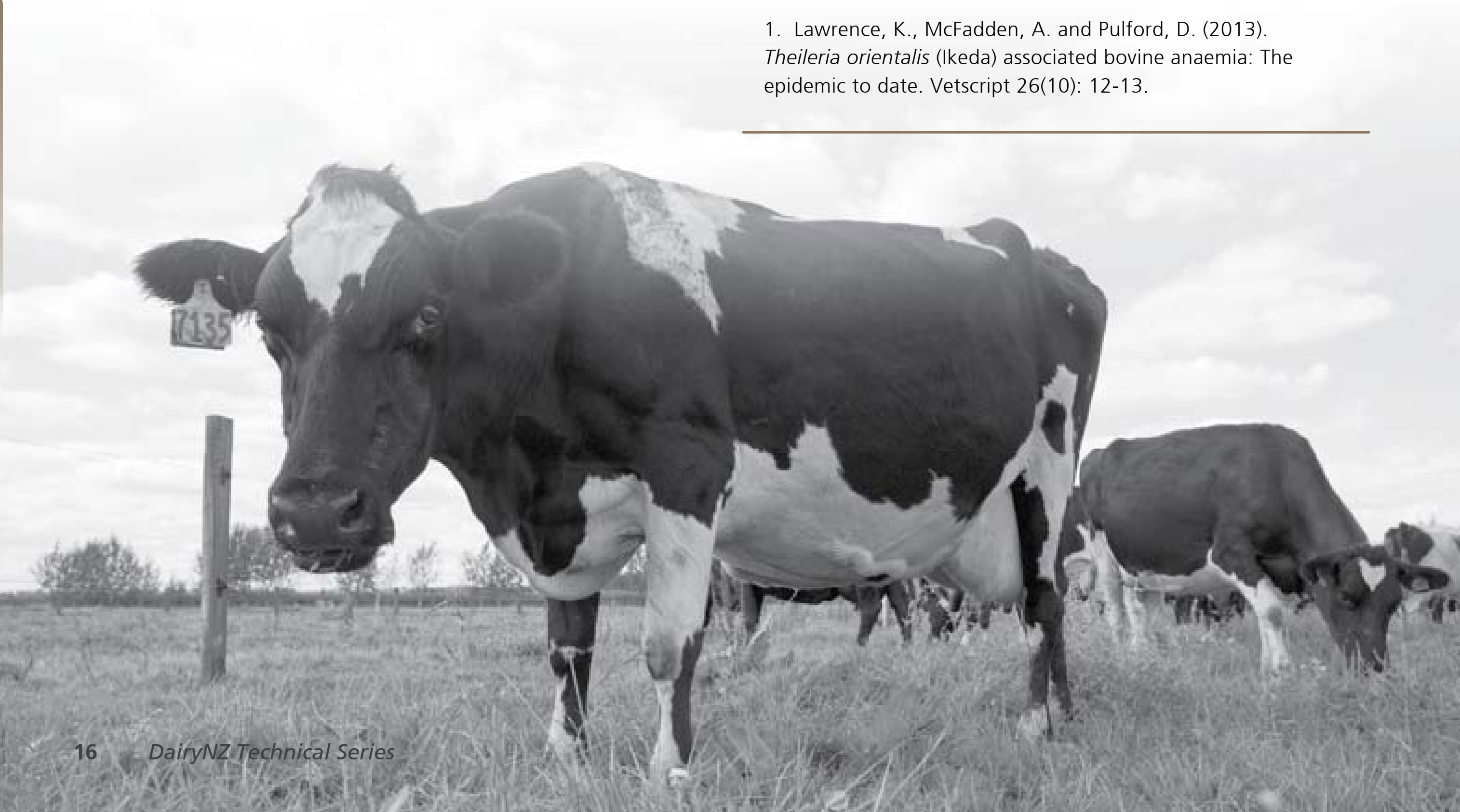
Considerations should include:

- pasture management to minimise tick numbers
- strategic use of tick treatment to minimise the effect of ticks on animal health and reduce the opportunity for infection (see pg 12)
- locating and managing cattle appropriately at stressful times
- keeping animals in good condition and well-fed so they are better able to cope with disease challenges and stressful events
- applying good biosecurity principles around the movement of animals onto the farm (the health status of incoming animals is known, appropriate isolation occurs and treatment to protect resident animals)
- training staff so there is ability to recognise signs of Theileriosis to ensure prompt action is taken to manage and care for sick animals.

