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# Eye and muzzle temperatures measured using infrared thermography to assess sheep stress during shearing and foot trimming

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**Abstract.** The aim of this study was to investigate the infrared thermography (IRT) to measure eye (IRTeye) and muzzle (IRTmuz) temperature to assess stress in sheep during shearing and foot-trimming procedures. IRT temperatures were measured on 89 ewes of two breeds (55 Churra da Terra Quente – CTQ - and 34 Ile-de-France – IF). The IRT images were collected before, during and at the end of each procedure. A FLIR infrared camera was used, and IRT images were analyzed using FLIR Tools+ software to determine IRTeye and IRTmuz. All statistical analyses were performed using the JMP software. Data were analyzed considering breed and time of IRT collection as factors. The IRTeye was higher than IRTmuz (37.26 vs. 31.60 ºC, P<0.01, respectively) for both breeds and procedures. The IF ewes show higher temperatures than CTQ for foot-trimming and shearing (37.49 vs. 37.11 ºC, P<0.05; 37.54 vs. 37.13 ºC, P<0.05, respectively). Time of IRT collection presents different values, the lowest (P<0.05) being observed during and the highest before both procedures. In conclusion, IRT was sensitive in obtaining IRTeye and IRTmuz, being a viable indicator of distress and a valuable tool to assess welfare in sheep during shearing and foot trimming.

**Keywords.** Infrared thermography – Sheep – Stress – Welfare.

***Températures des yeux et du museau mesurées à l'aide d'une thermographie infrarouge pour évaluer le stress des moutons pendant la tonte et le taillage des onglons***

***Résumé.*** *L'objectif était d'étudier la thermographie infrarouge (IRT) pour mesurer la température des yeux (IRTeye) et du museau (IRTmuz) pour évaluer le stress chez les moutons pendant la tonte et le taillage des onglons. L'IRT a été mesuré sur 89 brebis de deux races (55 Churra da Terra Quente-CTQ et 34 Ile-de-France-IF). L'IRT a été collecté avant, au milieu et à la fin de chaque procédure. Une caméra infrarouge FLIR a été utilisée, et les images IRT ont été analysées avec le logiciel FLIRTools+ pour déterminer IRTeye et IRTmuz. Les analyses statistiques ont été réalisées avec le logiciel JMP. Les données ont été analysées considérant la race et le temps de collecte comme facteurs. L'IRTeye était plus élevé que l'IRTmuz pour les deux races et les deux procédures. Les brebis IF présentent des températures plus élevées que les brebis CTQ pour le taillage des onglons et la tonte (37,49 contre 37,11 ºC, P <0,05; 37,54 contre 37,13 ºC, P <0,05, respectivement). Le temps de la collecte présente différentes valeurs (P <0,05), le plus bas étant observée au milieu et le plus haut avant les deux procédures. En conclusion, l'IRT était sensible à l'obtention d'IRTeye et IRTmuz qui sont indicateurs viables de détresse et un outil précieux pour évaluer le bien-être chez les moutons pendant la tonte et le taillage des onglons.*

***Mots-clés.*** *Thermographie infrarouge – Moutons – Stress – Bien-être.*

## I – Introduction

Infrared thermography (IRT) has a wide range of potential applications in studies relating to health and welfare of farm animals (Stewart *et al*., 2005; Mcmanus *et al.*, 2016). These include the measurement of body and eye temperature during management procedures, handling, transport and slaughter (Schaefer *et al.*, 1988; Mcmanus *et al.*, 2016). Some recent reports show the applicability of IRT when measuring physiological stress responses via eye temperature (cattle – Stewart *et al.*, 2008; George *et al.*, 2014; sheep – George *et al.*, 2014 and swine – Weschenfelder *et al.*,

