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Measurement of body temperature in animal studies: how, when, where and why?

Malcolm Mitchell

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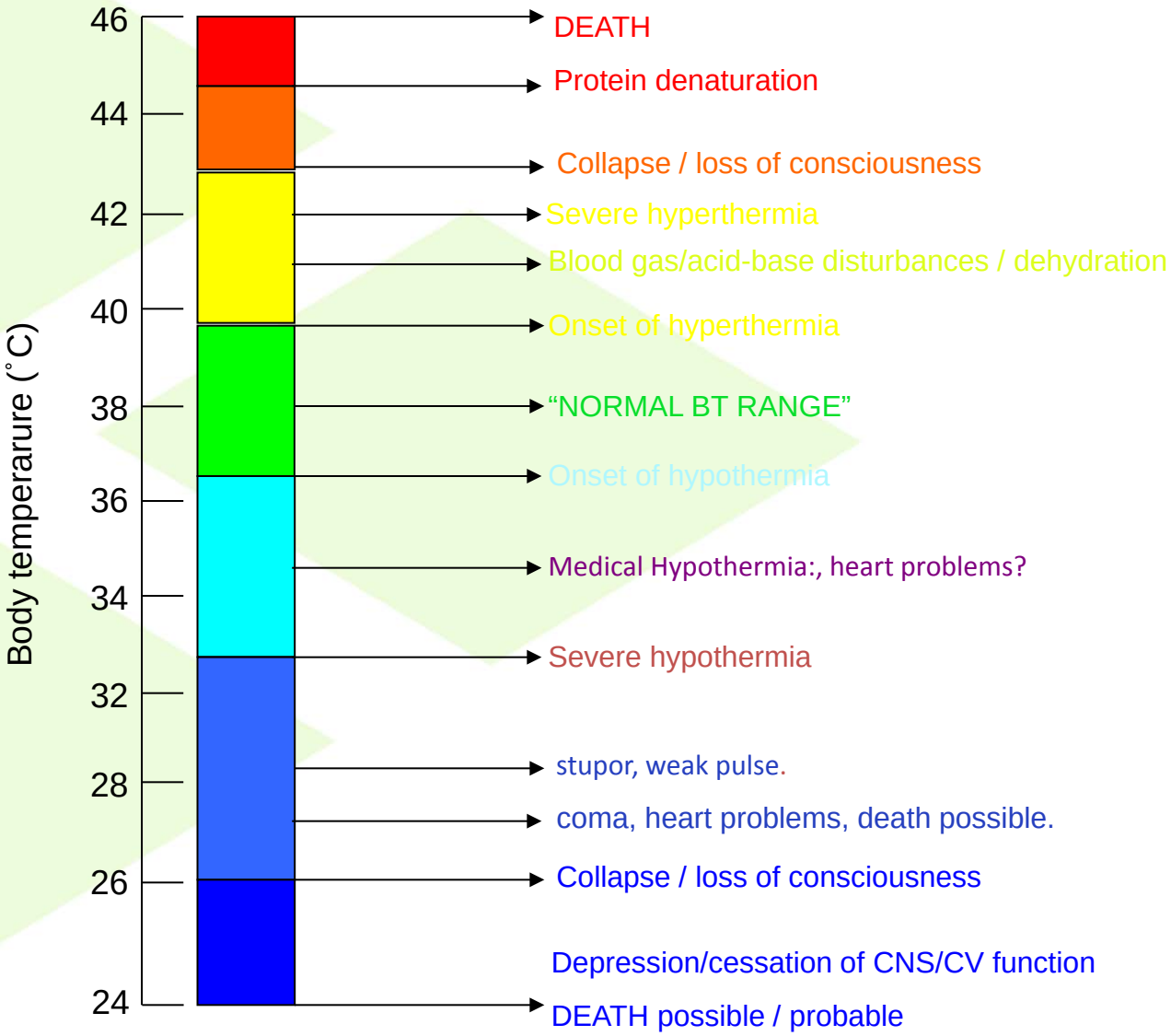
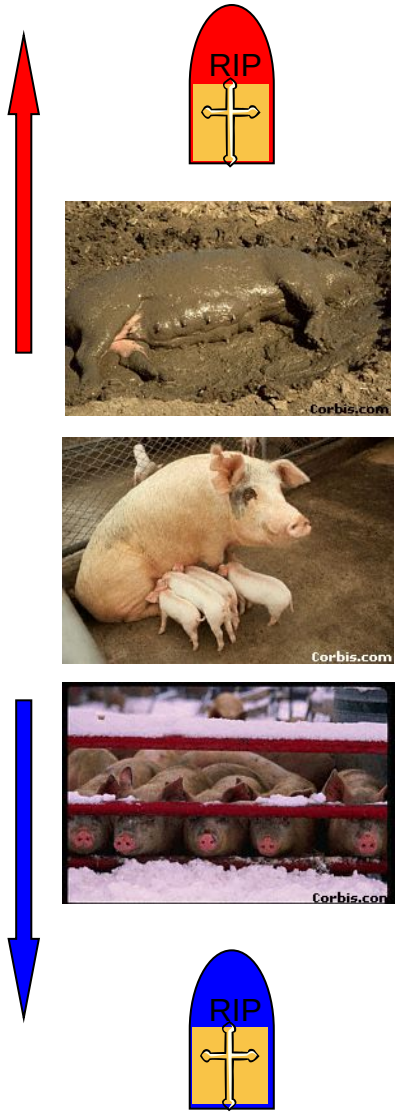
Leading the way in Agriculture and Rural Research, Education and Consulting