As always, farmers with concerns about the health of their animals should seek veterinary advice. Local veterinarians will be aware of the impact of Theileriosis in the area and can provide information to assist with decisions about managing the disease on-farm.

References

1. Lawrence, K., McFadden, A. and Pulford, D. (2013). *Theileria orientalis* (Ikeda) associated bovine anaemia: The epidemic to date. Vetscript 26(10): 12-13.



Managing the disease – what next?

Eric Hillerton, DairyNZ chief scientist

Theileriosis will not go away and the geographical range of infection is likely to expand. The good news, however, is that the likely impact and severity of the disease will lessen over time.

Ikeda Theileriosis will have future cycles of disease affecting New Zealand cattle and is likely to follow a similar epidemiological pattern to most infectious diseases, with the impact and severity lessening over time.

This is usually because the virulence of the causative organism decreases as an evolutionary factor. It is self-limiting for a parasite/pathogen to kill its host or render it too ill to allow for successful completion of its life-cycle. Also, the proportion of naive animals in the general population will shrink and, hopefully, a degree of immunity will develop.

So, infection will probably remain common 'forever' but not disease (e.g. Chitose Theileriosis [another strain] has been known in New Zealand for 30 years and is well distributed). The DairyNZ herds at Newstead, Hamilton, have 40% of cows infected with Chitose but no anaemia or other signs of disease. Ikeda Theileriosis should develop similarly.

The geographical range of infection will be limited by the availability of ticks; how well farmers identify and treat tick infestations; the introduction of infected animals to naive animals (i.e. animals that have not been exposed to the disease previously); and how farmers control animal movement on their own farms (i.e. their biosecurity protocols).

The latter is about testing animals for purchase or movement, and minimising the likelihood of infection being transmitted.

Future impacts will vary, as herd replacement brings in temporarily naive animals (unless they are infected as young stock); as susceptibility varies with animal physiology (e.g. the 2013 clinical problems occurred in immune-compromised cows around calving); and due to the amount of exposure from the size of the tick population.

The Australian experience

Various parts of Australia suffered from Ikeda Theileriosis a few years before New Zealand. Their experiences are useful in planning what might happen next, how to prepare and how to respond.

The clinical picture appears much less severe in Australia, so they did not need to resort to emergency drug use. They now believe this form of treatment is not necessary. The approach in Victoria is to apply good nursing policies which include minimising unnecessary walking, milking once-a-day or even once every two or three days, supplying high quality feed and providing any other supportive treatment necessary.

The most contentious of the Australian views is not to use tick control unless ticks are a special burden. The argument is that a small scale exposure of healthy animals to infected ticks is actually a 'vaccination', despite the fact that the cow may become permanently infected.

If no disease results, the immune system is probably controlling the infection. A study of one herd suggests no effect of infection on milk volume.

New Zealand next year

These are ideas that New Zealand veterinarians, epidemiologists, animal scientists and farmers need to consider before the next issue to face us in New Zealand, the emergence of (uninfected) tick larvae in March/April.

If these larvae feed on infected cows, the survivors to the nymphal stage will transmit infection to naive cattle in July-September.

It may be necessary to challenge some of the responses and perceptions we have been using in the past few months to evolve an effective system of control. Thus the ideas mooted here have been considered in the development of a seasonal theileriosis management plan included with this issue of the *Technical Series*.

Where to from here?

