

Stress is cool

Assessment of stress using thermal imaging

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@RuediNager

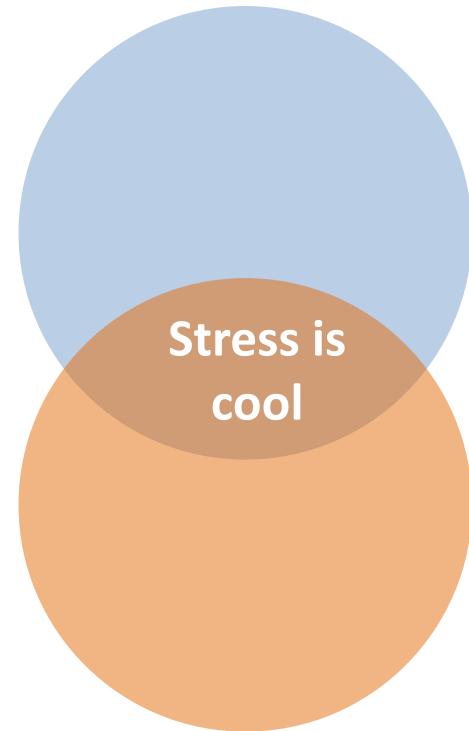


Dorothy McKeegan

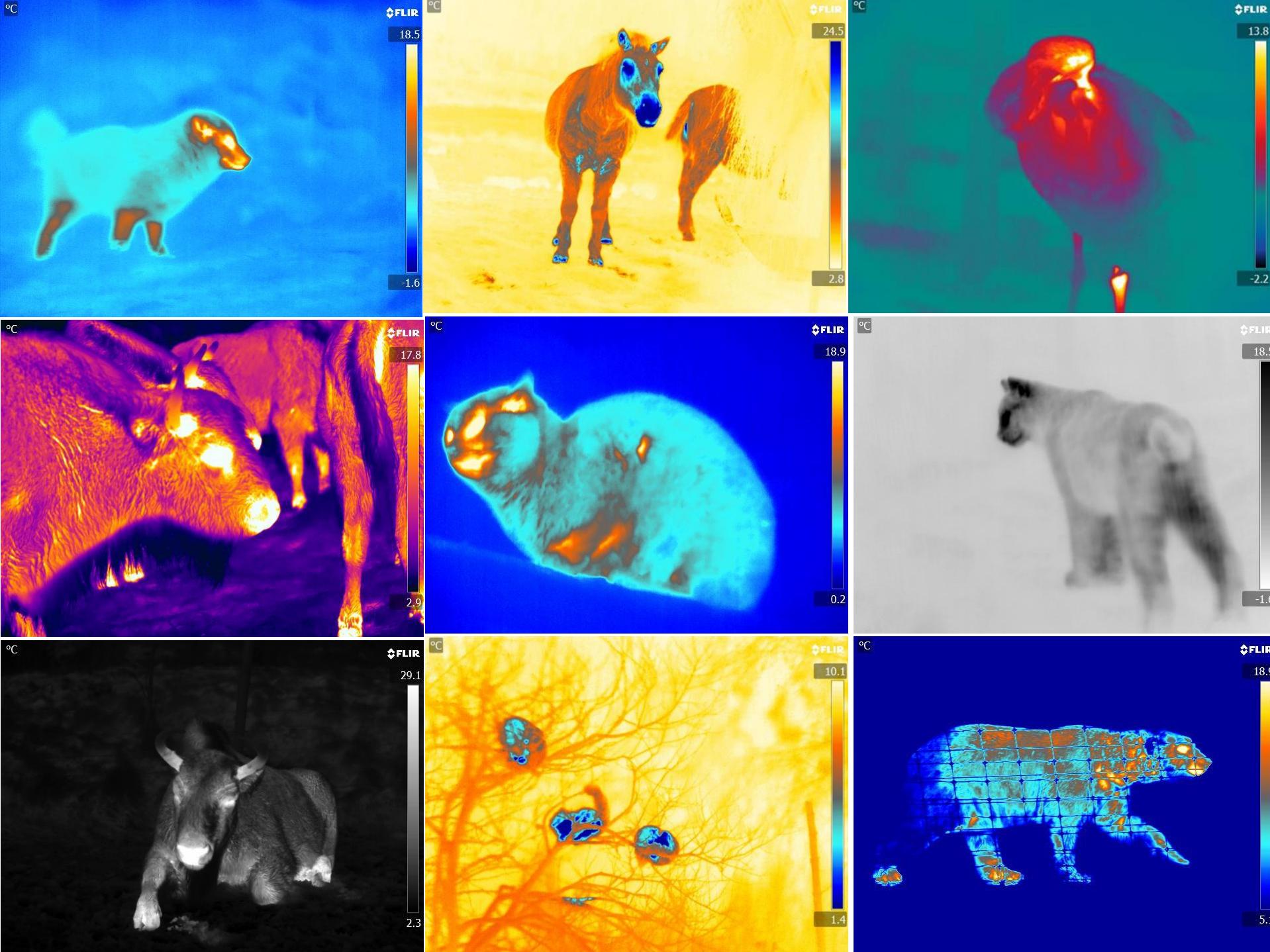


Dominic McCafferty

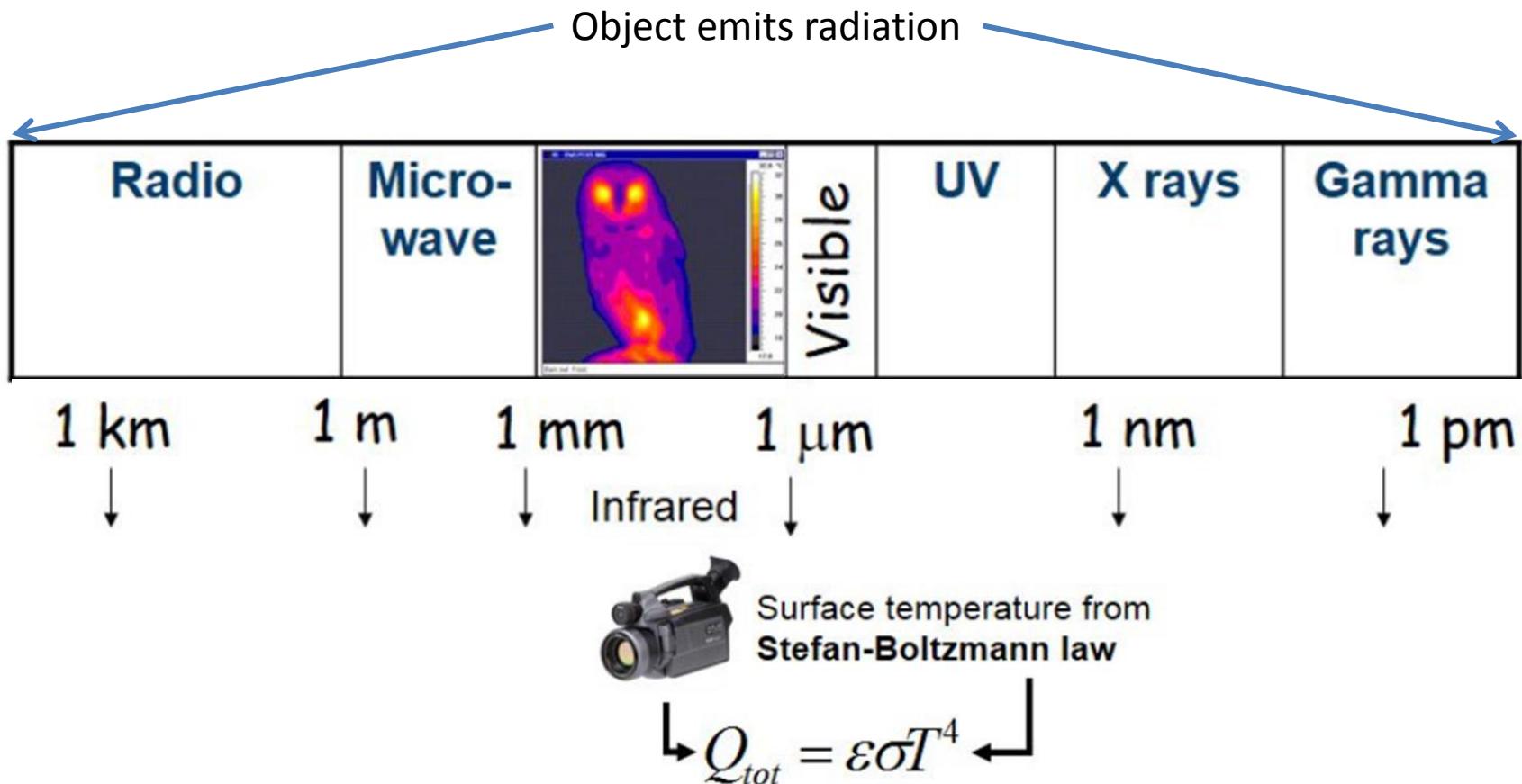
Animal Welfare



Thermal Ecology



What is Thermal Imaging?



Q_{tot} = Total radiation (Wm^{-2})

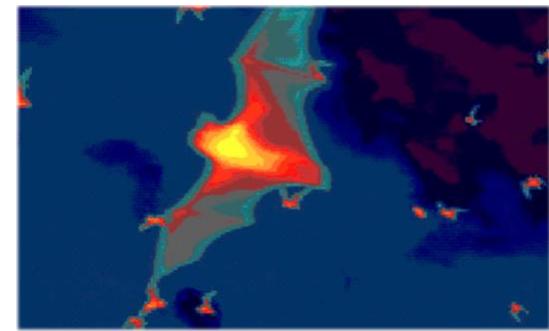
T = Temperature (K), ε = emissivity

σ = Stefan-Boltzmann constant

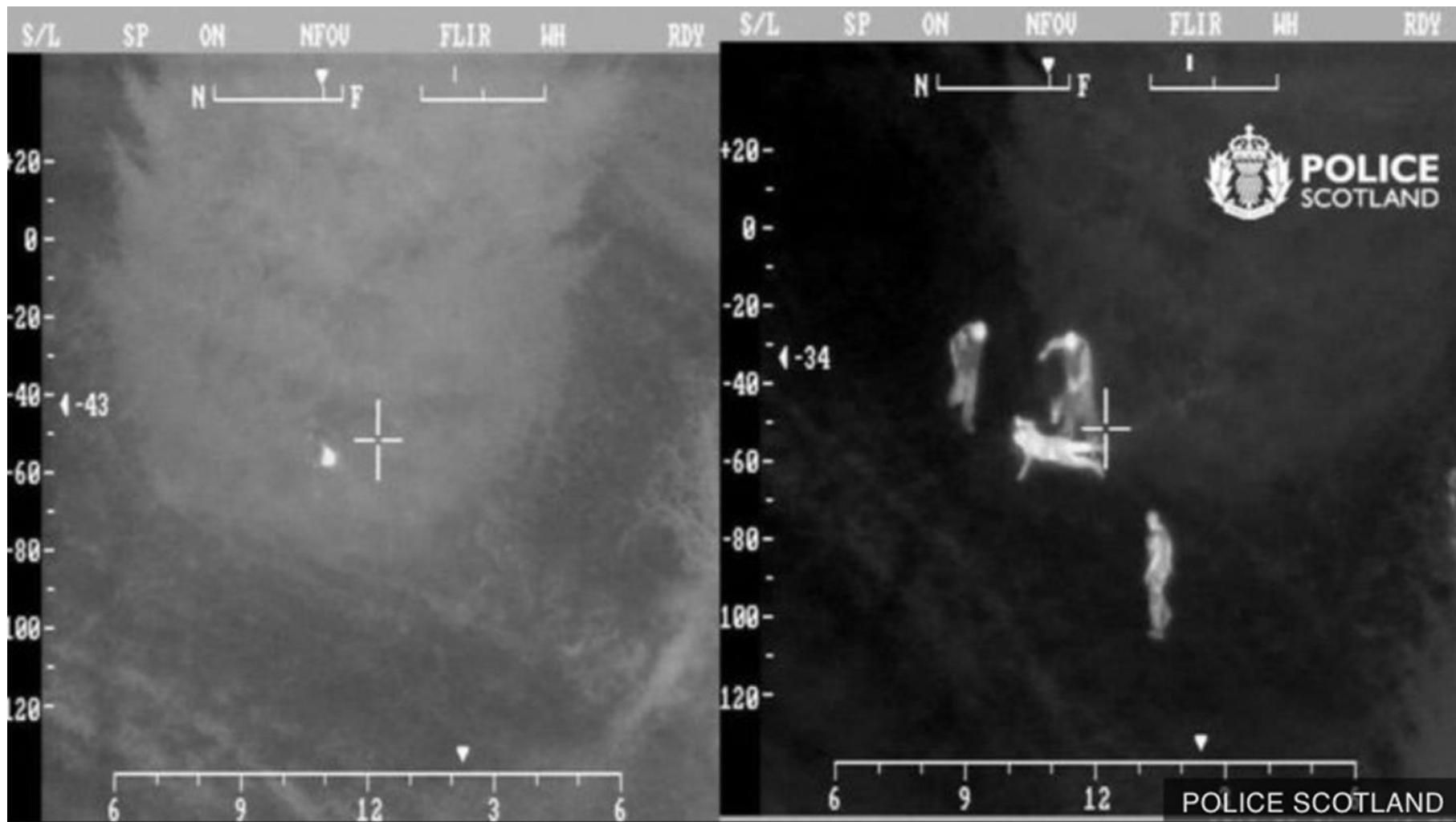
$$(5.67 \times 10^{-8} \text{ Wm}^{-2} \text{ K}^{-4})$$