Range of animal body temperatures





Thermal Challenges

A significant problem for global animal production is thermal stress

Too hot

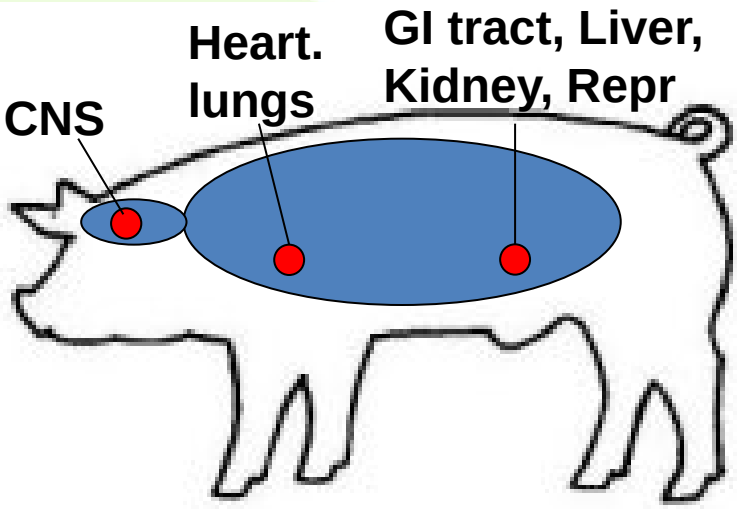
Too cold

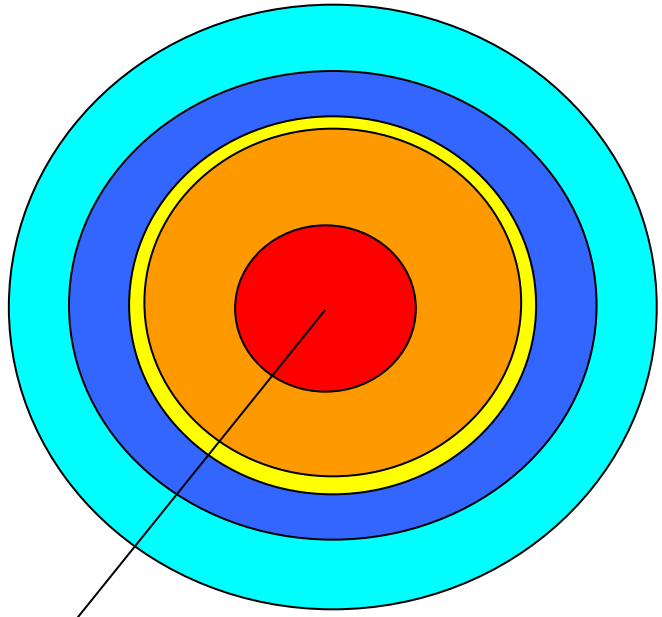
Body Temperature

- Indicator of health status/disease
- Indicator of stress
- Indicator of welfare
- Environmental stress and responses

Our subjects will be pigs! - we will examine three different approaches to estimate body temperature

Body Temperature Theory



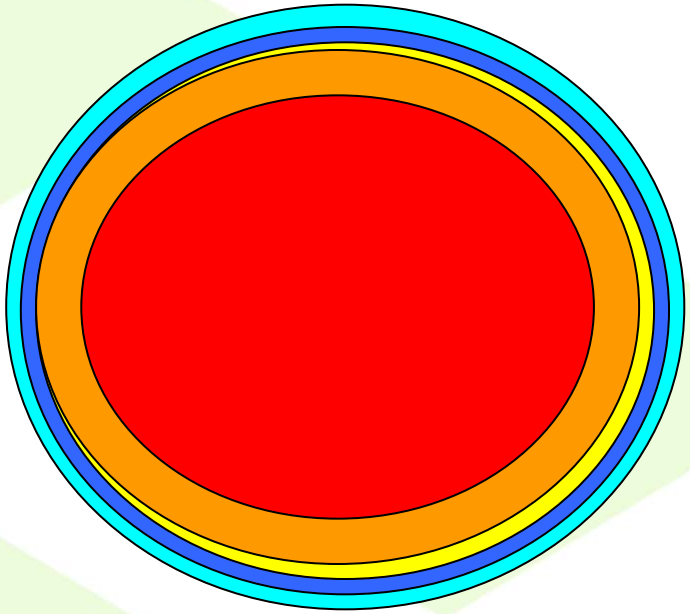


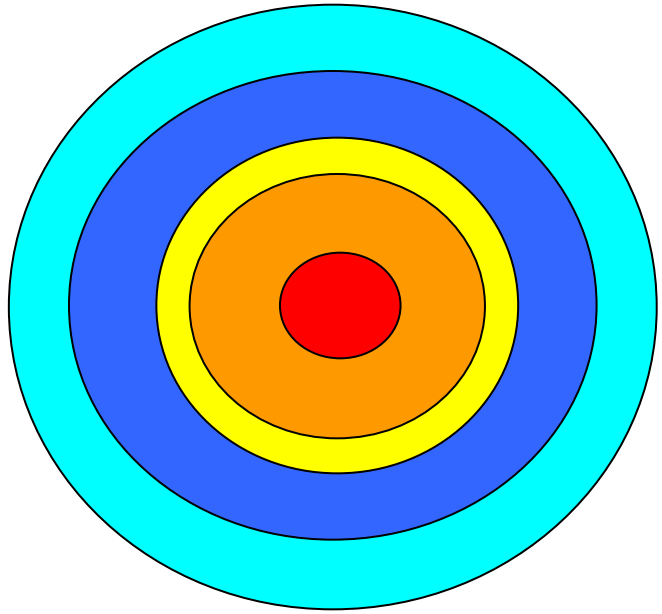
Thermal core

Organs

Concentric Thermal Shells

Body Temperature Theory





VASODILATATION, SWEATING / PANTING, PTIOLERECTION, POSTURE, BEHAVIOUR

VASOCONSTRICTION, SHIVERING, COAT, POSTURE, BEHAVIOUR

Concentric Thermal Shells

Considerations

- Sampling frequency / continuous record
- Required time course and duration
- Handling of animals
- Accessibility
- Degree of invasion
- Ethical and regulatory issues
- Cost
- Simplicity / technology / operatives / training

How to measure BT?

The default position is measure "Rectal Temperature"

Three alternative approaches:-

- **Core temperature by implanted devices**
- **Body temperature by injected transponder chips**
- **Surface temperature**
  - **Non-contact thermometry**
  - **Thermal imaging**

How to measure BT?