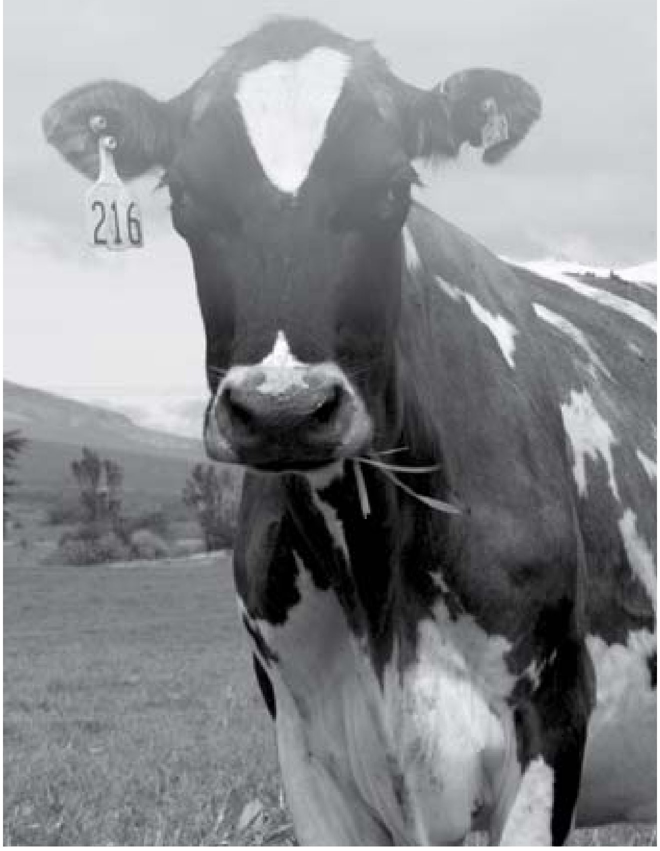
- Ikeda Theileriosis will have future cycles of disease affecting New Zealand cattle but the impact and severity is likely to lessen over time.
- Infection will probably remain common 'forever' but not disease (e.g. Chitose Theileriosis [another strain] has been known in New Zealand for 30 years and is well distributed).
- New Zealand veterinarians, epidemiologists, animal scientists and farmers need to consider the options before the emergence of (uninfected) tick larvae in March/April.
- If they feed on infected cows, the survivors to the nymphal stage will transmit infection to naive cattle in July-September.
- A seasonal management plan included in this issue will help manage theileriosis going forward.

What does measuring mRNA tell us?

Rachel Boyle, Talia Grala, Claire Phyn and Jane Kay, DairyNZ research

From previous articles:

- a cell uses a recipe (gene) to make a protein
- mRNA is translated into an amino acid chain
- this chain folds to form a functional protein.



Going back to the recipe book analogy, every cell in an organism has the exact same recipe book, but the RNA tells us what the cells are 'making' at that time or which genes are being expressed.

We can extract the mRNA from different tissues (udder, liver, fat, uterus) and then use a variety of techniques to find out what is going on at a molecular (or gene) level.

Because we can tell which genes the mRNA is made from, we can quantify how much a gene is being transcribed by counting the number of copies of the mRNA. Variation in mRNA copy number is called `differential expression'.

Expression of a gene can affect the activity of various chemical and biological pathways that cause the physical effects we can measure in the cow, such as milk yield and composition, or body weight and body condition score.

We can measure differential expression by extracting the mRNA from tissues and comparing different treatments, or cows with different conception rates or milk production levels. Our two main methods for measuring mRNA are quantitative polymerase chain reaction (qPCR) and microarrays.

Treatment effect on genes

The qPCR method measures the number of copies of mRNA from a specific gene. We choose key genes involved in processes such as milk synthesis, body fat synthesis and immune responses to tell us what effect a treatment is having on those specific genes.

For example, we wanted to know if cows milked once-a-day had improved body condition score because of either greater body fat synthesis or lower body fat mobilisation. Using qPCR, we targeted genes that we know make enzymes to synthesise or degrade body fat.

Quantifying the mRNA of these genes indicated that cows milked once-a-day had greater expression of the genes that make body fat compared with cows milked twice-a-day.

Microarrays measure the mRNA copy number for thousands of genes at once, and not just for targeted genes. This is a great way of finding genes that were not previously known to be involved in a particular biological process, so sometimes microarrays are used for 'gene discovery'.

Gene involvement

'Gene discovery' is a bit of a misnomer, as microarrays do not discover 'new' genes, but they can tell us which genes are involved in various processes or responses.