The Use of Thermal Imaging

Surveillance

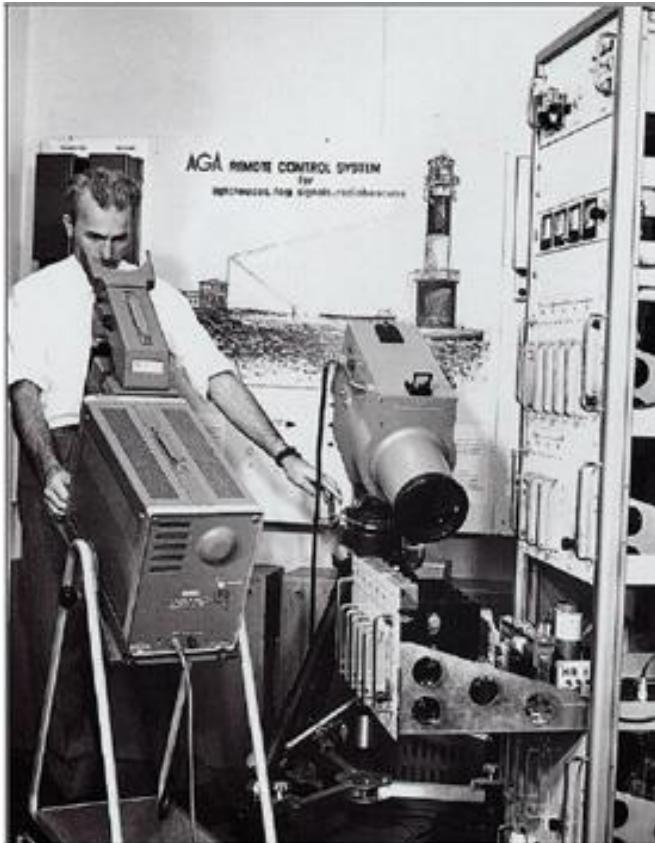


The Use of Thermal Imaging



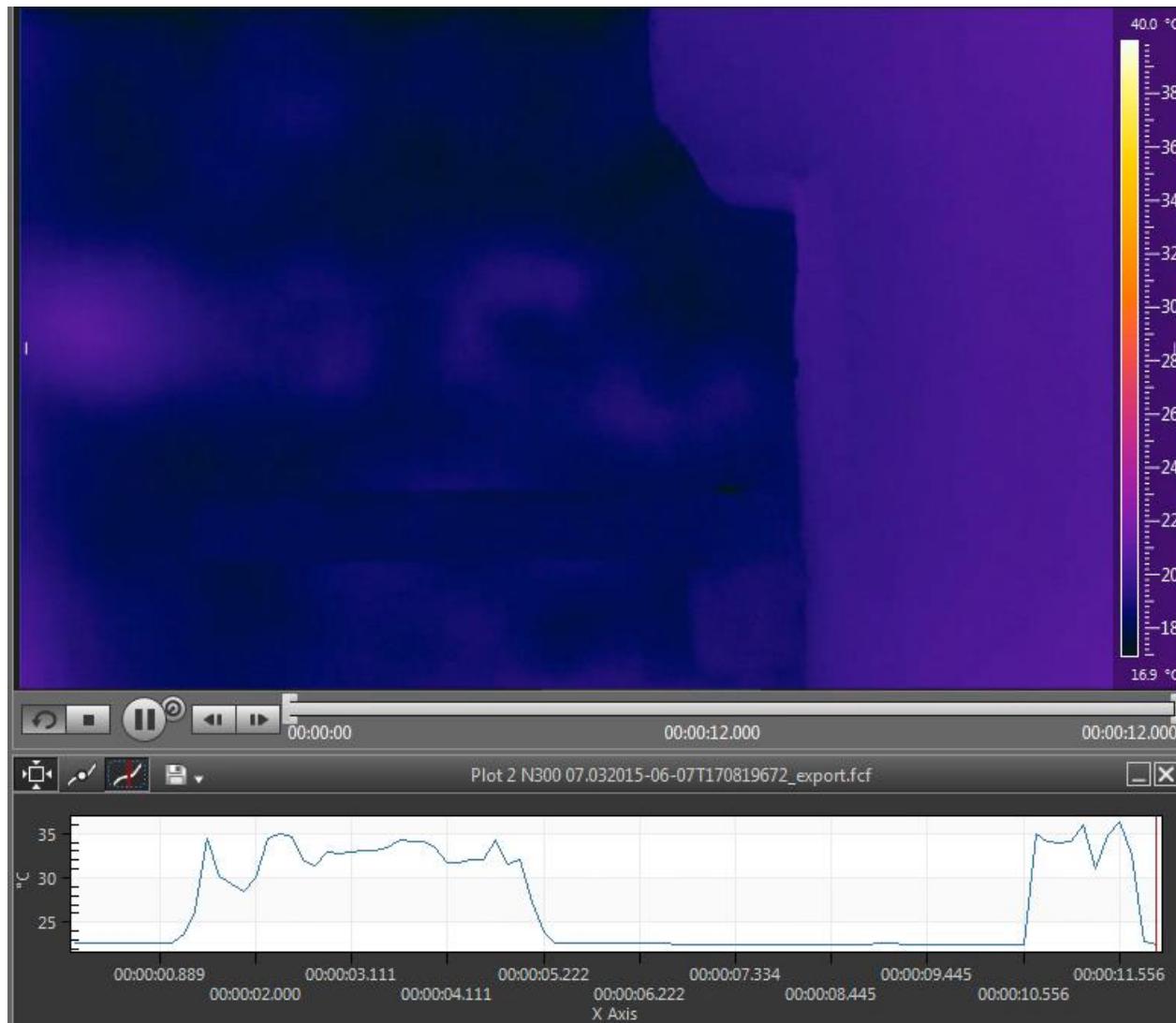
Two stills captured by the helicopter's thermal imaging camera during the pursuit

The Use of Thermal Imaging



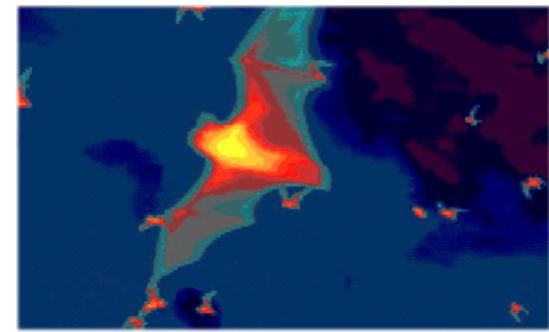
Thermal imaging cameras become smaller, cheaper and with better resolution

The Use of Thermal Imaging

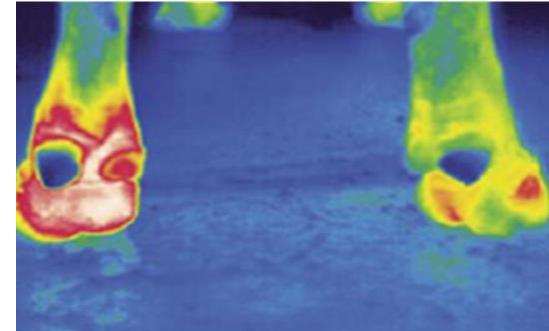


The Use of Thermal Imaging

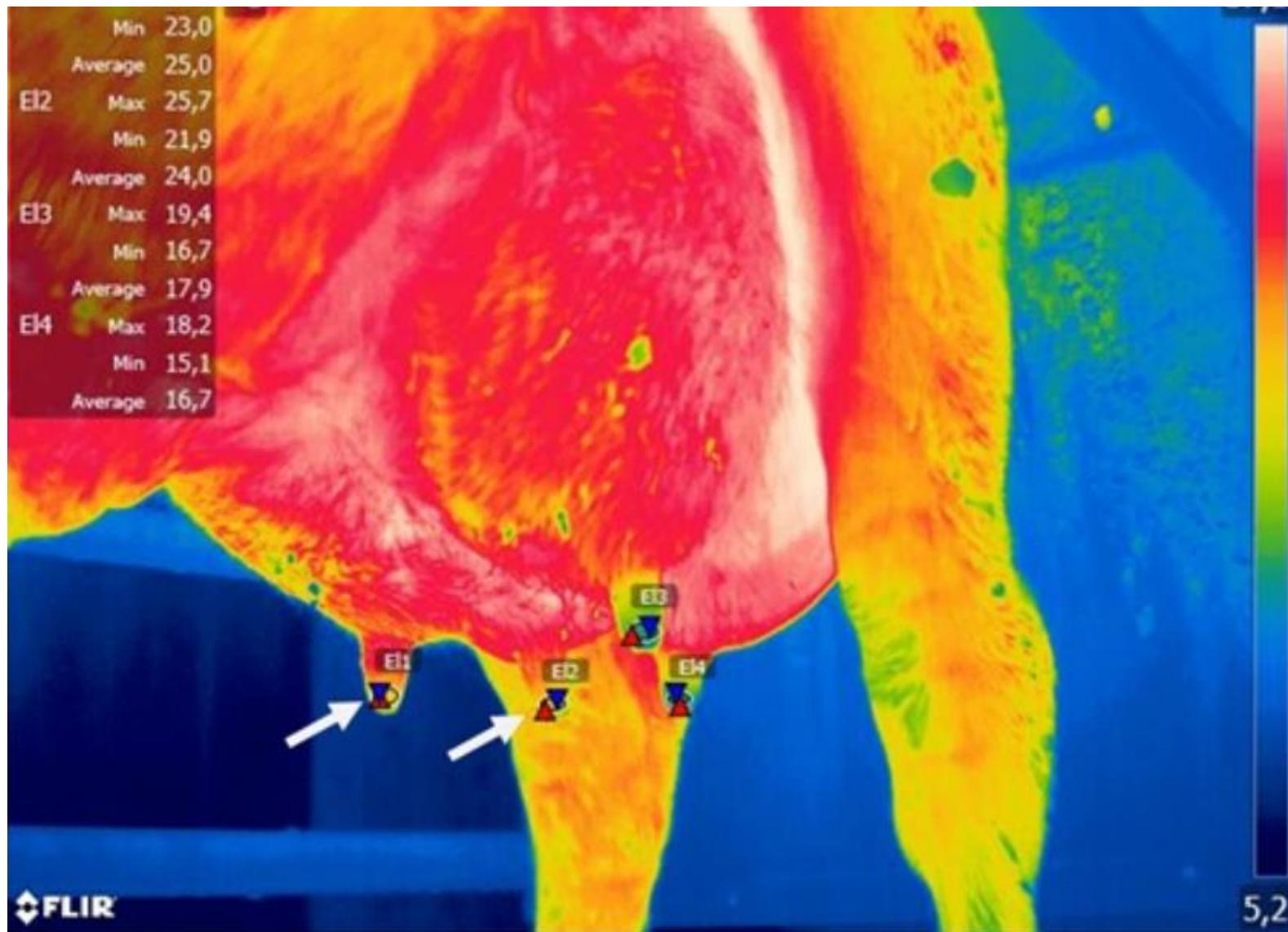
Surveillance



Animal Health

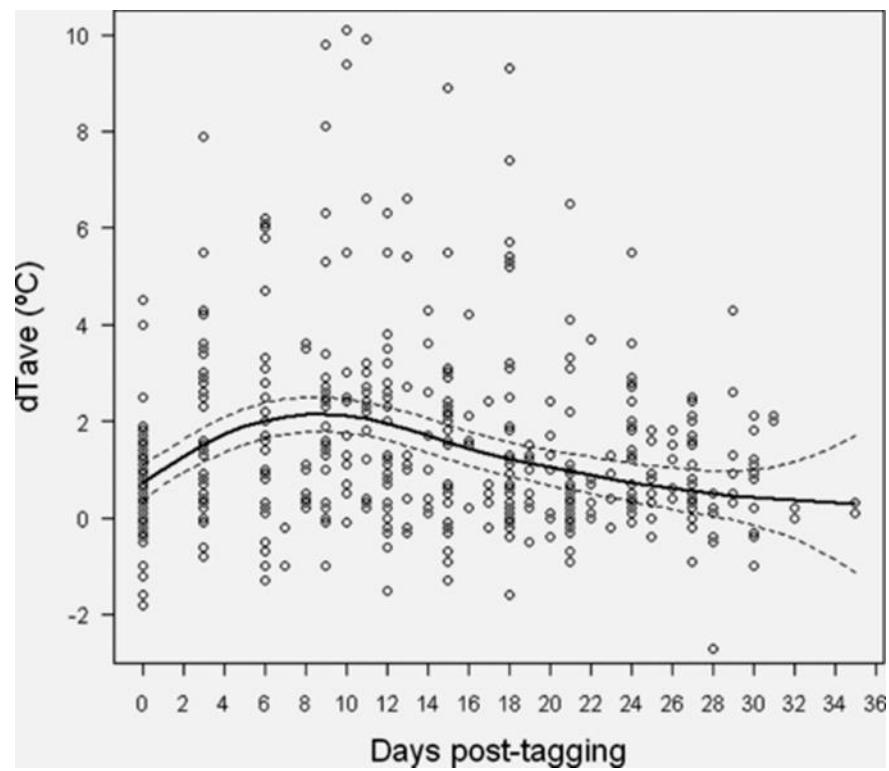
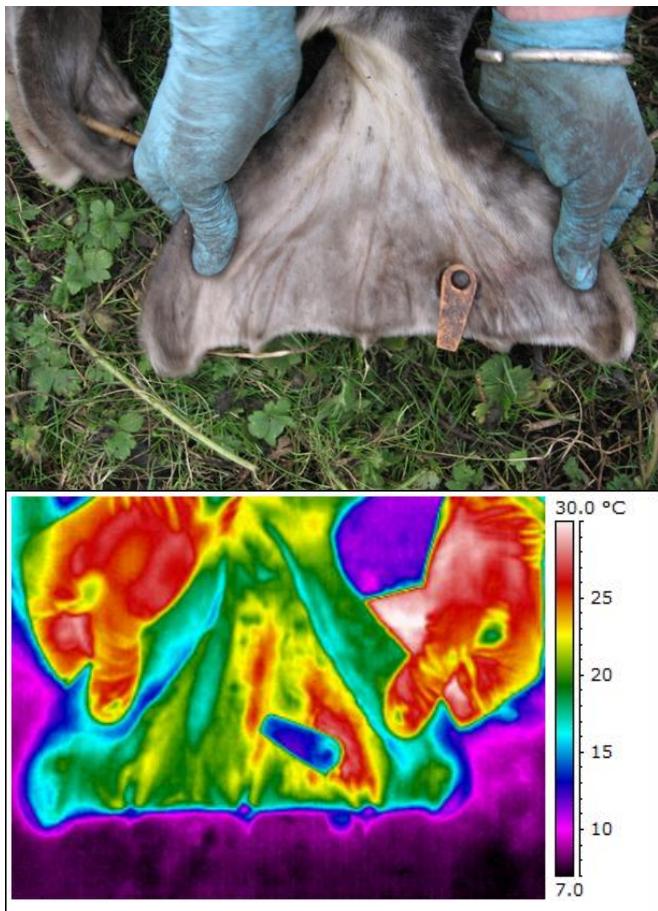