- DBT by implanted sensors
- Radio-telemetry and
- Temperature data logging
- Useful for continuous measures in experimental and commercial situations
- Thermal challenge and stress responses
- Long term / chronic
- Accurate and absolute values for DBT
- Complex
- Invasive / ethical and regulatory issues
- Expensive

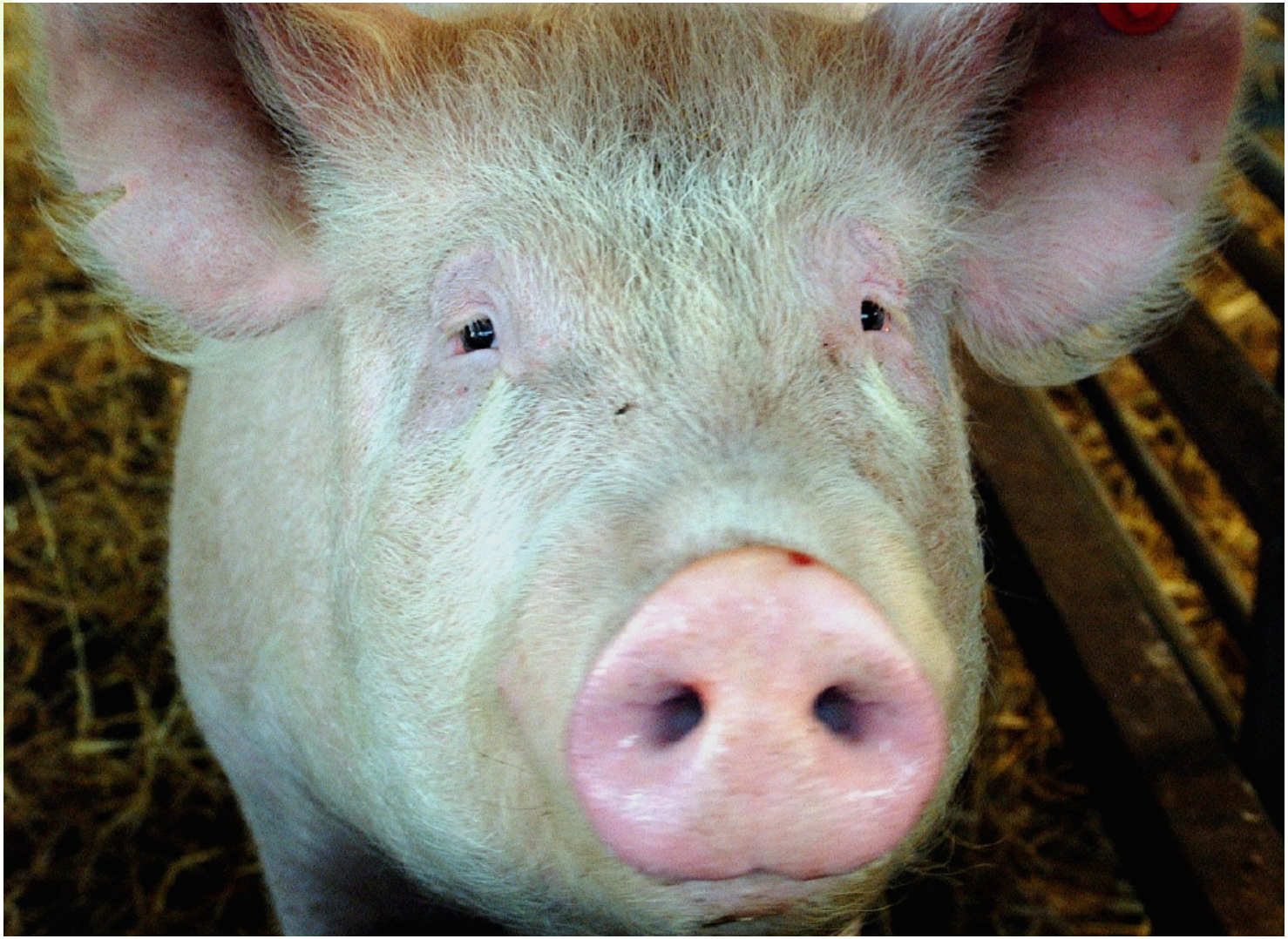
How to measure BT?

- DBT by Transponder chips
- Simple / easy
- Minimally invasive
- Accurate?
- Relatively inexpensive
- Point sampling – not continuous
- Not automated
- Requires access to animals
- Accurate?

How to measure BT?

- Surface Temperature / Thermal imaging
- Simple?
- Non-invasive
- Accurate?
- Range of costs
- Point sampling – not continuous
- Not automated
- Requires access to animals
- Accurate?