2013). These reports take advantage of some IRT features, namely its portability, the remote reading of temperature, which allows for no physical contact with the animal, and the accuracy of temperature measurement (Speakman and Ward, 1998; Berry *et al.*, 2003). Although the effects of various farm animal management stressors and respective welfare outcomes may be assessed by body and eye temperature, little is known about the applications of IRT to assess shearing and foot-trimming stress of sheep. It is recognized that both procedures are stressors that cause physiological changes and alterations of blood flow patterns, which manifest as changes in body surface temperature (Beausoleil *et al.*, 2004). Moreover, with IRT it is possible to identify changes in eye temperature as a result of a stress-induced physiological response and consequent changes of blood flow patterns (Stubsjøen *et al.*, 2009; Riemer *et al.*, 2016). The aim of this study addresses the question of whether the eye and muzzle temperature variations measured using IRT can assess shearing and foot-trimming stress of sheep.

## II – Material and methods

### 1. Animals, environment and management procedures

The present study observations were conducted on 89 multiparous ewes, ranging in age from three to seven years old, of two different breeds. Fifty-five ewes of the local breed Churra da Terra Quente (CTQ) and 34 of Ile-de-France (IF) breed. The ewes were housed at UTAD - University of Trás-os-Montes and Alto Douro, Vila Real (41 º 17 ‘18:52” N 7 º 44’ 31.97’’ W) where the study took place during 3 days in July 2016. The environmental temperature and relative humidity ranged from 21.7 to 24.8 ºC and 48.3 to 52.3%, respectively.

In this study shearing and foot-trimming were elected as stressors to which thermography would be applied to assess thermal measurements and respective physiological mechanisms of stress responses to these management procedures. Over the course of three days all sheep were sheared by one experienced worker. Foot-trimming was performed by two experienced operators with the animals sitting on their rump. To ensure identical levels of stress, each procedure was conducted following a similar routine. Both procedures were conducted in similar housing conditions and protected from sunlight and wind.

### 2. Thermographic image capture and image analysis

An infrared camera FLIR F4 (FLIR Systems AB, Sweden) was used to collect thermographic images (thermograms) of the eye and muzzle of sheep. Thermograms of the eyes and muzzle were acquired before, during and at the end of shearing and foot-trimming. This camera has a thermal sensitivity of <0.02°C. The FLIR Tools+ software was used to analyze the thermograms. Analysis of the thermograms was undertaken to determine temperature in five points of the eye and muzzle (Figure 1). All ewes were scanned from the same side at a 90° angle and at a distance of 1.0 m.

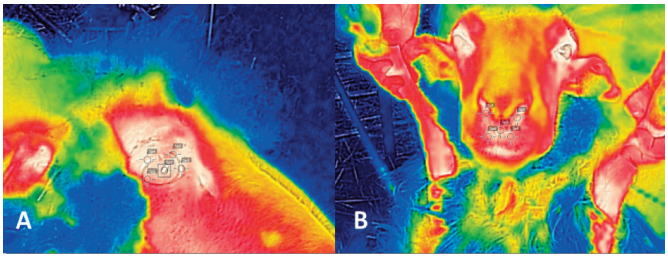


**Fig. 1. Examples of eye (A) and muzzle (B) thermograms. Both thermograms show the five points used for temperature determination.**

## 3. Statistical analysis

All statistical analyses were performed using the JMP-SAS software (Version 13, SAS Institute Inc. Cary, NC, USA). Data was analyzed considering breed and time of thermograms capture as factors. The IRT of eye and of muzzle were analyzed separately. Least significant difference Student's t-test was used to compare means.

# III – Results and discussion

**Table 1. Effects of breed and time (before, during and end of procedure) on IRT eye and muzzle temperature obtained during shearing and foot-trimming procedures**