The Use of Thermal Imaging



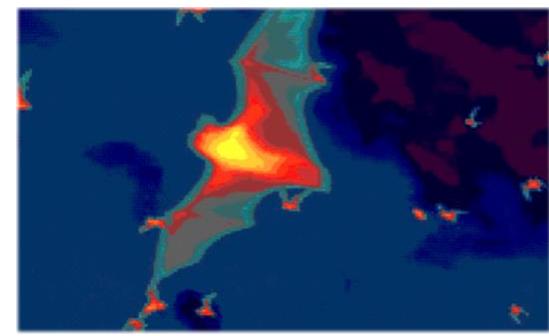
The Use of Thermal Imaging

Marking of Marine Mammals

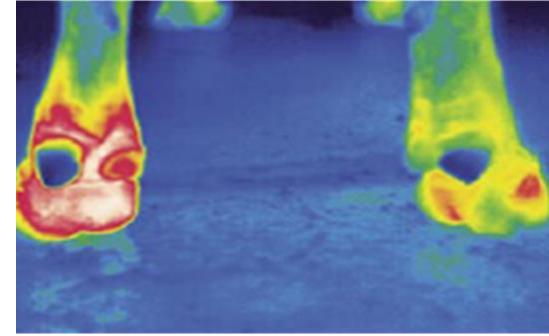


The Use of Thermal Imaging

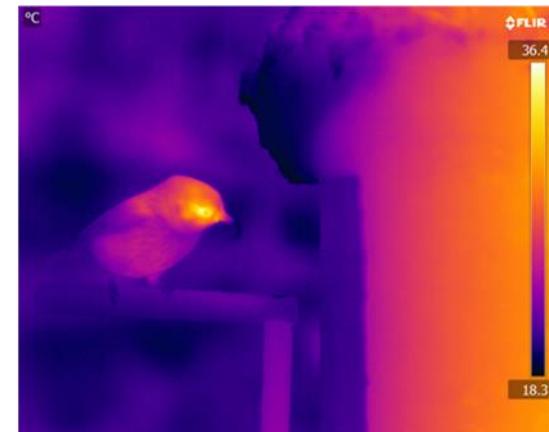
Surveillance



Animal Health



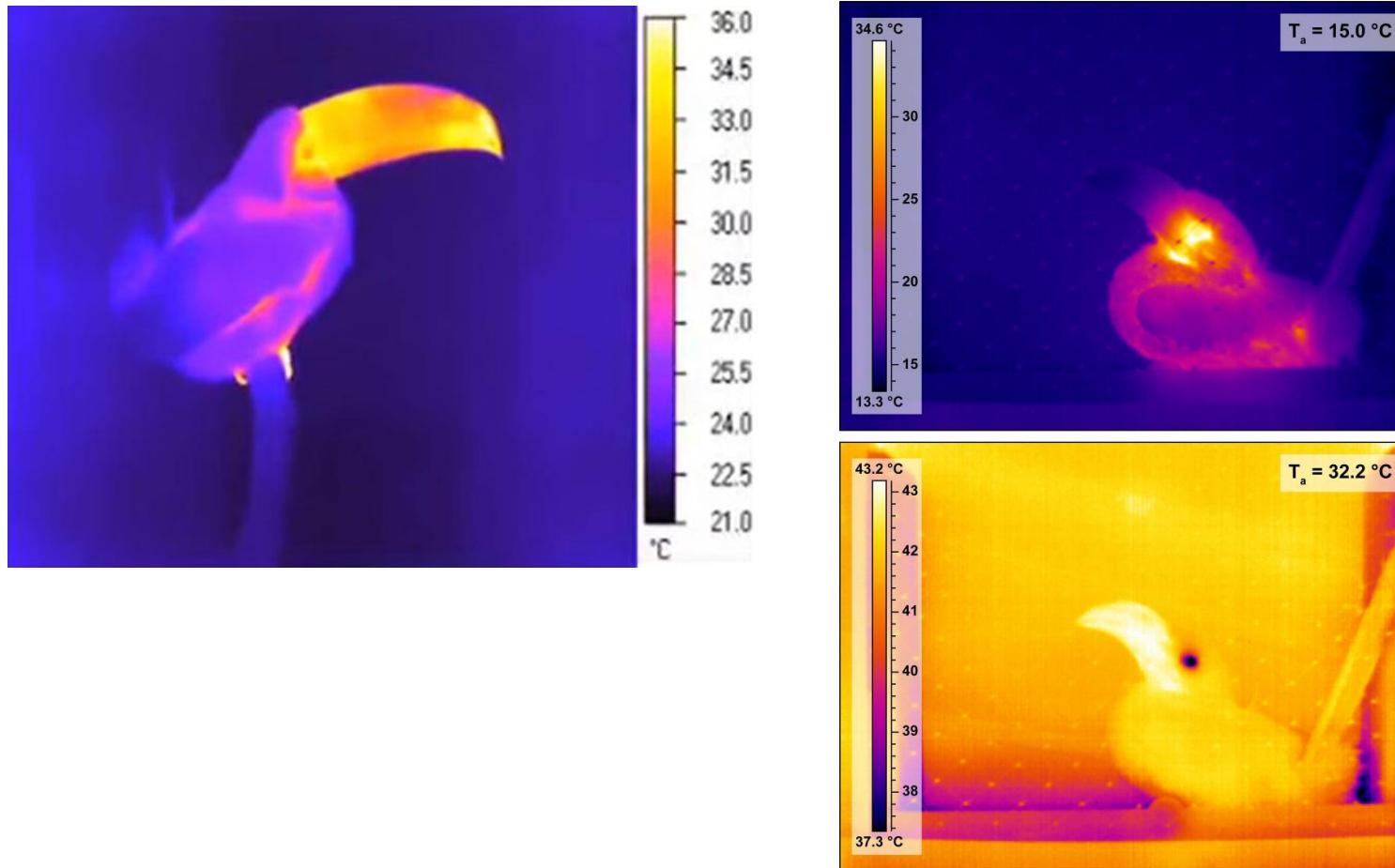
Physiology



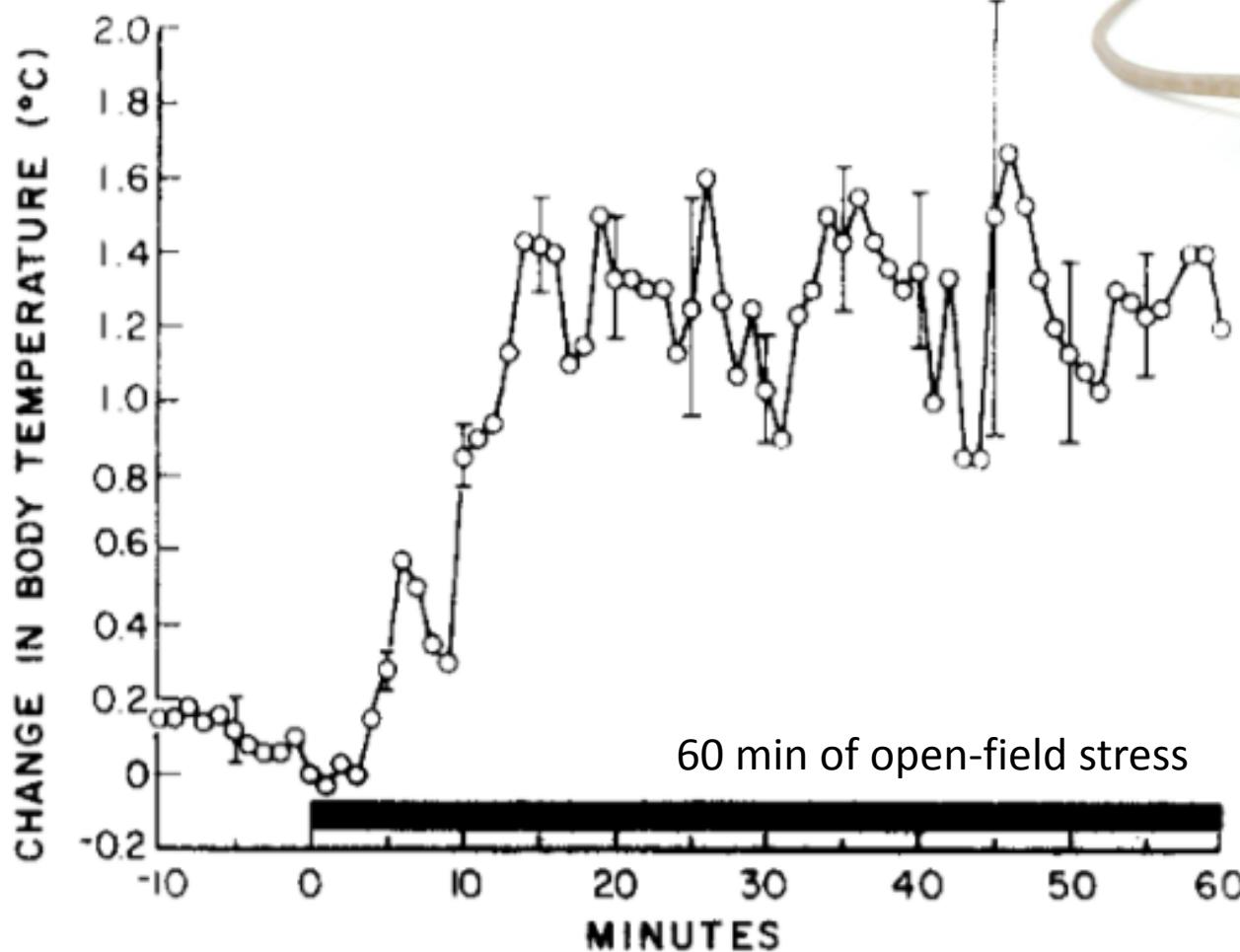
The Use of Thermal Imaging

Thermal Physio-ecology

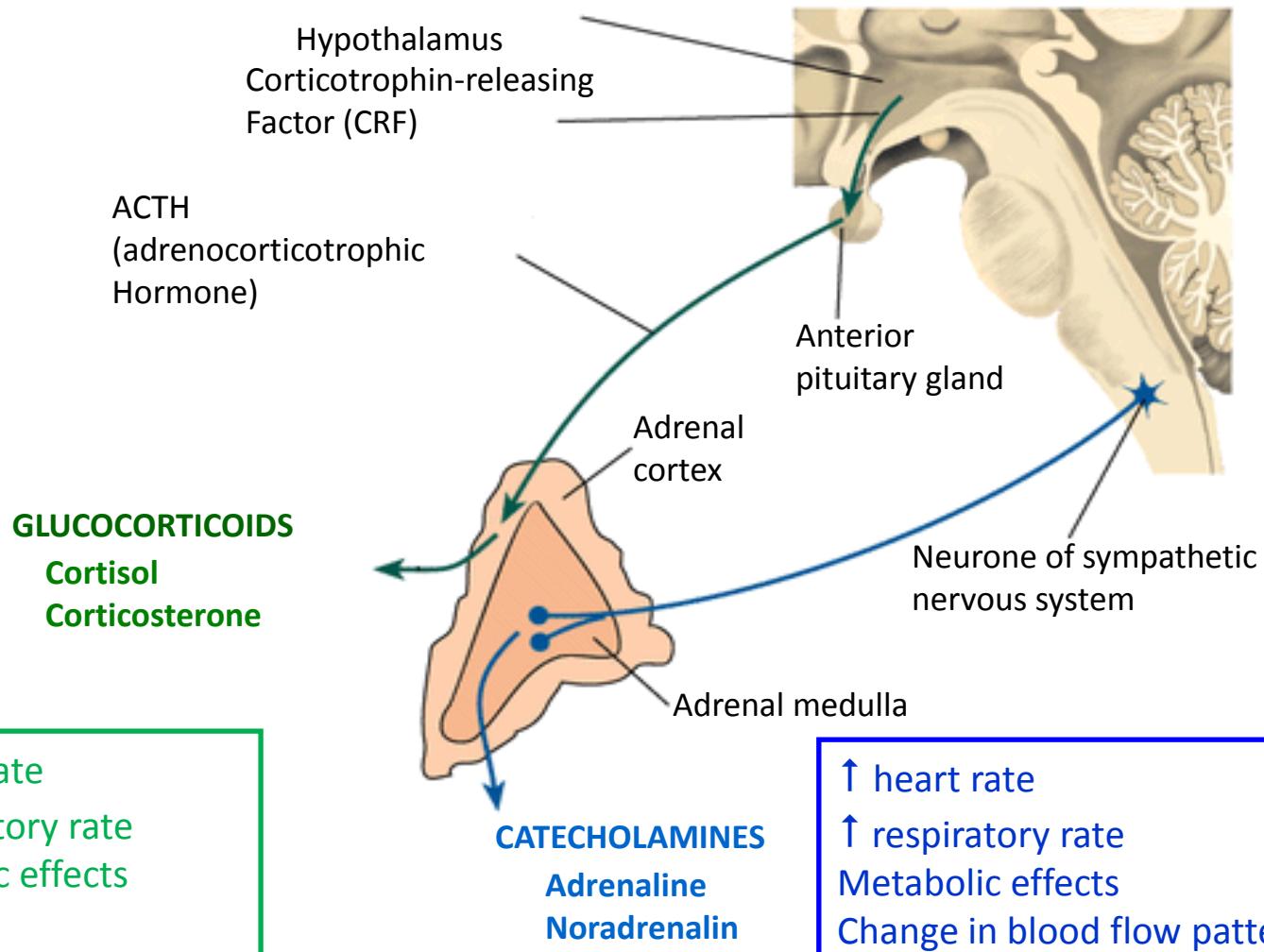
Thermal Radiator



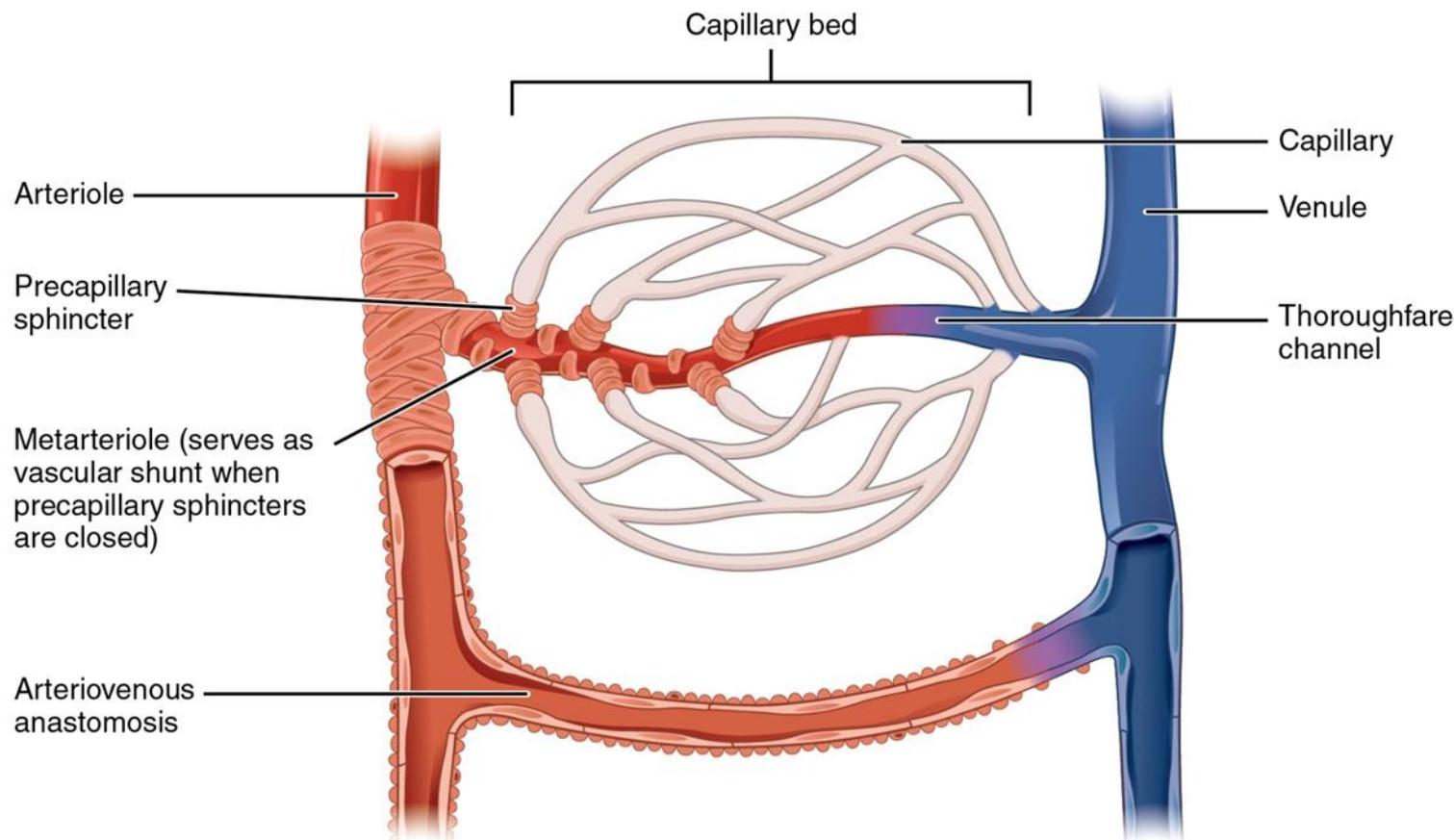
Stress-induced hyperthermia



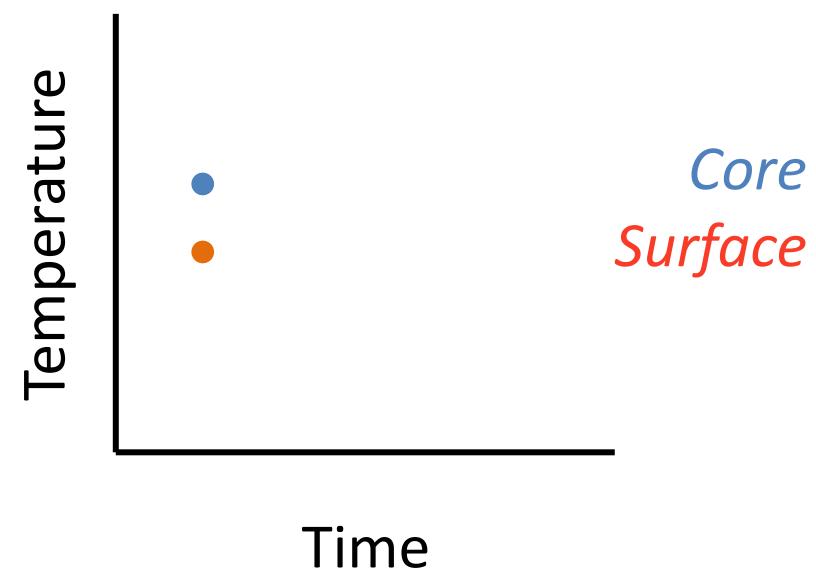
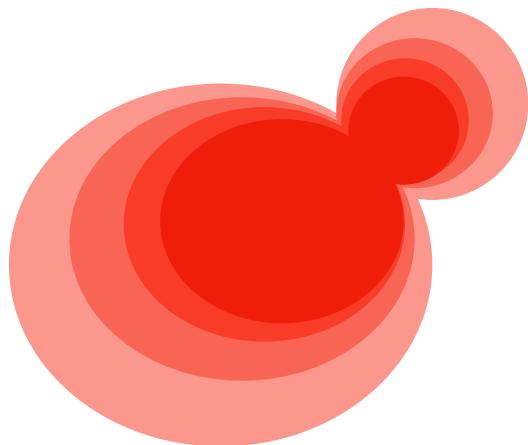
Two pathways to a stress response



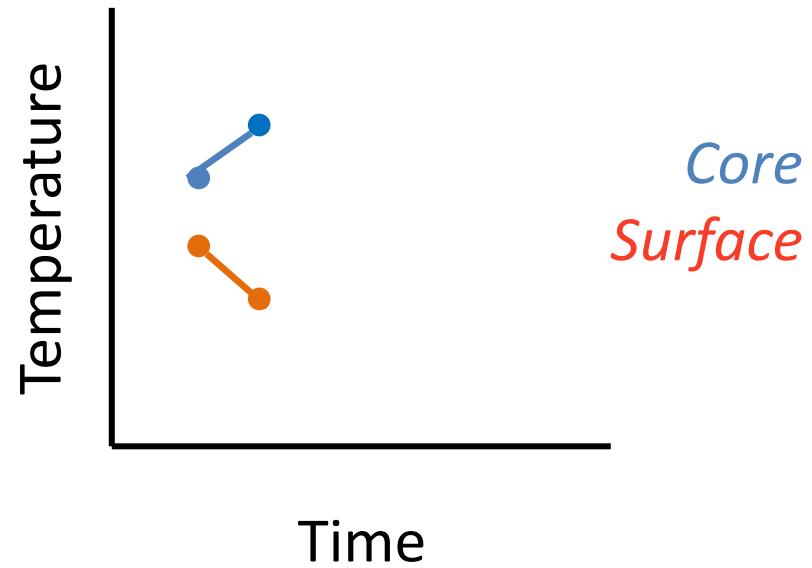