Pig Telemetry



Pig Telemetry

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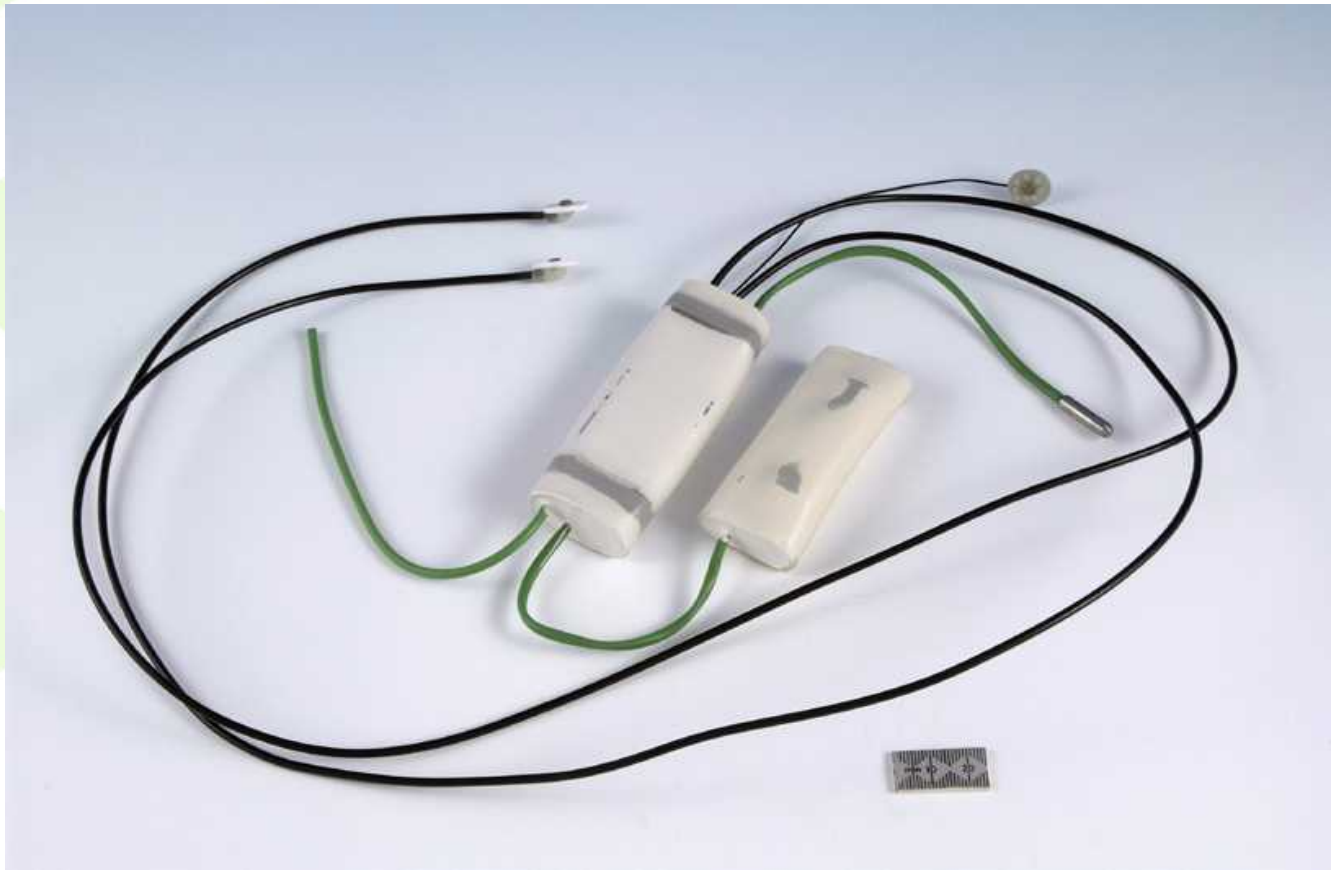
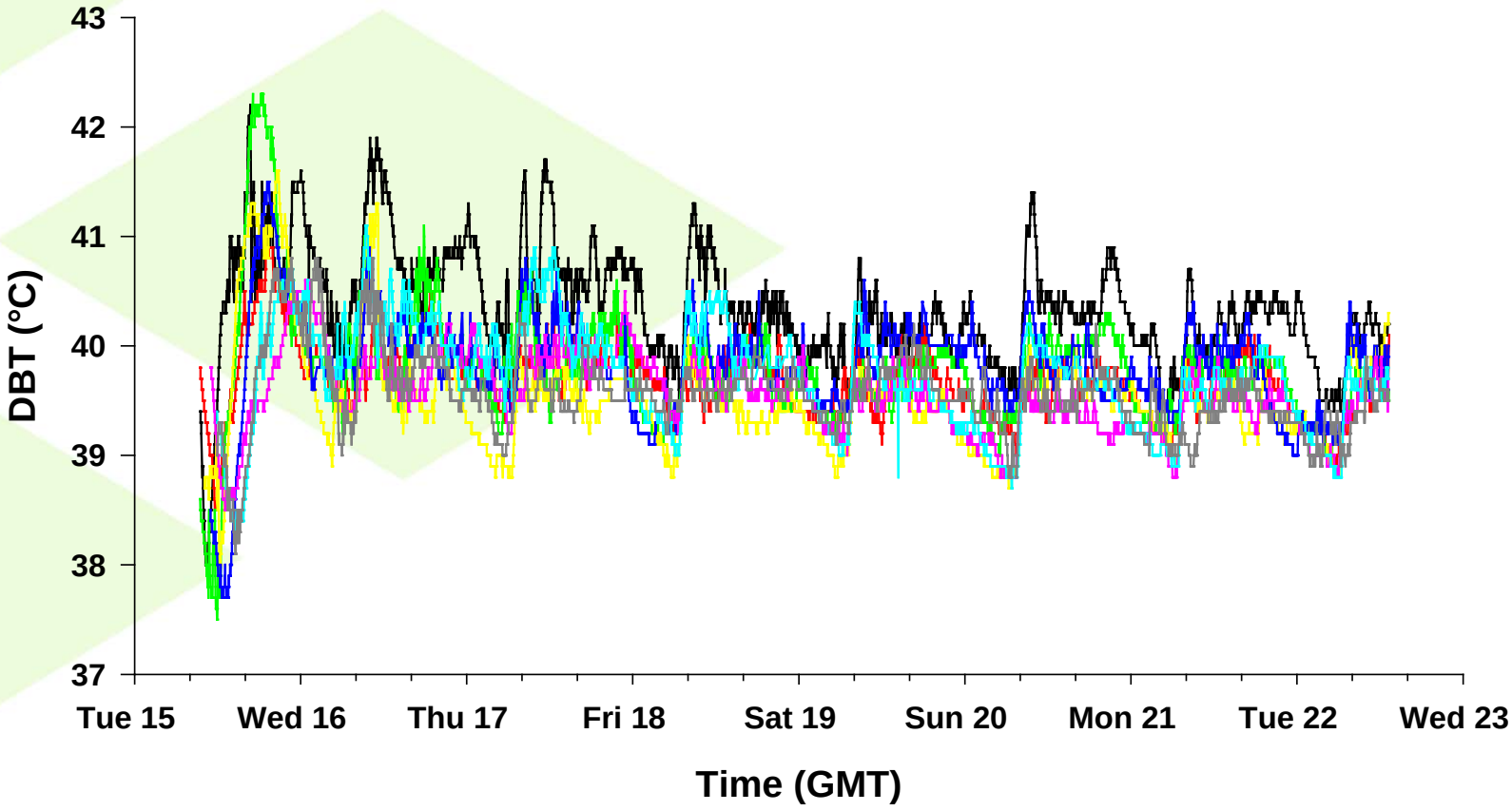
Large mammal Tx

