

## ANZCCART Student Award

# Infrared thermography and heart rate variability for non-invasive assessment of animal welfare

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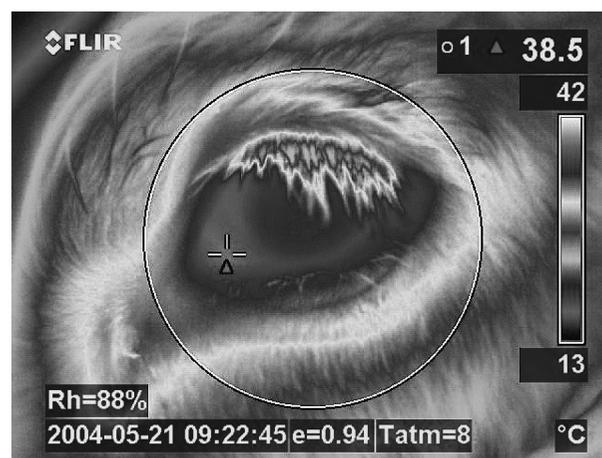
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## Introduction

The assessment and alleviation of pain and stress during and following routine husbandry procedures used on farms (e.g., disbudding and castration of calves) are important components of farm animal welfare. Despite evidence which demonstrates the welfare benefits of using analgesics, in most countries it is still common practice and legal to conduct procedures such as disbudding, dehorning and castration of young calves without pain relief. There are many reasons why there is a lack of use of analgesics in farm animals including practical and economical factors.

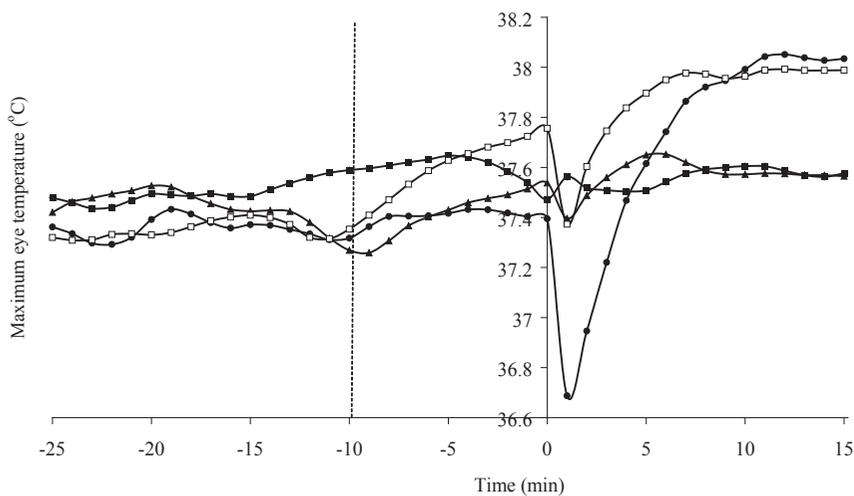
The assessment and management of pain in farm animals has been reviewed previously (e.g., Mellor et al. 2000; Vinuela-Fernandez et al. 2007). A major issue for animal welfare research is that many of the techniques used to measure stress and pain involve invasive procedures, such as blood sampling, that may cause a stress response themselves and there is a lack of reliable, non-invasive tools (Stewart et al. 2005). In order to improve animal welfare, new technologies and tools to evaluate the welfare impact of different husbandry practices are necessary.

This article provides a brief review of a series of experiments that investigated a novel combination of



Infrared image of the eye region of a dairy calf. From Stewart et al. 2008b.

eye temperature (using infrared thermography, IRT) and heart rate variability (HRV, using Polar S810i™) as a non-invasive tool to detect pain. For more detail, the reader is referred to a series of recent papers (Stewart et al. 2005; 2007; 2008 a, b). The main approach was to measure eye temperature and HRV responses of cattle during routine husbandry practices (e.g., cautery disbudding and surgical castration) with and without local anaesthetic. IRT detects heat emitted from superficial capillaries around the eye as blood flow is regulated under autonomic control. HRV provides a more detailed measure of a stress response than heart rate alone as it is possible to measure the balance between sympathetic and parasympathetic tone, therefore providing a more detailed interpretation of autonomic activity (von Borell et al. 2007).