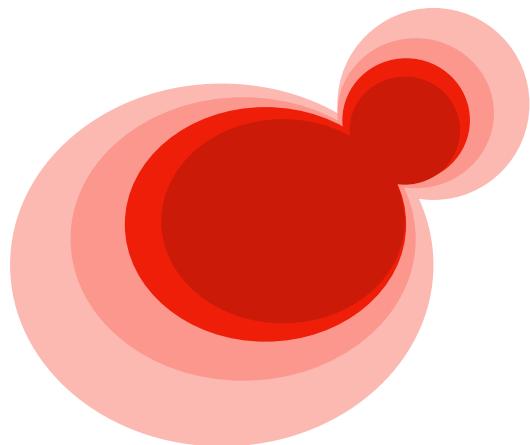
Arteriovenous anastomoses (AVAs)



Peripheral vasoconstriction

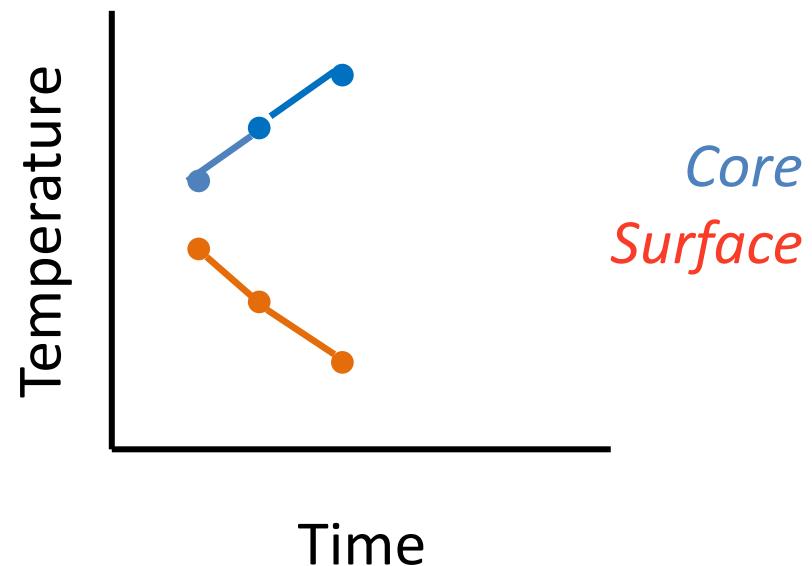
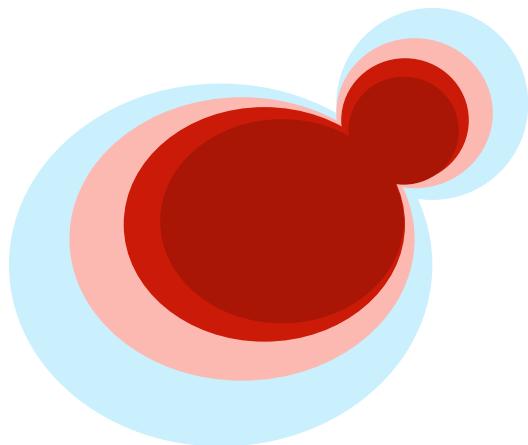


Peripheral vasoconstriction



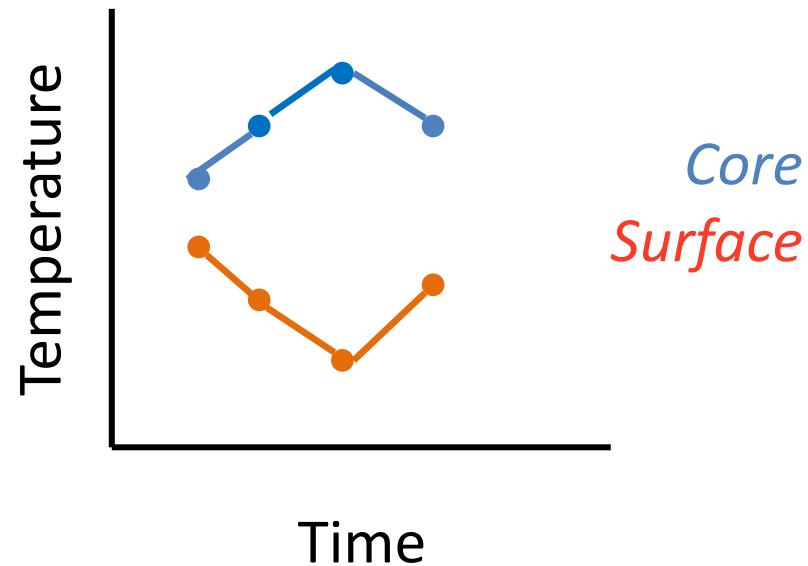
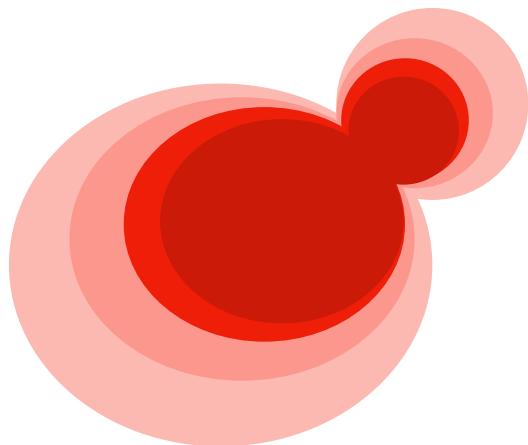
Initially warm blood is re-directed to the core

Peripheral vasoconstriction



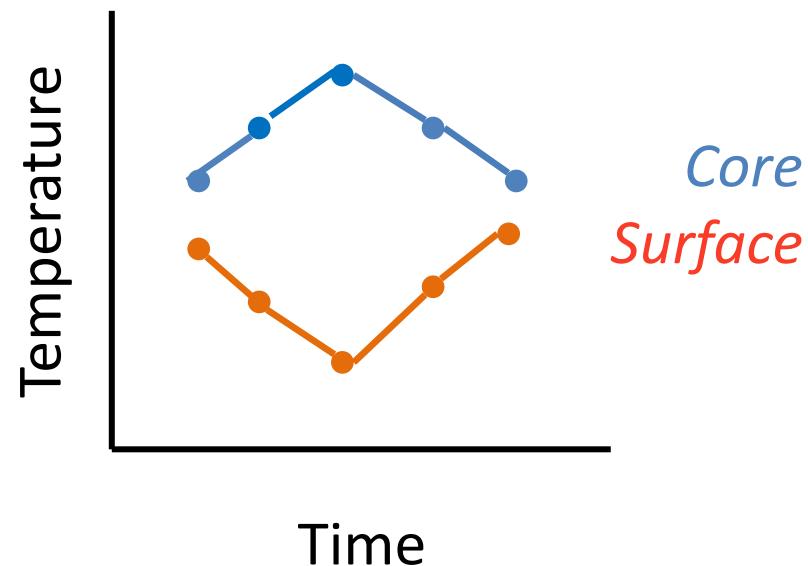
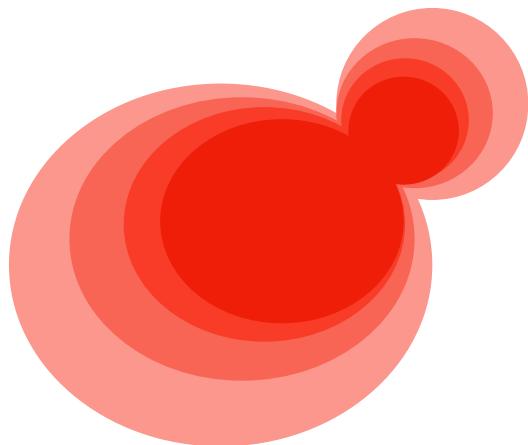
Initially warm blood is re-directed to the core

Peripheral vasoconstriction



Initially warm blood is re-directed to the core
Then core heat dissipates back to the surface

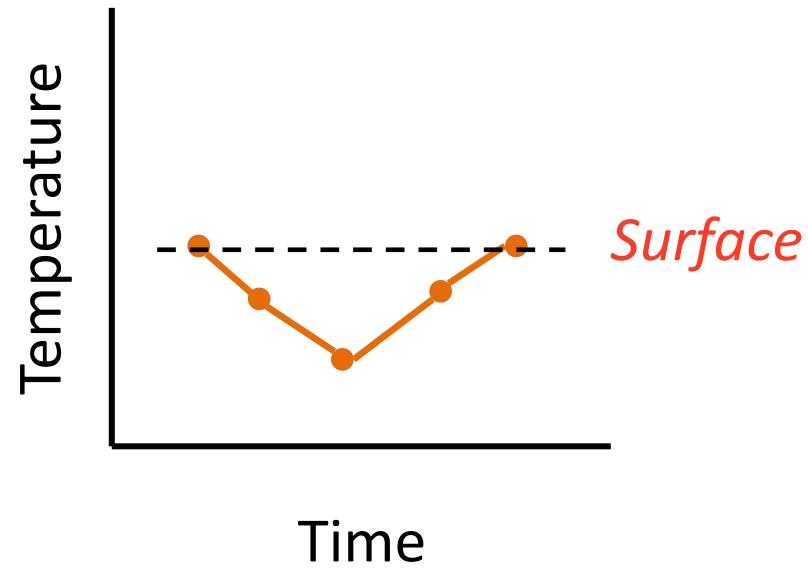
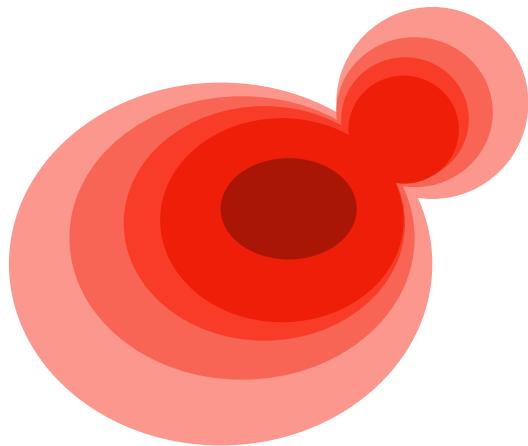
Peripheral vasoconstriction