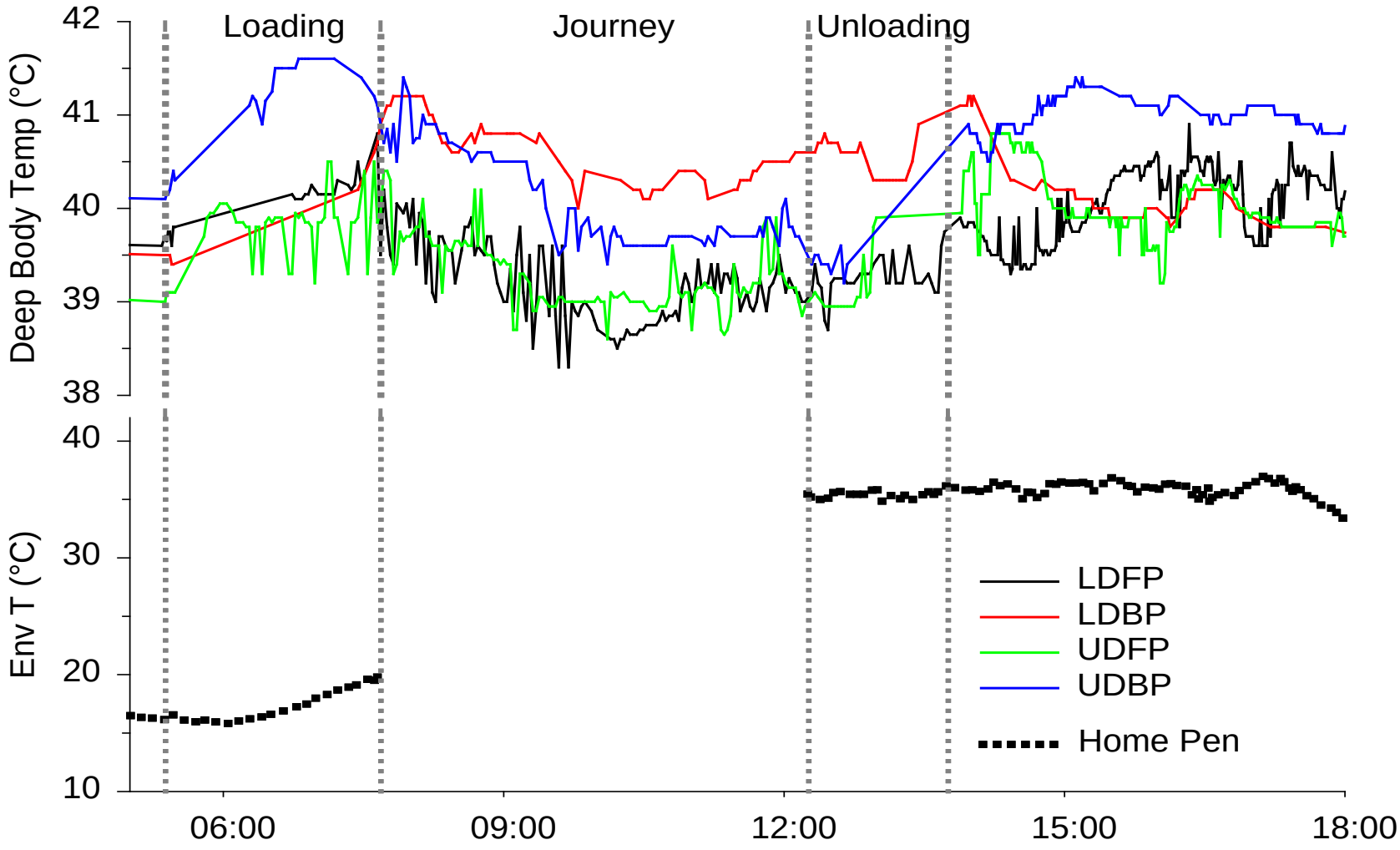


Telemetry implant surgery

PIG – DBT – DIURNAL RHYTHM

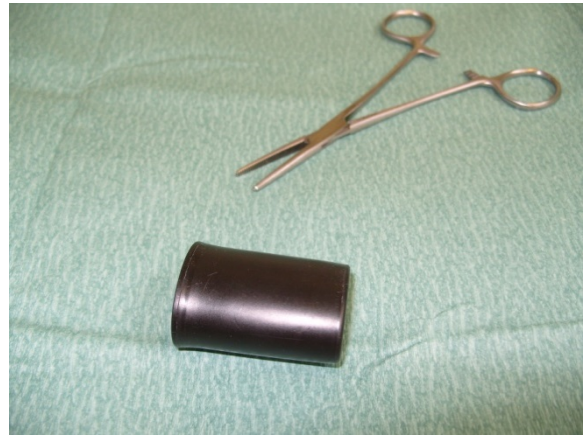


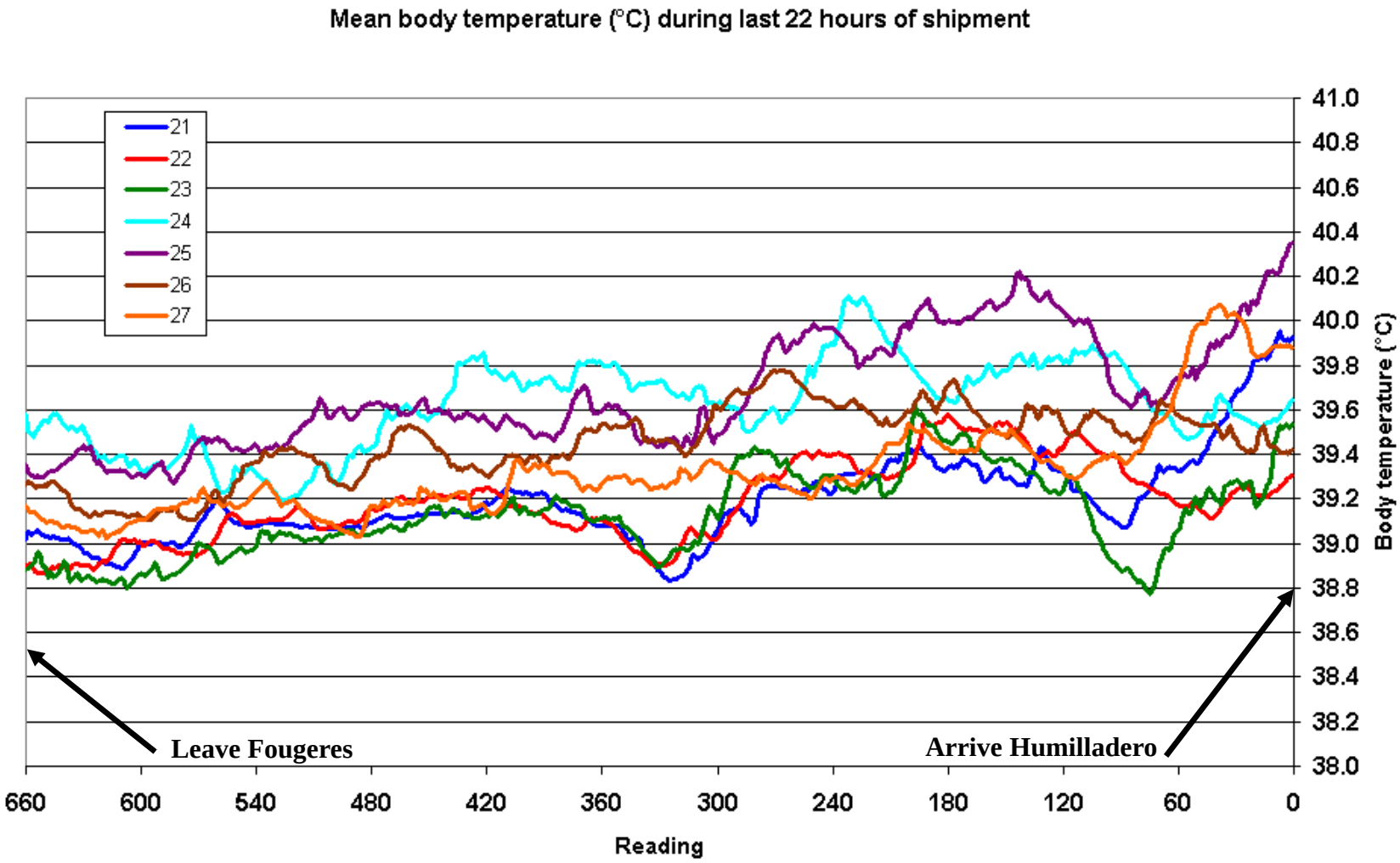
PIGS (Transport)



Pig Body temperature data logging

- **Real time data**



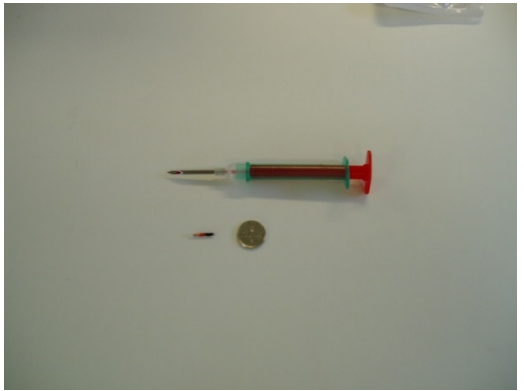

Mean body temperature (°C) during last 22 hours of shipment
21
22
23
24
25
26
27
41.0
40.8
40.6
40.4
40.2
40.0
39.8
39.6
39.4
39.2
39.0
38.8
38.6
38.4
38.2
38.0
Body temperature (°C)
Leave Fougeres
Arrive Humilladero
660
600
540
480
420
360
300
240
180
120
60
0
Reading

Summary

- **Both radio-telemetry and data logging are appropriate methods for the continuous monitoring in livestock**
- **The efficiency of data capture for both methods is high**