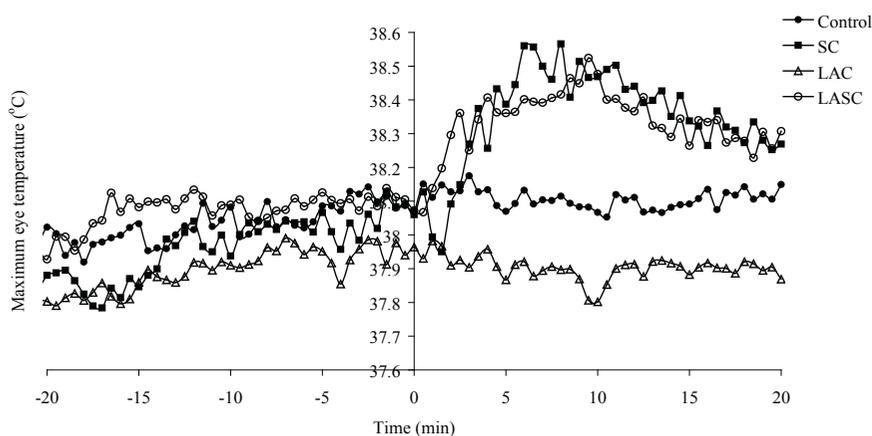
**Fig. 1** Eye temperature (°C) for control (■,  $n=8$ ), local anaesthetic control (▲,  $n=8$ ), disbudded with local anaesthetic (□,  $n=8$ ) and disbudded without local anaesthetic (●,  $n=6$ ). The dashed vertical line indicates the time that local anaesthetic or the sham procedure was administered and 0 min indicates the time of treatment. From Stewart et al. (2008b)

## Results and discussion

Responses to pain following disbudding without local anaesthetic included a rapid drop in eye temperature (Figure 1), a prolonged heart rate increase (up to 3 hours) and an acute HRV response [reduced high frequency (HF) power and increases in the low frequency (LF) power and the LF/HF ratio] that indicated an acute change in the sympatho-vagal balance with a possible shift towards increased sympathetic activity (Stewart et al. 2008b). When calves were disbudded with local anaesthetic, a drop in eye temperature was also detected when local anaesthetic wore off after 2 hours, due to the onset of pain at this time. This drop in eye temperature was accompanied by an increase in heart rate and sympathetic activity (increased LF and

LF/HF ratio) and a decrease in lying behaviour and parasympathetic tone (decreased HF). We hypothesised that the drop in eye temperature was caused by the redirection of blood from the capillary beds via sympathetically mediated vasoconstriction. The role of the autonomic nervous system was confirmed by a drop in eye temperature that occurred following an infusion of epinephrine.

Following castration without local anaesthetic, there was an increase in eye temperature (Figure 2) and an increase in parasympathetic tone (increase in the root mean square of successive R-R interval differences and HF and decrease in LF and LF/HF ratio). Further research is required to investigate the underlying mechanism for the increase in eye temperature.



**Fig. 2** Eye temperature (°C) for control (●,  $n=8$ ), castrated without local anaesthetic (■,  $n=6$ ), local anaesthetic control (▲,  $n=8$ ) and castrated with local anaesthetic (○,  $n=8$ ). 0 min indicates the time of treatment.

## Summary and conclusions

This research showed that during stress or pain, the heat emitted from superficial capillaries around the eye changes as blood flow is regulated under autonomic nervous system control and these changes can be quantified using IRT. A combination of IRT and HRV were able to non-invasively detect different autonomic responses to different aversive procedures. Somatic pain from disbudding caused acute sympathetic responses and prolonged HR elevation, whereas deeper visceral pain caused by castration caused a short-lived HR increase and increased eye temperature and parasympathetic tone. There are many factors that could influence these different physiological responses, such as the location of the pain, the type of tissue involved, different intensities of pain, and the level of fear associated with the particular procedure. Eye temperature and HRV offer advantages over other indicators of stress and pain because of the ability to non-invasively collect data with little interference, therefore minimising the confounding factors associated with other measures. A combination of eye temperature and HRV measures may be a complementary index to other indicators currently used to measure pain and stress, and could replace invasive procedures, such as measurement of plasma catecholamines, to measure autonomic responses for assessing animal welfare. This combination may provide more sensitive, detailed and immediate measures of acute pain than hypothalamic-pituitary-adrenal axis activity and could have wider applications to test the efficacy of analgesics and measure animal emotions.

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