Initially warm blood is re-directed to the core
Then core heat dissipates back to the surface, until it reaches again the equilibrium

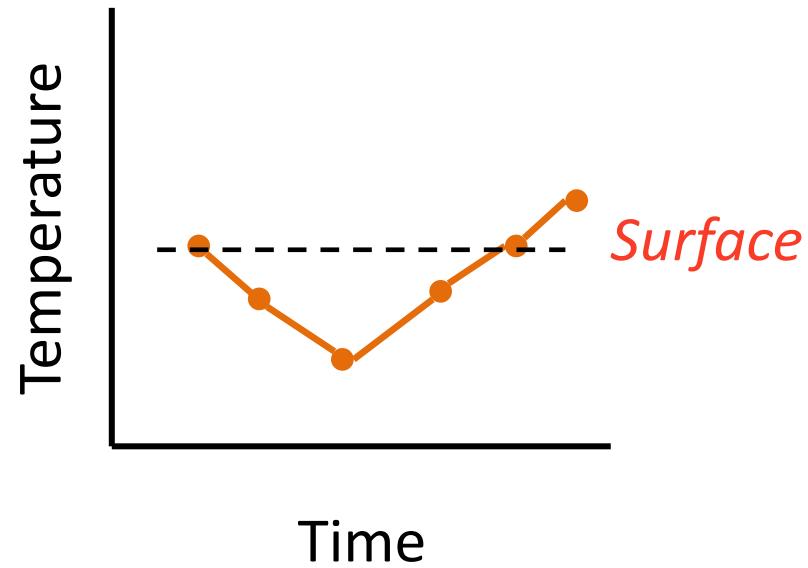
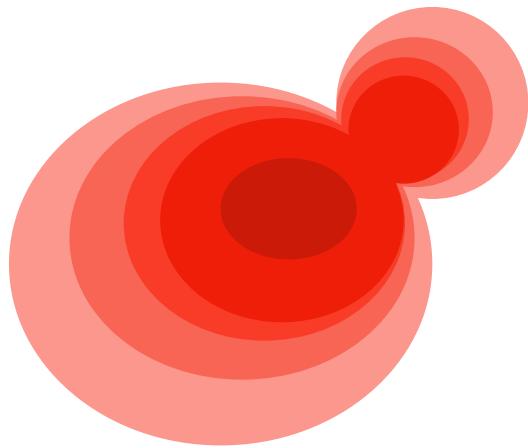
Stress & Thermal Imaging

Extra heat production in the core



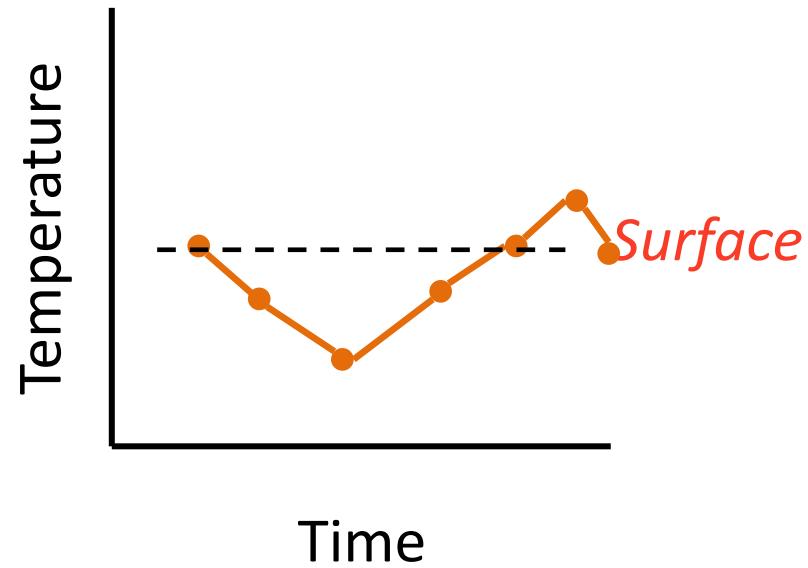
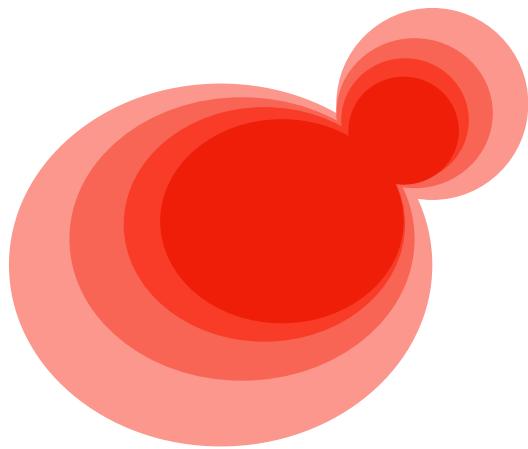
Metabolic processes may produce additional heat in the core

Extra heat production in the core



Metabolic processes may produce additional heat in the core that gets dissipated to the surface

Extra heat production in the core



Metabolic processes may produce additional heat in the core that gets dissipated to the surface, until again the equilibrium is reached.

Surface temperature as a measure of stress

What we need to know?

- Does it indicate acute stress?

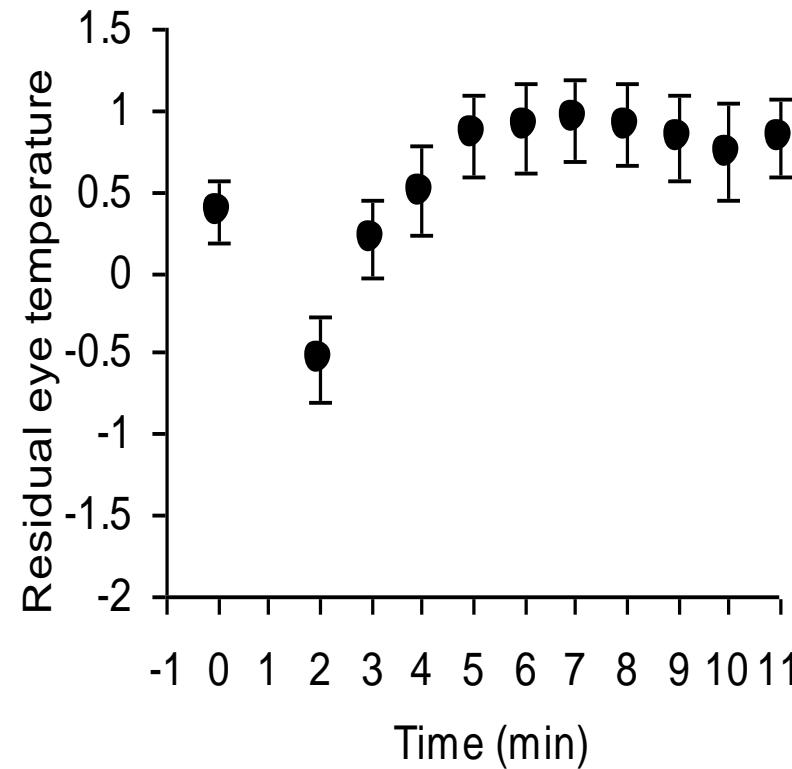
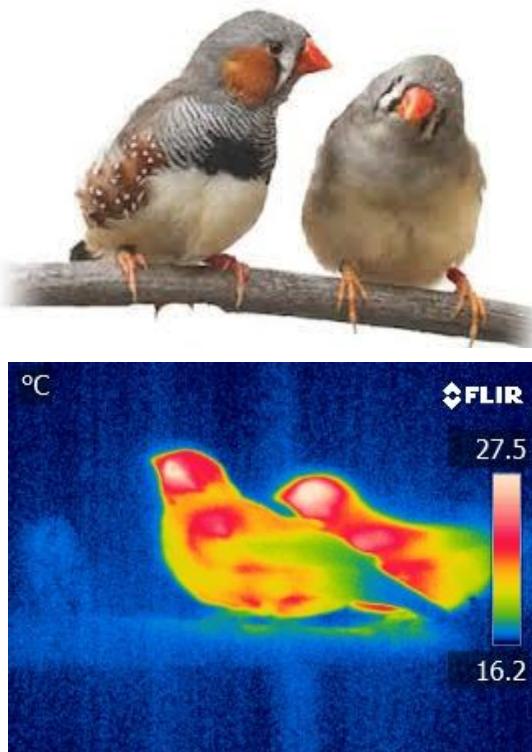
And what about chronic stress?

- Is the surface temperature response proportional to stressor intensity
- Valence?



Surface temperature & acute stress

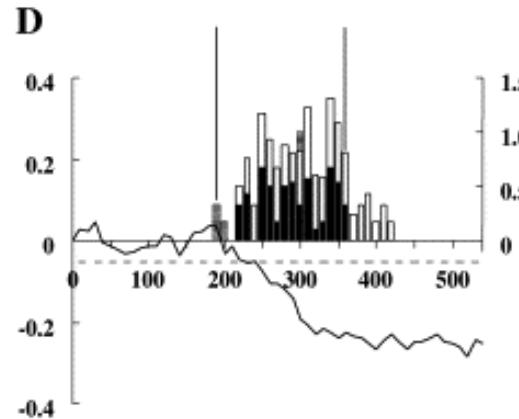
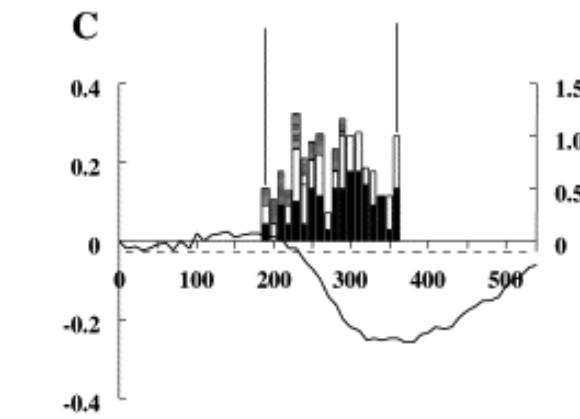
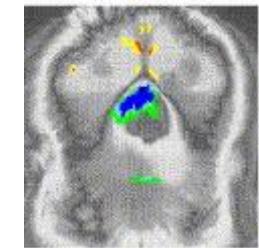
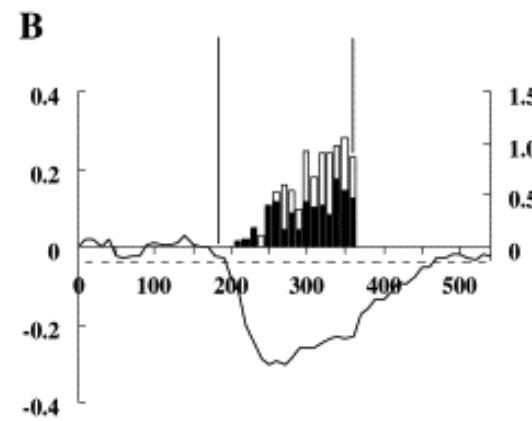
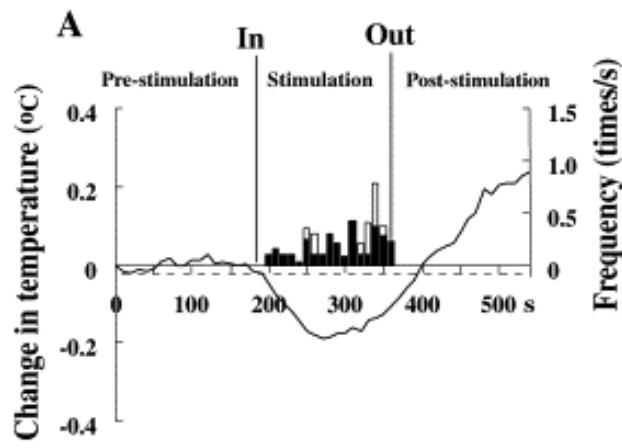
Acute eye temperature response to transport and handling in Zebra Finches



Mean Residual (\pm SE) eye temperature over time in zebra finches moved individually to a novel cage

Surface temperature & acute stress

Acute nasal temperature response to threatening person in Rhesus Macaques



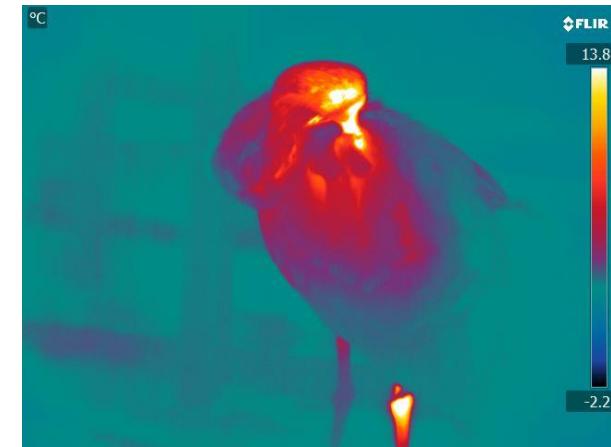
Surface temperature as a measure of stress

What we need to know?

- Does it indicate acute stress?

Yes, it indicates acute stress 

And what about chronic stress?



- Is the surface temperature response proportional to stressor intensity
- Valence?



Surface temperature & acute stress

Acute nasal temperature response to handling in Domestic Hen



Fig. 1. Thermal image of a domestic chicken, showing the measurement regions for the head, eye and comb.