- **Both methods provide valuable and important information that can be incorporated in to physiological stress response modelling**
- **Continuous monitoring of physiological variables during stress may assist in improving animal welfare in practical and commercial setting**

idENTICHIP with Bio-thermo

- ***idENTICHIP* is an electronic CMOS "microchip" transponder housed in a glass enclosure or capsule**
- **The capsule is 14mm long and 2.1 mm wide**
- **The "implanter" is a sterile syringe with a 31 mm needle**
- **The capsule weighs 120 mg**



idENTICHIP with Bio-thermo

idENTICHIP with Bio-thermo

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Experimental protocol

Hot 30°C and 32ºC both with 70% RH

Thermoneutral 15ºC with 55% RH

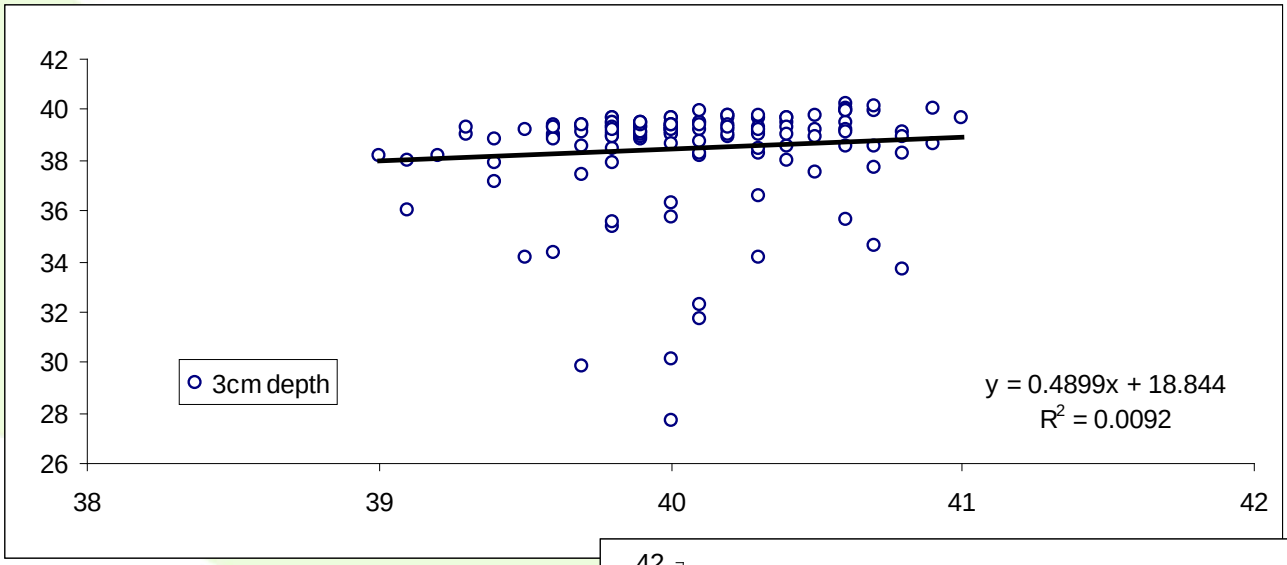
Cold -10°C or -15ºC (95% RH)

