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BRIEF COMMUNICATION: The use of infrared thermography and feeding behaviour for early disease detection in New Zealand dairy calves

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Introduction

Neonatal calf diarrhoea (NCD) is a disease impacting livestock industries economically and in terms of animal health and welfare. In New Zealand, the most prevalent pathogens associated with NCD are rotavirus and *Cryptosporidium* (Mawly et al. 2015), but other common pathogens include coronavirus and *Salmonella*. By the time an animal presents with clinical signs of disease, much of the associated tissue damage to the intestinal submucosa may have already occurred, hence affecting production. Therefore, there is a need to develop methods for early disease detection, which ideally could be incorporated into automated systems for real-time, remote sensing.

Infrared thermography (IRT) is a non-invasive method of detecting radiated heat. The use of IRT in livestock and veterinary applications was reviewed by Luzi et al. (2013). Studies have shown IRT can be used for early identification of calves with BRD (bovine respiratory disease) and BVD (bovine viral diarrhoea), using changes in eye temperature (Schaefer et al. 2004, 2012). Schaefer et al. (2012) demonstrated that images could be collected automatically at a water trough. In dairy calves, the behavioural information (e.g. number of visits) gathered remotely at an automatic calf-feeding (ACF) system can be used for identification of at risk animals (Svensson & Jensen, 2007; Borderas et al. 2009). However, the use of these automated systems has not been fully investigated under New Zealand conditions, where calves are exposed to different pathogens and management.

This study was part of a larger project investigating automated methods for early disease detection. The aim of this part of the study was to investigate the thermal responses of different body areas and feeding behaviour associated with the onset of NCD.

Materials and methods

Procedures were approved by the University of Waikato Animal Ethics Committee under the New Zealand Animal Welfare Act 1999 (Protocol #955).

Animals & experimental design

The study was undertaken at a farm in the Waikato, between August and October 2015. Forty-three mix-breed calves (20 male and 23 female) were sourced from commercial farms and transported to the facility at four

days old. Calves were housed in one of two separated, purpose-built indoor pens (6.6 x 8.1 m) with a 30 m² area of wood chip bedding (25 cm deep). Calves were fed as described below using an ACF and given *ad libitum* access to meal, water and hay.

The trial consisted of two replicates of two treatments into which calves were randomly assigned upon arrival. At six days of age, one group of calves were infected with rotavirus (n=20 (10 males:10 females)) and the second group acted as uninfected controls (n=23 (10 males:13 females)). Calves were infected with rotavirus through an oral drench containing a mixture of 40 mL water and 6 mL faeces (collected from two calves positive for rotavirus).

Clinical observations

Health checks were carried out daily to identify when calves began to display clinical signs of illness. Calves were assessed based on their general appearance/posture, coat condition, gut fill, rectal body temperature and faecal consistency. Dehydration was evaluated by assessing 'sunken eyes' and performing a skin tent test to measure elasticity. In order to verify disease a faecal sample was collected and analysed (NZVP, Hamilton, NZ) for the presence of rotavirus, coronavirus, *Cryptosporidium*, and *Salmonella*. Once identified as clinical, calves were treated accordingly with electrolytes and antibiotics where necessary.
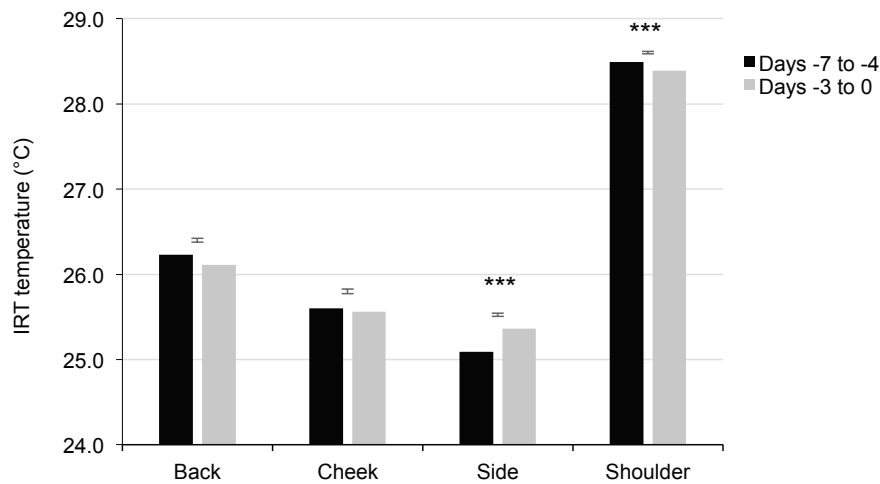
Infrared thermography

IRT images of the animals' side, dorsal area, eye and cheek were collected daily, using an IRT camera (ThermaCam S60, FLIR, Sweden). The camera was calibrated for ambient temperature, humidity and emissivity (0.98). Images were collected in the pen at a set distance (1-3 m) and angle (90°) from the left side of the animal (except for dorsal images). Images were analysed using FLIR Researcher (Version 2.10, Sweden) to calculate the maximum, minimum and average temperatures for each area. The dorsal images were split into two areas (over the shoulder blades, 'Shoulders' and lower back 'Back').