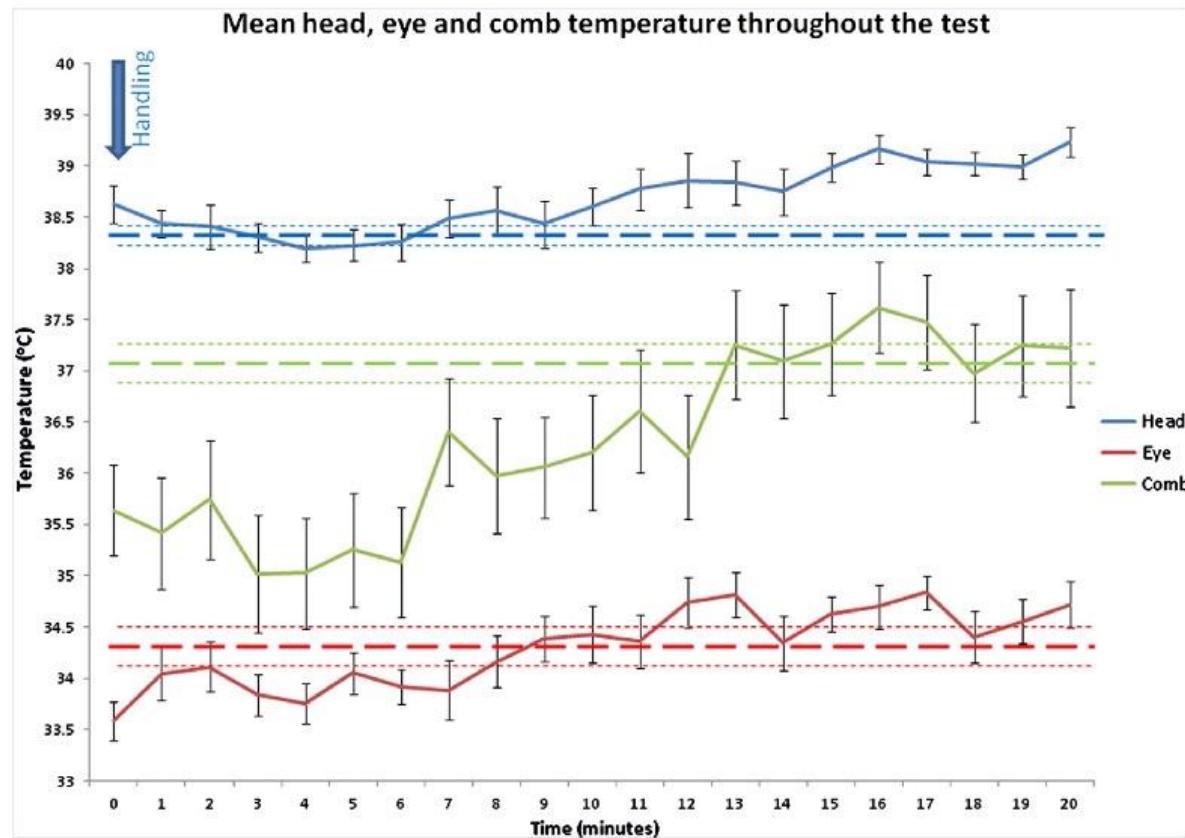
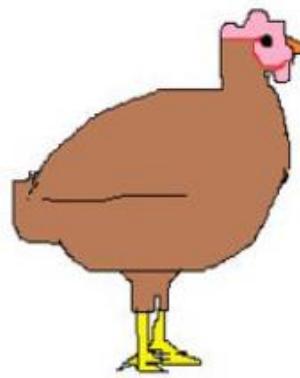


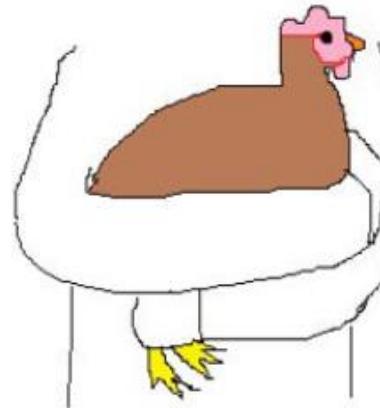
Fig. 3. Plot of the mean head, eye and comb temperatures (\pm SEM) of the 19 hens throughout the test. Dashed line = Baseline \pm SEM.

Proportionality of surface temperature response to handling

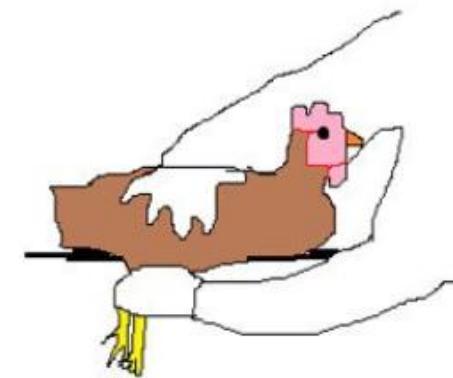
unstressed



cradled



side-pinned



control

CORT $2.0 \pm 0.9 \text{ ng/ml}$

30 s handling trial

 $2.6 \pm 1.5 \text{ ng/ml}$

30 s handling trial

 $3.2 \pm 1.5 \text{ ng/ml}$ 

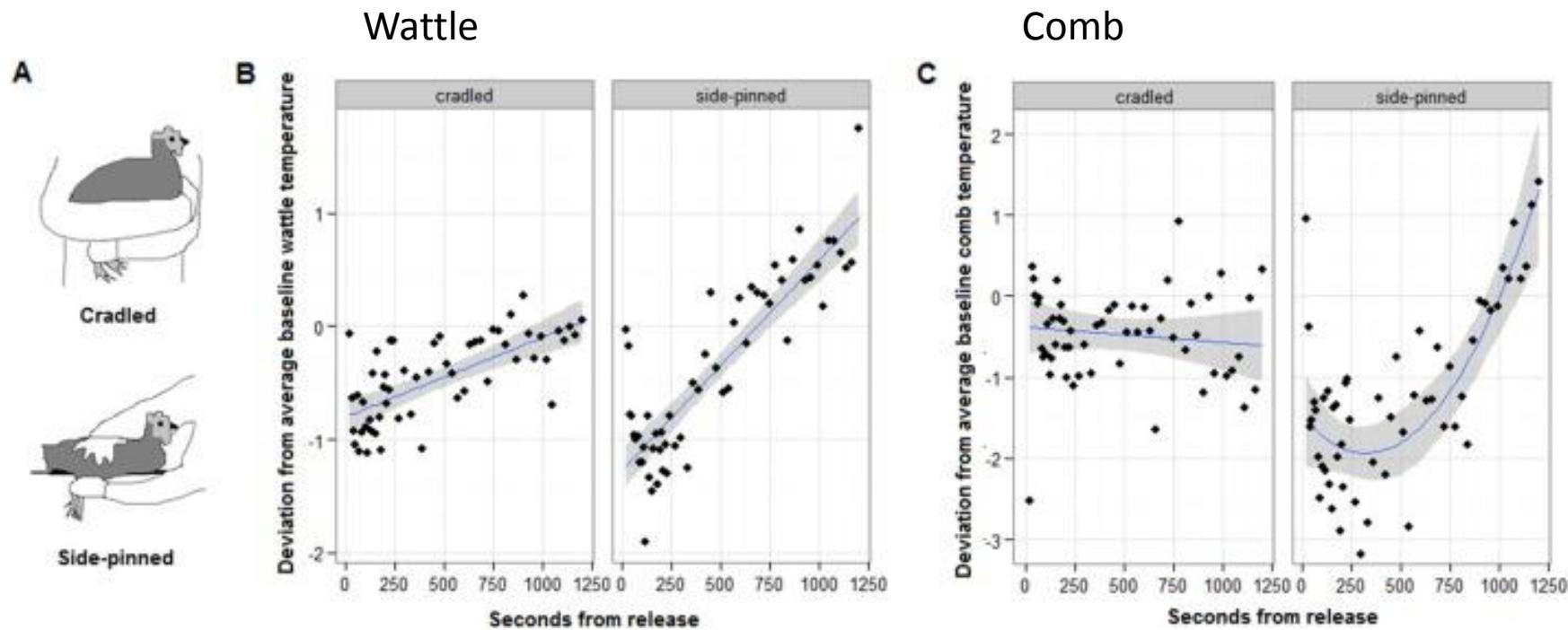
94% of obs

84% of obs

70% of obs

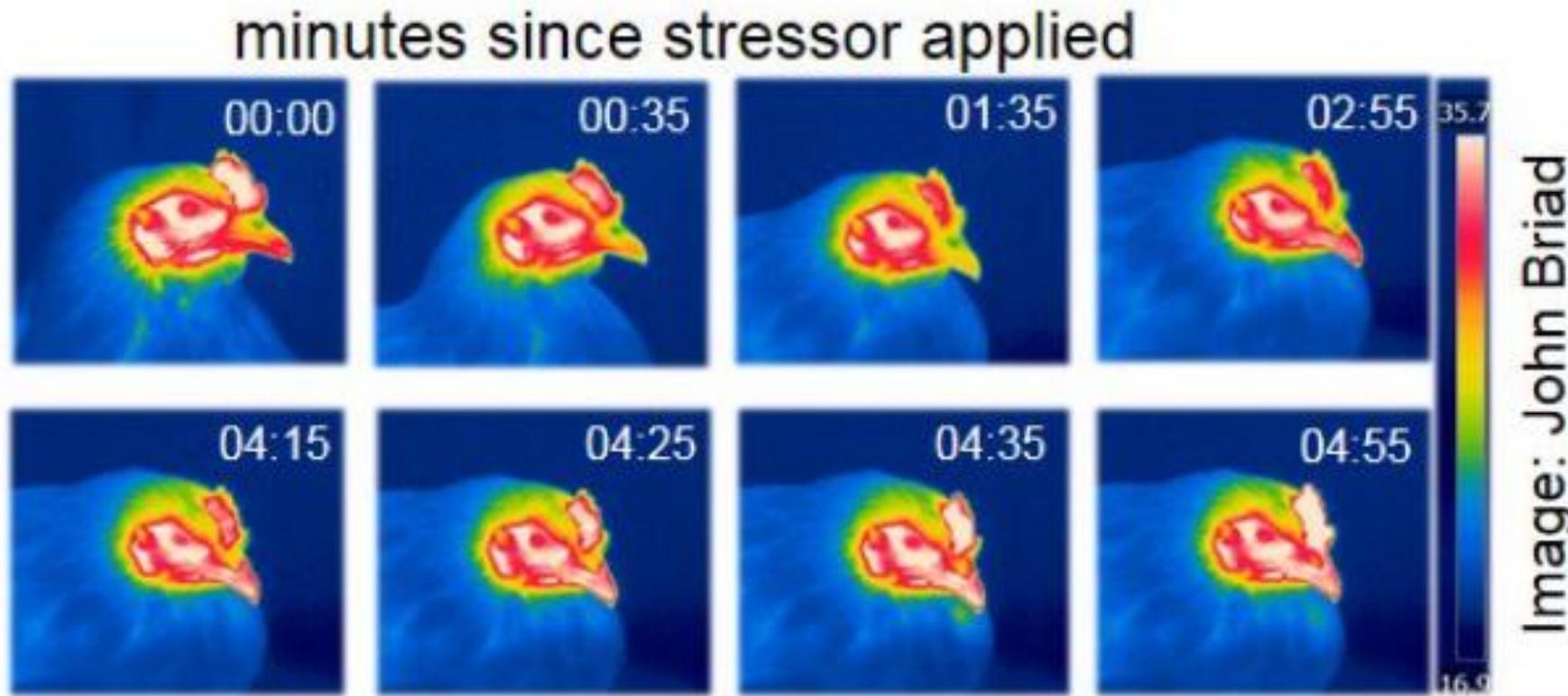
ACTIVE

Proportionality of surface temperature response to handling



More severe handling has greater initial drop and post-stress increase beyond the baseline (deviation = 0)

Proportionality of surface temperature response to handling



The maximum temperature possibly underestimates the extent of the response – look how the comb as a whole cools and then rewarms

Surface temperature as a measure of stress

What we need to know?

- Does it indicate acute stress?

Yes, it indicates acute stress 

And what about chronic stress?



- Is the surface temperature response proportional to stressor intensity

Yes, proportional (at least for acute stress) 

- Valence?

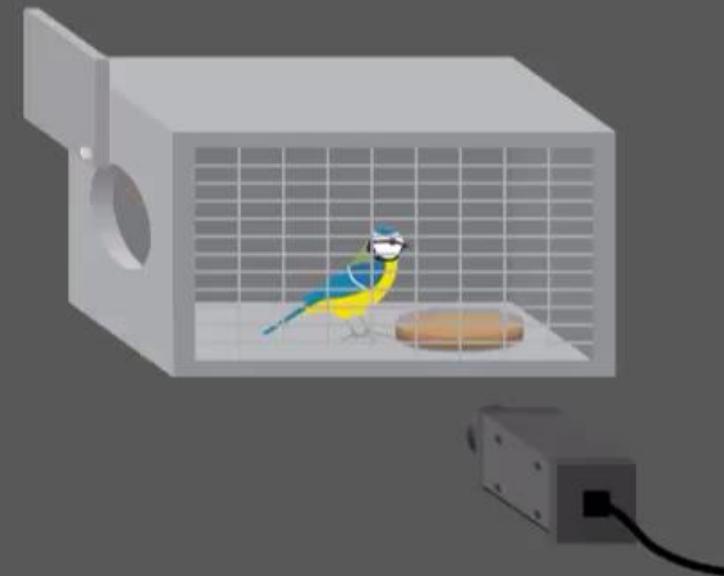
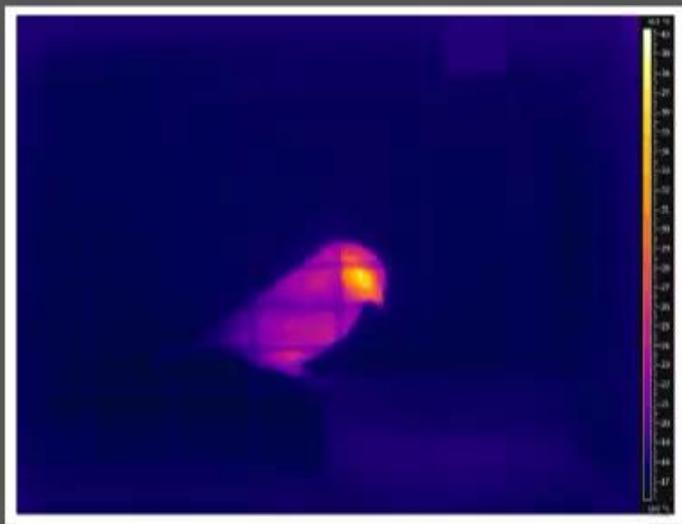