| Effect | Eye | | Muzzle | |
|---|---|---|---|---|
| | Shearing | Foot-trimming | Shearing | Foot-trimming |
| Breed | | | | |
| CTQ | 37.13$^{b}$ | 37.11$^{b}$ | 31.59$^{a}$ | 31.60$^{a}$ |
| IF | 37.54$^{a}$ | 37.49$^{a}$ | 31.64$^{a}$ | 31.59$^{a}$ |
| Time | | | | |
| Before | 37.77$^{a}$ | 37.71$^{a}$ | 31.73$^{b}$ | 31.75$^{a}$ |
| During | 36.81$^{c}$ | 36.83$^{c}$ | 31.24$^{c}$ | 31.24$^{b}$ |
| End | 37.42$^{b}$ | 37.35$^{b}$ | 31.88$^{a}$ | 31.79$^{a}$ |
| Probability Breed | <.0001 | <.0001 | 0.334 | 0.804 |
| Time | <.0001 | <.0001 | <.0001 | <.0001 |
| Breed*Time | <.0001 | 0.004 | 0.599 | 0.389 |

Temperatures are presented in Celsius (°C). For breed and time, eye and muzzle temperatures during shearing and foot-trimming procedures values with different superscript letters are different (P<0.05).

Breed had a significant effect (P<0.0001) on eye temperature (Table 1.), the IF breed showing the highest values (P<0.05) for both shearing (37.54 vs 37.13°C) and foot-trimming (37.49 vs 37.11°C). On the contrary, effect of breed on muzzle temperature was not significant (P>0.05), with an average value of 31.6°C for shearing and foot-trimming.

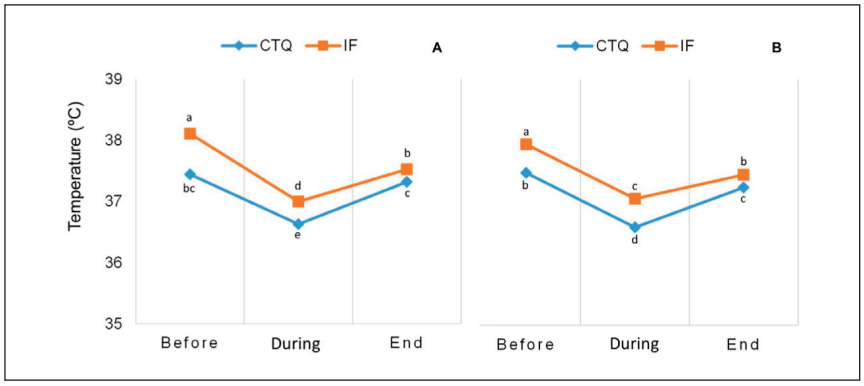


**Fig. 2. Eye IRT temperature variation before, during and at the end of shearing (A) and foot-trimming (B) for CTQ and IF sheep. For shearing and foot-trimming and for both breeds markers with different superscript letter are different (P<0.05).**

Time only had a significant effect on eye temperature (P<0.0001) for both procedures. Significant differences (P<0.05) were observed before, during and at the end of shearing and foot-trimming for both eye and muzzle. The highest temperature values for eye measurements was observed before, followed by end and during procedure time. However, a different pattern was observed for the muzzle, with higher values for end followed by time before and during the procedure time.

The interaction Breed x Time was only significant (P<0.0001) for eye measurements and this effect is represented on Figure 2.

For both sites, the pattern of variation is similar but more marked variation was observed for shearing measurements on IF breed and for foot-trimming on CTQ breed. Time of IRT collection presents different values, the lowest (P<0.05) being observed during both procedures. Fear and distress have been associated with a drop temperature of peripheral tissues as result of a sympathetically-mediated vasoconstriction response and consequent reduction of blood flow (Herborn *et al.*, 2015). Reduction of IRT temperature measured in the eye has been observed in cattle (Stewart *et al.*, 2008) and sheep (Stubsjøen *et al.*, 2009; George *et al.*, 2014). These studies found that IRT is able to detect small, yet significant, differences in eye temperature which is key to assess a stressful procedure. Our IRT eye temperature results are in agreement with those published in these papers, though those with the IRT muzzle temperature have not been so sensitive in distinguishing small temperature variations.

## IV – Conclusions

This study shows that IRT is sensitive to be utilized as a technique for non-invasive remote stress assessment in order to assess animal welfare related with stressful procedures, such as shearing and foot-trimming of sheep.

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