In our research, we have used microarrays to compare the genetic and physical effects of various states of fertility (e.g. fertile vs. sub-fertile cow strains, pregnant vs. non-pregnant). Fertility is a very complex process, so selecting target genes is more difficult than for body fat synthesis.

In this case, the microarray compared the expression of 17,000 genes between fertile and sub-fertile cows. This told us there were many genes that were differentially expressed between these two groups of cows, including some that were not previously known to be important for fertility.

Summary

- RNA tells us what the cells are 'making' at that time.
- Changes in mRNA copy number tell us what effect a treatment has at the molecular level.
- We can measure specific genes either one at a time, or many thousands at once.

Focus on international research

DairyNZ comments on three recently published key science papers

Amaral and others (2012) Sward structure management for a maximum short-term intake rate in annual ryegrass
Grass and Forage Science 68: 271-277
This Brazilian study tested the hypothesis that different sward structures, constructed by varying the pre- and post-grazing sward heights of annual ryegrass (Lolium multiflorum Lam) affect the short-term intake rate by dairy cows. The management strategy of grazing a 25 cm sward down to 10 cm post-grazing afforded a higher short-term intake rate. The authors noted that when considering the residual sward height effect on subsequent rates of sward regrowth, the strategy of grazing from 15 cm to 10 cm would maximise growth rates.

DairyNZ comment: The above study highlights the dilemma between achieving high forage intake without compromising seasonal and annual herbage production, and sward quality at subsequent grazing rounds. A 10 cm post-grazing height is higher than current DairyNZ recommendations. However, the challenge of feeding cows of high production potential (high BW), particularly at lower stocking rates, without the reduction in pasture quality may require re-evaluation of the optimum post-grazing sward height.

Farina and others (2013) An integrated assessment of business risk for pasture-based dairy farm systems intensification
Agricultural Systems 115: 10-20
The complementary forages system (CFS) integrates both pasture and forage crops (e.g. triple crop rotation of maize, forage rape and Persian clover or field peas, and a double crop rotation of maize and Persian clover), achieving more than 25t DM/ha of home-grown forage utilised. An integrated modelling approach assessed the business risk of the CFS and compared it to a pasture plus grain system (PG), and to a base pasture system (Base). Risk analysis indicated that milk price was the variable with the highest impact on operating profit followed by forage yields. When integrating all variables, PG showed the highest business risk, followed by Base and CFS, respectively. The CFS system showed a lower inter-annual variation in feed consumption, and a lower impact of forage yields on operating profit, indicating that the CFS system was able to compensate 'bad years' in terms of amount of pasture utilised per ha with feed produced by the forage crops area. The authors noted that a high level of forage management was required to achieve optimum yields for the CFS system to be successful.

DairyNZ comment: The limit to the potential yield from pasture based systems in New Zealand is well-recognised. However, a considerable proportion of pasture is still wasted and DairyNZ advises, as the first step to increase milk production, the use of feed budgets to increase pasture utilisation. However, future dairy systems may need to integrate pasture and crops to ensure the benefits of both are captured. Recently funded DairyNZ-led research "Forages for reduced nitrate leaching" will investigate the potential of integrating forage crops and diverse pasture mixes in dairy systems.

Jacobs and others (2012) Gradients in fracture force and grazing resistance across canopy layers in seven tropical grass species
Grass and Forage Science 68: 278-287
A glasshouse study assessed the physical properties of plants that contribute to grazing resistance between tropical grass species. Grazing resistance increased down the plant profile from top to bottom. High stem densities did not always increase grazing resistance due to low stem fracture force. For a common leaf fracture force, leaf density did contribute to increased grazing resistance.

DairyNZ comment: The principles relating sward structure with grazing resistance are similar for temperate species (e.g. perennial ryegrass). Currently there is little information on the phenology of New Zealand-bred perennial ryegrass cultivars. Within the DairyNZ Forage Value Index research programme, DairyNZ has initiated work to quantify plant phenotypic variation and its relationship with selective behaviour and grazing efficiency/forage intake.