Blaumeise

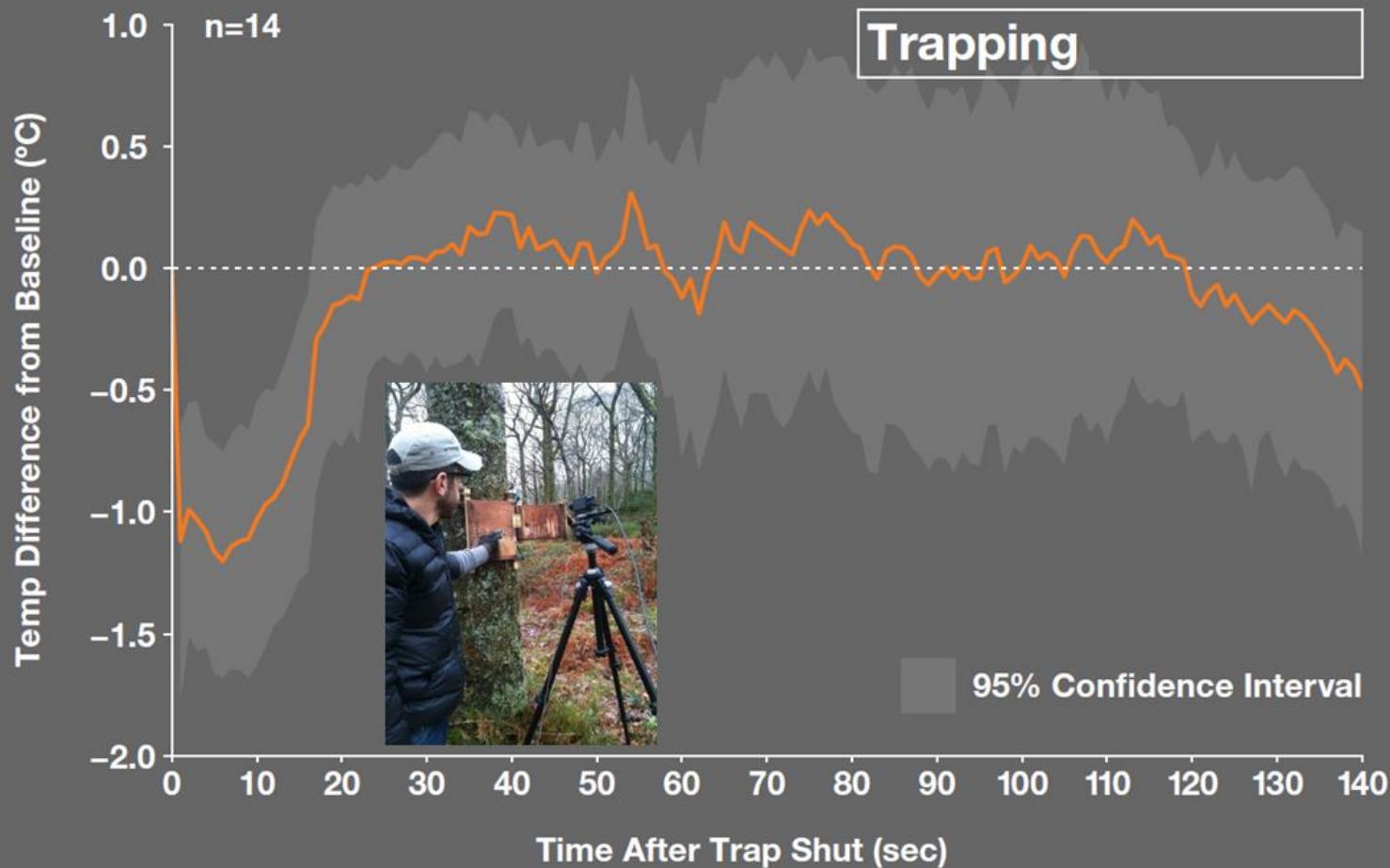
© Pau

Overwintering Birds

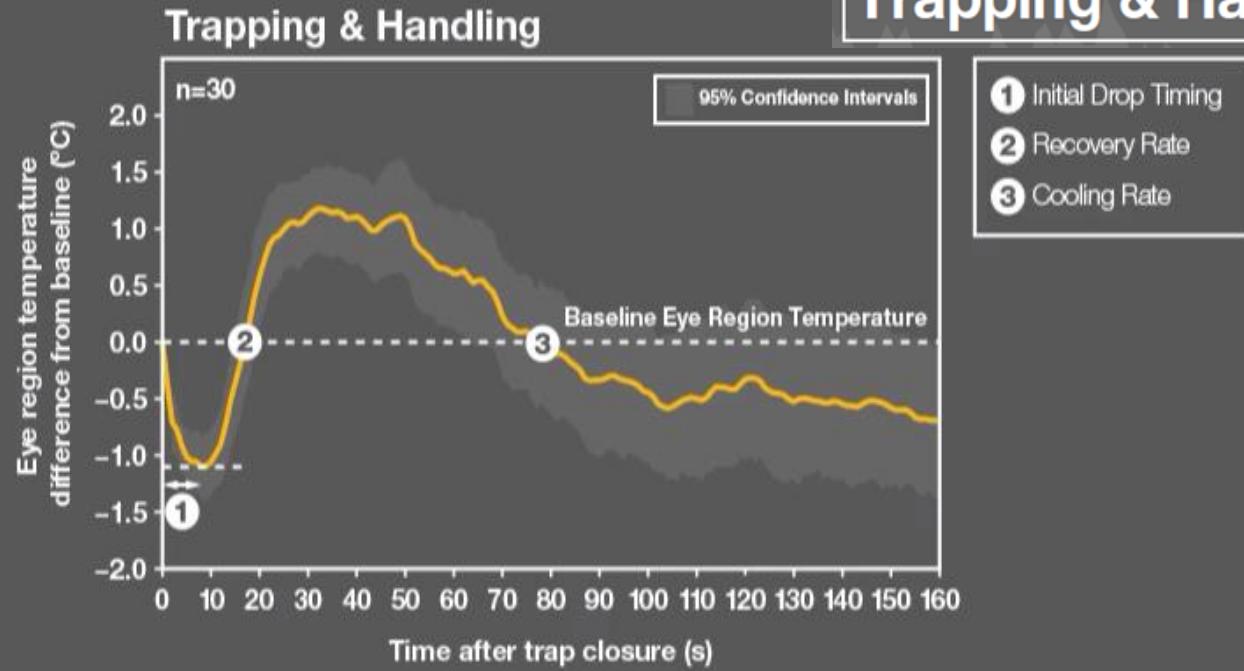
3/6



Thermal Imaging in a Wild Bird



Acute Physiological Stress



The dynamics of this response is related to baseline glucocorticoid levels (Jerem et al in rev)

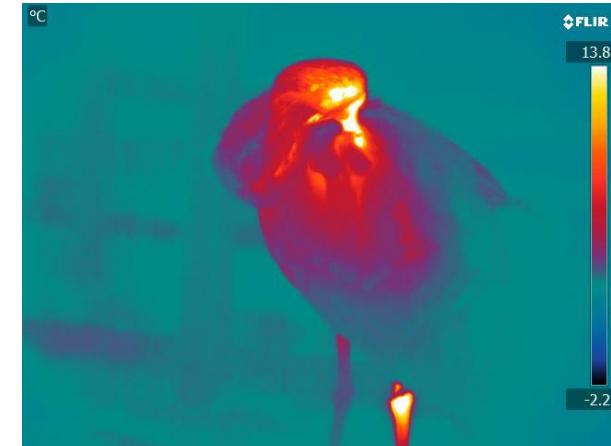
Surface temperature as a measure of stress

What we need to know?

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Yes, it indicates acute stress 

And what about chronic stress?



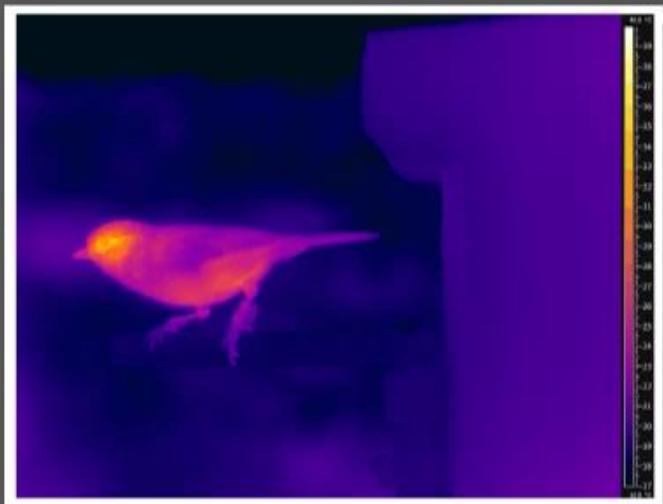
- Is the surface temperature response proportional to stressor intensity

Yes, proportional (at least for acute stress) 

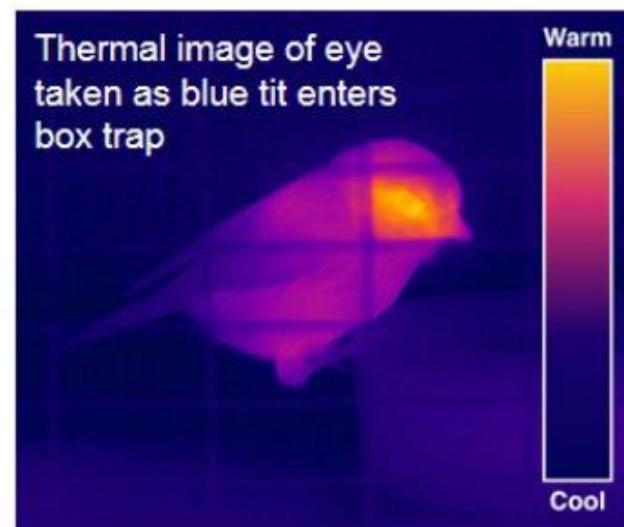
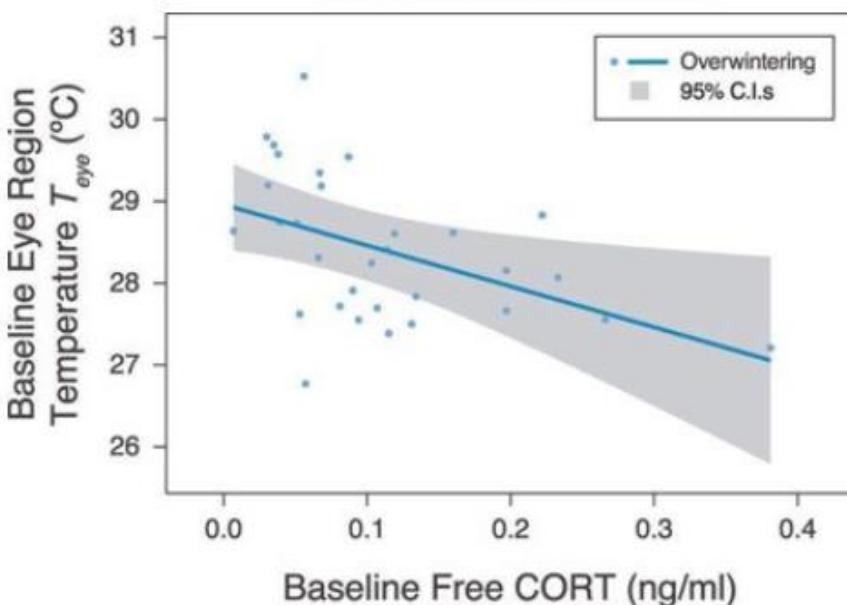
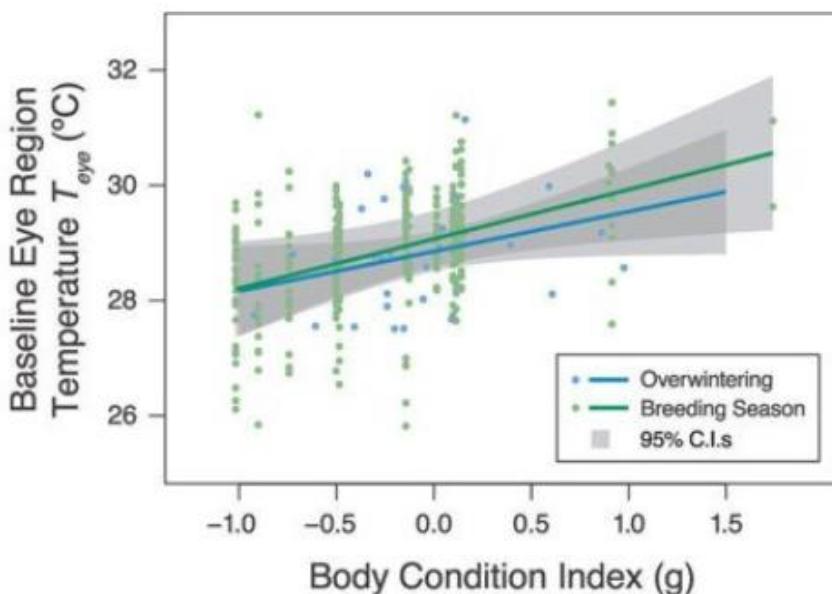
- Valence?

Breeding Season

3/6



Chronic Stress & Thermal Imaging



There is a negative relationship between ***Baseline Eye Region*** temperature and free CORT, because

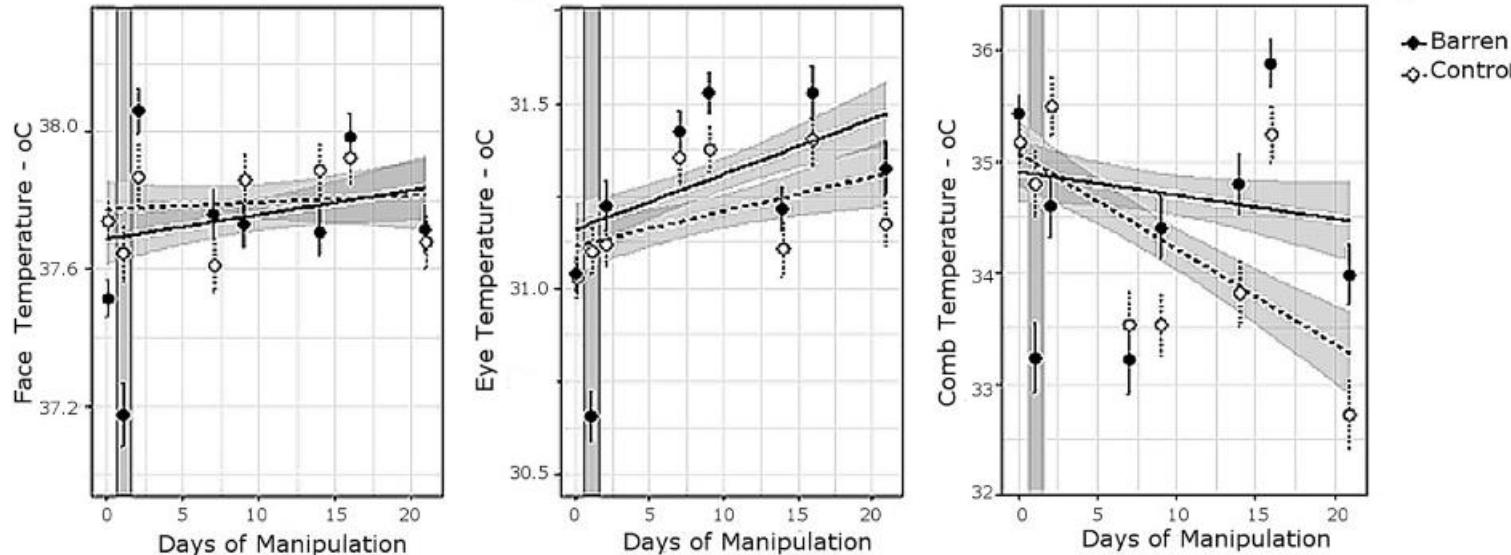
- more stressed birds have reduced surface temperature
- birds in poor body condition reduce metabolic heat production