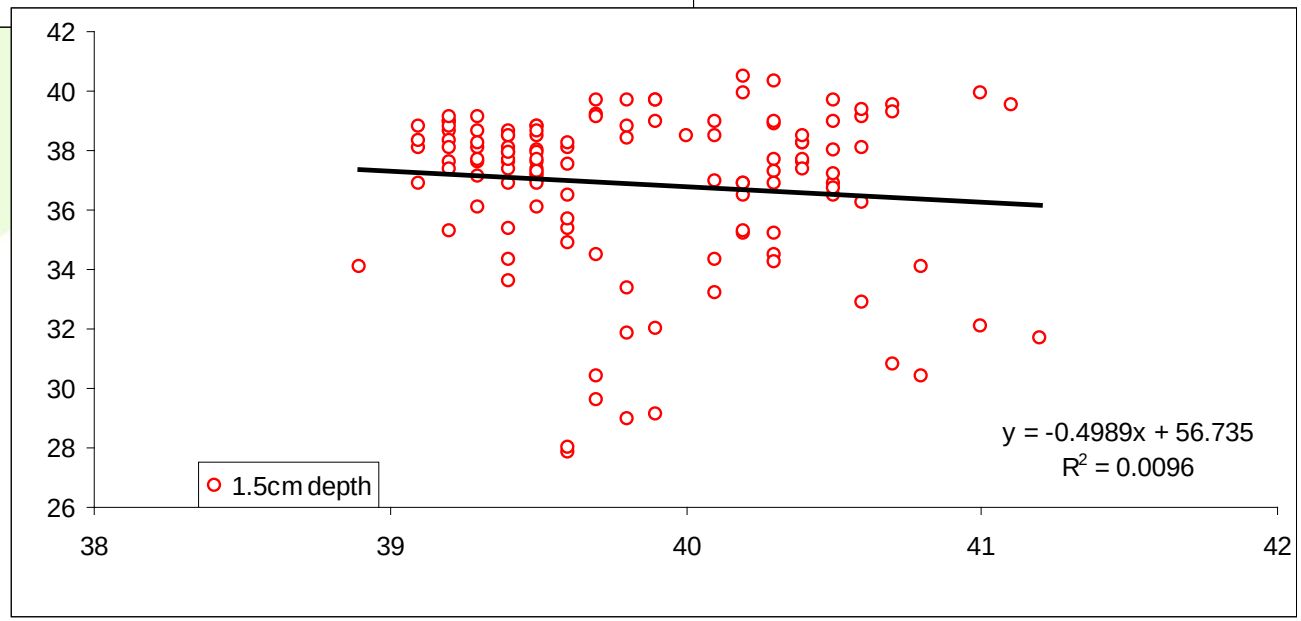
Ramp up 2 hours (from TN)

Hold 1 hour

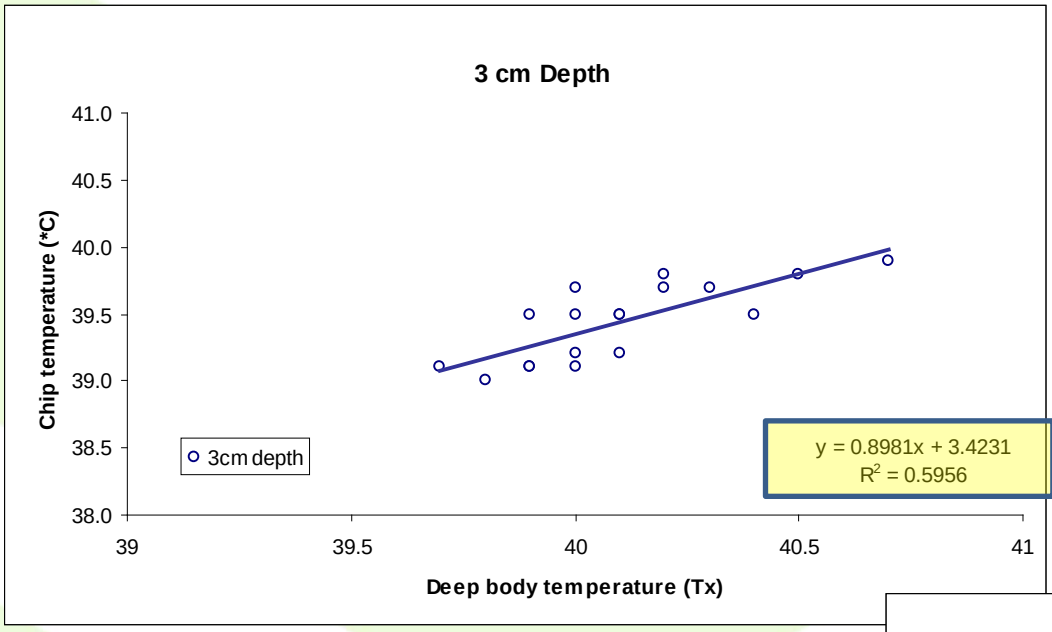
Ramp down 1 hour (to TN)