Feeding behaviour

Each pen had an ACF (A&D Reid, Temuka, New Zealand) with an electronic identification (EID) system. Initially calves were given 4 L of milk replacer/day which was later increased to 6 L per day. Each daily allowance

Figure 1 Mean (± SEM) IRT temperature of the body areas during days -7 to -4 compared to days -3 to 0 relative to clinical identification of NCD (day 0) in forty mix-breed calves. *** P<0.001.

(Fig.1). Temperature decreases may be due to the animal attempting to reach a state of fever in order to fight against the infection by restricting blood flow to the skin and extremities, which restricts heat loss and enables the animal to maintain homeostasis. In comparison, the increase in side temperature may be due to the close proximity to the site of infection (rumen fossa), and the localised inflammation of the intestines.

Schaefer et al. (2004) investigated IRT as an early detection method for BVD and took images from a number of body areas (side, back, hooves, ear, nose and eye) and found eye temperature increased several days prior to clinical signs. In contrast, in the present study, there was no change in eye temperature.

was split into three allocations of 2 L with six hours stand-down time between each allocation. Milk consumption and the number of visits (rewarded and unrewarded) were recorded.

Statistical analysis

The effectiveness of the treatment was variable, but an unexpected outbreak of *Salmonella* resulted in all calves developing NCD, therefore, treatment was ignored and each animal was analysed as its own control. Three animals were excluded from the analysis due to insufficient data. For all variables, comparisons were made between days -7 to -4 to days -3 to 0 relative to clinical identification (day 0). For feeding behaviours, comparisons were also made between days -7 to -1 (Pre) to days 0 to 6 (Post). The sign test measured the significance of changes between periods. Standard error of the means (SEM) and standard error of the difference (SED) were used to measure variability. For IRT data, ambient temperature and humidity were included as covariates to adjust for environmental conditions.

Results and discussion

There was a decrease in shoulder (P<0.001) and an increase in side (P<0.001) temperature during the four days before clinical signs compared to the previous four days

Inconsistencies between studies are likely due to the different pathogens and mode of action associated with each disease. However, the present results confirm those of Schaefer et al. (2004) in that changes in IRT temperature occur in the days prior to clinical signs. No change in cheek temperature was found in response to NCD.

In the four days before clinical signs, there were no changes in feeding behaviours compared to the previous four days, except for an increase in the number of visits per day (P=0.024), which was likely due to calves still learning to use the ACF. However, milk consumption, total number of visits and percentage of unrewarded visits to the ACF were all found to decrease and percentage of rewarded visits increased after calves became clinical (P≤0.002; Table 1). Milk allowance needs to be considered when using changes in feeding behaviour to identify diseased animals. Borderas et al. (2009) found that when fed high allowances, sick calves decreased milk consumption and visits to the ACF; however, when fed low allowances consumption was not affected. Also, similar to the present findings, Svensson & Jensen (2007) reported that sick calves decreased the number of unrewarded visits and suggested that this was

Table 1 Mean (± SEM) and difference for feed consumption, total visits, percentage of rewarded and percentage of unrewarded visits comparing days -7 to -4 to days -3 to 0 and days -7 to -1 (Pre) to days 0 to 6 (Post) relative to clinical identification of NCD (day 0) in forty mix-breed calves.

	Days -7 to -4	Days -3 to 0	Difference	P value	Days -7 to -1	Days 0 to 6	Difference	P value
	Average				Average			
Milk consumption (% of daily allowance)	64.8±3.3	58.6±3.2	-6.2	0.099	64.2±2.7	37.5±3.7	-26.7	<0.001
Total visits/per day	5.2±0.6	5.3±0.3	0.1	0.024	5.5±0.4	3.3±0.3	-2.2	<0.001
% Rewarded visits/per day	62.4±2.5	63.6±2.1	1.2	0.430	61.7±1.7	70.2±2.7	8.5	0.002
% Unrewarded visits/per day	37.6±2.5	35.8±12.3	-1.8	0.430	38.3±1.7	26.4±2.1	-11.9	<0.001

a useful indicator of disease. Unrewarded visits represent calves testing the ACF to see if milk is available so a decrease suggests a reduction in appetite.

Although IRT temperature and feeding behaviours were found to change in response to illness, for feeding behaviour these changes were typically only significant once calves became clinical. However, a change in side and shoulder temperatures were detected prior to clinical signs and may be useful indicators for early disease detection. IRT could be implemented into automated dairy systems for daily animal-health monitoring.

Acknowledgements

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