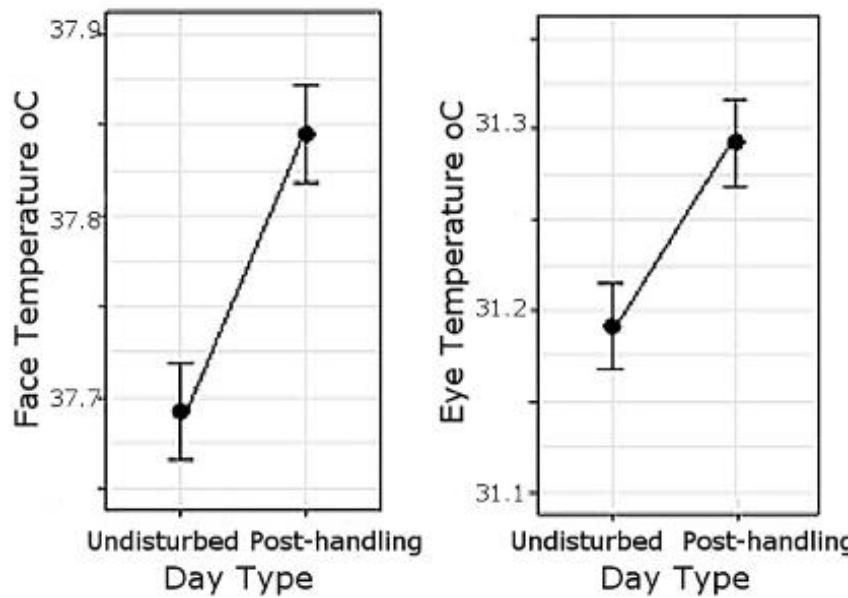
Hens kept in an enriched environment: *Herborn et al 2018 Physiol & Behav 191,47*

Enrichment withdrawn

- Immediate drop in surface temperature in the barren environment
- barren-housed birds showed behaviours indicative of negative welfare and an increase in glucocorticoid levels over 3 weeks
- Comb temperature remained high in unenriched birds compared to control birds (where a drop may mean normal development)

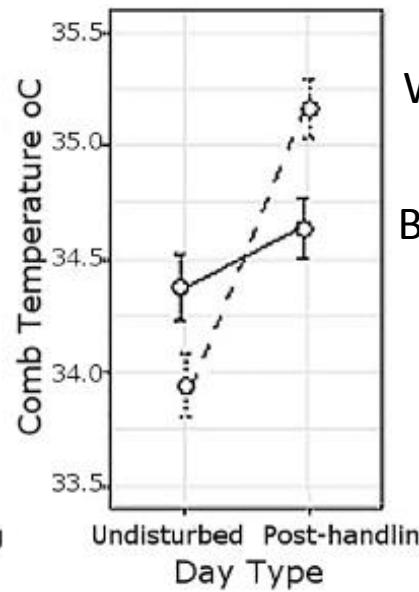
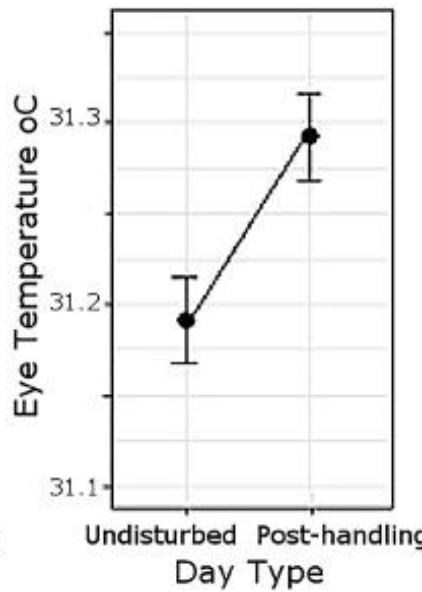
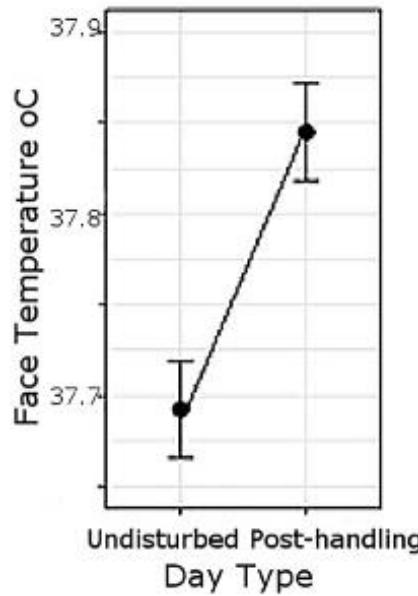


Response of birds in enriched and barren environments to acute stressors



Higher surface temperatures
on days after
handling than on other days

Response of birds in enriched and barren environments to acute stressors



Higher surface temperatures on days after handling than on other days

Birds that are less intensively handled had lower comb temperature on other days, but stronger response to handling

Surface temperature as a measure of stress

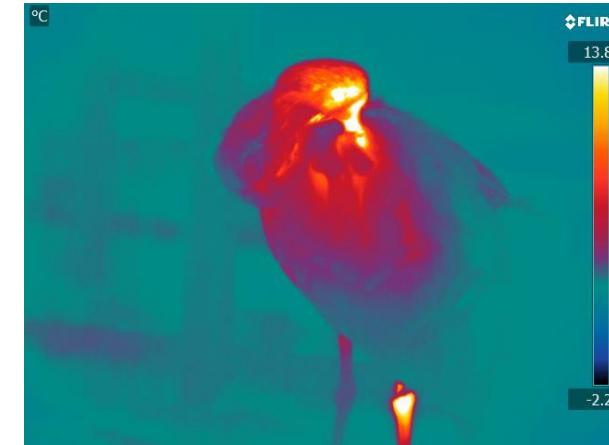
What we need to know?

- Does it indicate acute stress?

Yes, it indicates acute stress 

And what about chronic stress?

Yes, it can also indicate chronic stress 



- Is the surface temperature response proportional to stressor intensity

Yes, proportional (at least for acute stress) 

- Valence?

Valence

Response to a stimuli

emotional arousal

Is the response different if the stimuli
is associated with a positive or
negative experience

emotional valence

Response to being fed mealworms?



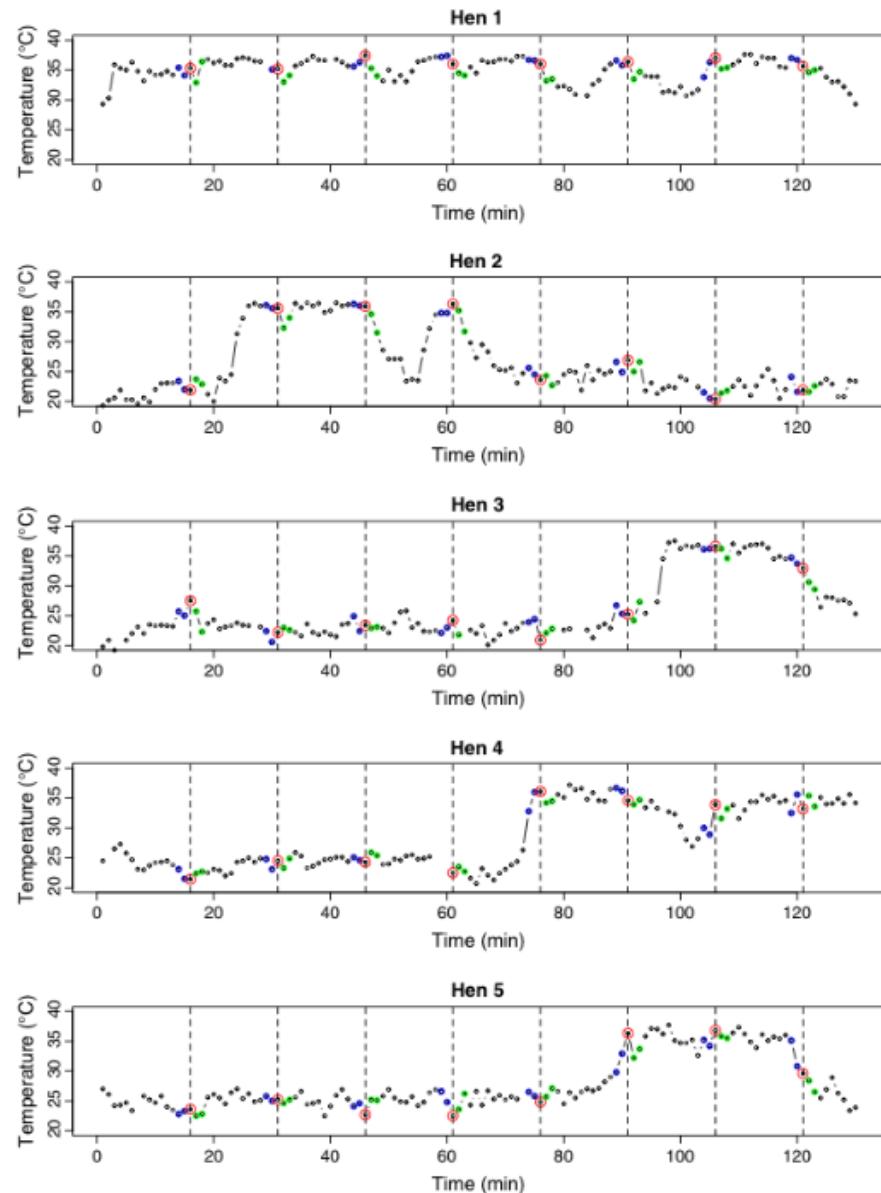
Stress & Thermal Imaging

Valence

Drop in comb temperature when receiving mealworms at high initial comb temperatures: resembles an acute response

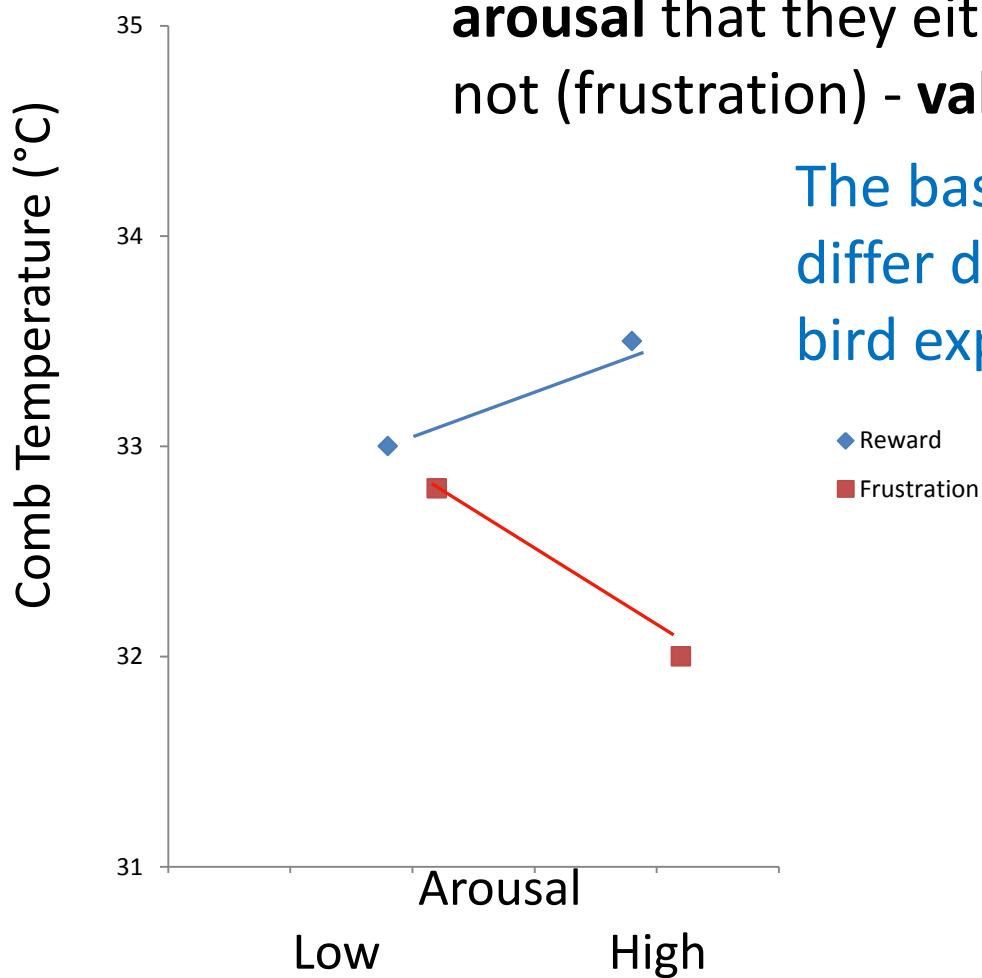
→ may just pick up arousal but not valence

But comb temperatures increases at lower initial temperatures; this might be feeding-induced thermogenesis



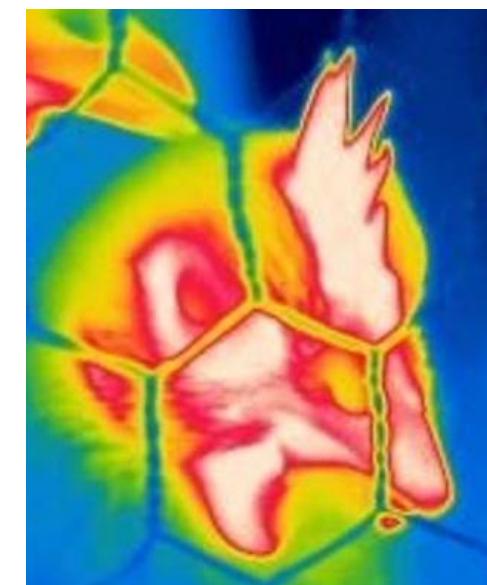
Stress & Thermal Imaging

Valence



Birds presented with few or many mealworms - **arousal** that they either could access (reward) or not (frustration) - **valence**

The baseline comb temperatures differ depending on what the bird experienced half a day earlier



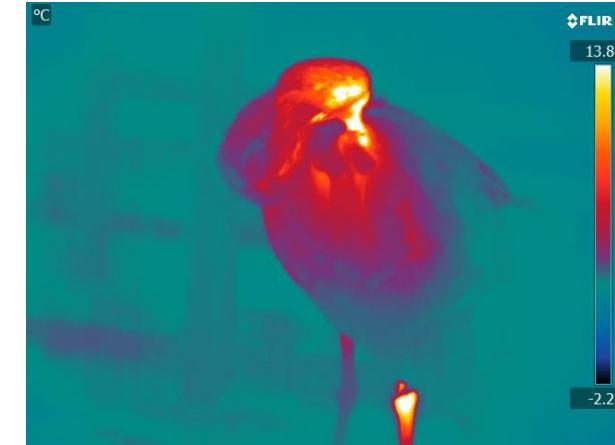
Summary

Surface temperature as a measure of stress

What we need to know?

- Does it indicate acute stress?

Yes, it indicates acute stress 



And what about chronic stress?

Yes, it can also indicate chronic stress 

- Is the surface temperature response proportional to stressor intensity

Yes, proportional (at least for acute stress) 

- Valence?

Some promising signs, but more work needed 

°C

FLIR

Thank you for your attention !



Katherine Herborn
Paul Jerem
Neil Evans
James Graves
John Braid
Many helpers with watching
thermal videos
Staff at Cochno & SCENE

18.3

36.4