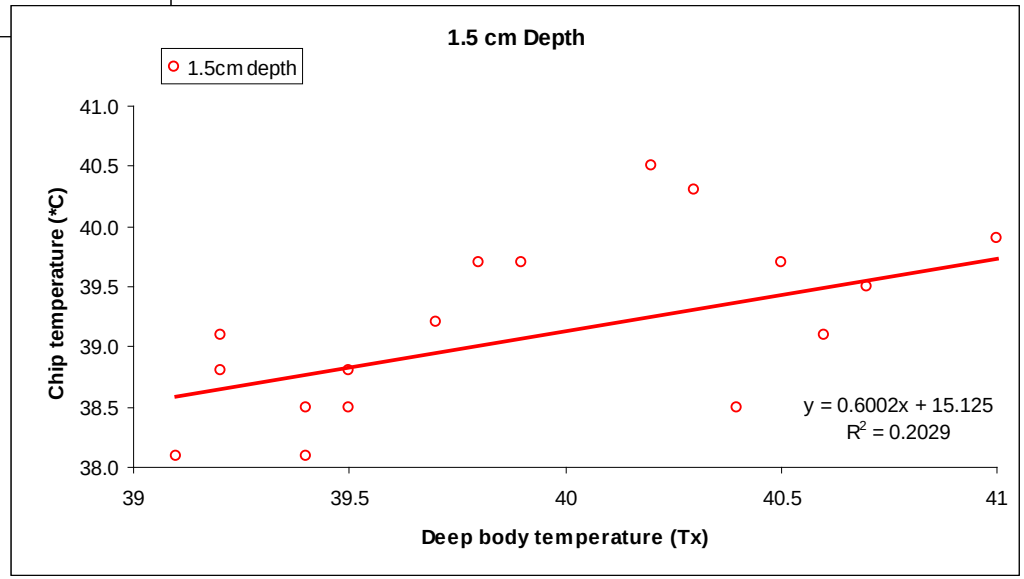
DBT by Tx (x axis) and idENT (y axis)





HIGH TEMPERATURE TREATMENTS





RFID CHIPS

(1) The i*dentichip* units may be used to monitor DBT in pigs during exposure to elevated ambient temperatures or during heat stress.

(2) The units should be injected with the applicator needle perpendicular to the skin to ensure "full depth" (3.0 cm) of implantation to ensure accurate readings.

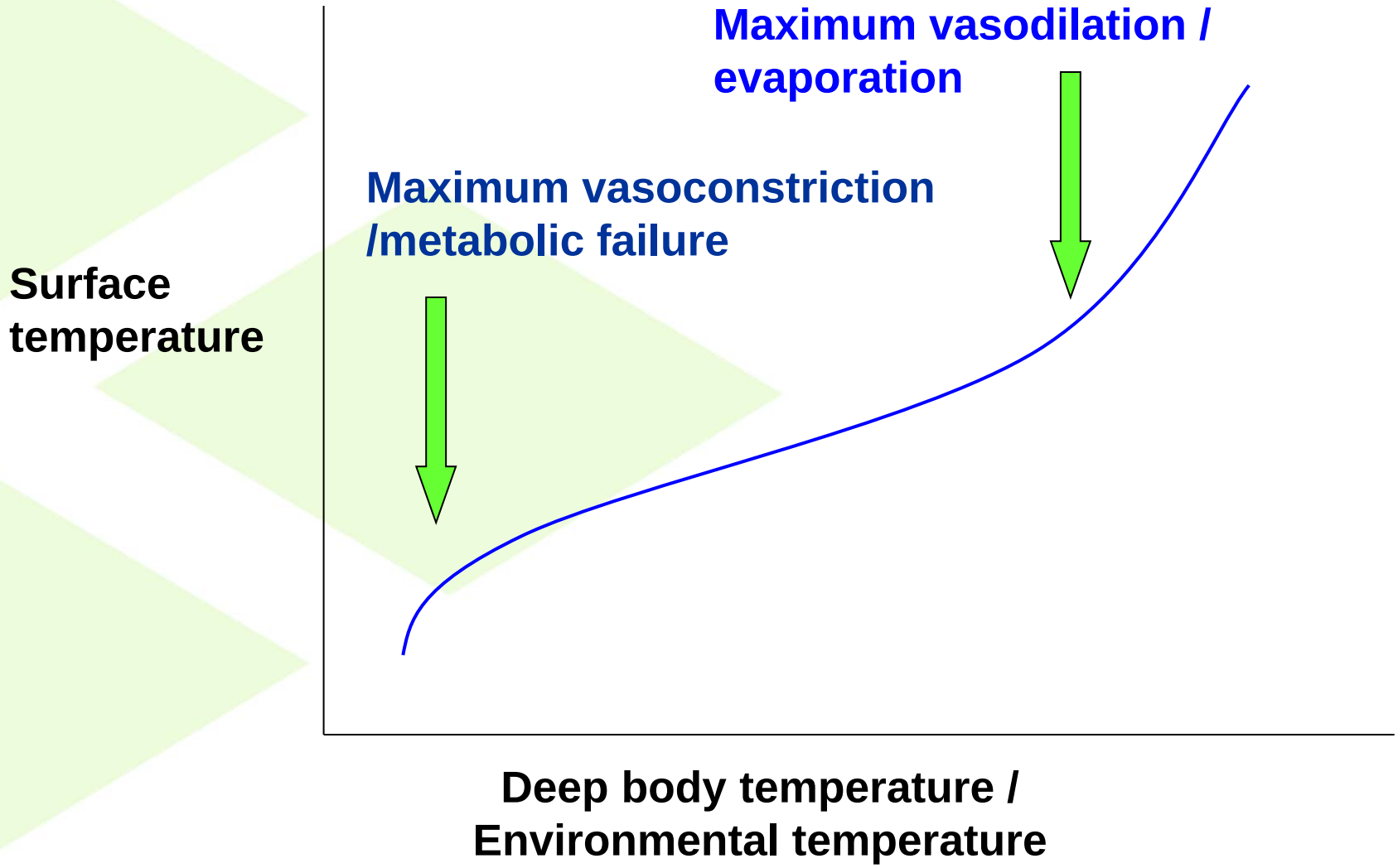
(3) The optimum injection site in pigs is on the back of the neck. This site is easily accessible in practical environments, migration of the unit is minimal and the values of DBT obtained at this site are physiologically meaningful (see above).

Non-contact IR thermometry

- **Determine possible relationships between surface temperature, measured by IRT, and deep body temperature in pigs over a wide range of thermal micro-environments typical of the range and extremes in practice.**

- **To test the hypothesis that surface temperature may be employed in pigs as an index of the extent and adequacy of thermoregulatory responses and thermal stress**

Possible relationship between T_s and T_b / T_e



Methods

- **Surface temperature – 5 sites**
- **Deep body temperature (Tx)**
- **Paired reading in a range of environmental thermal conditions**

Methods

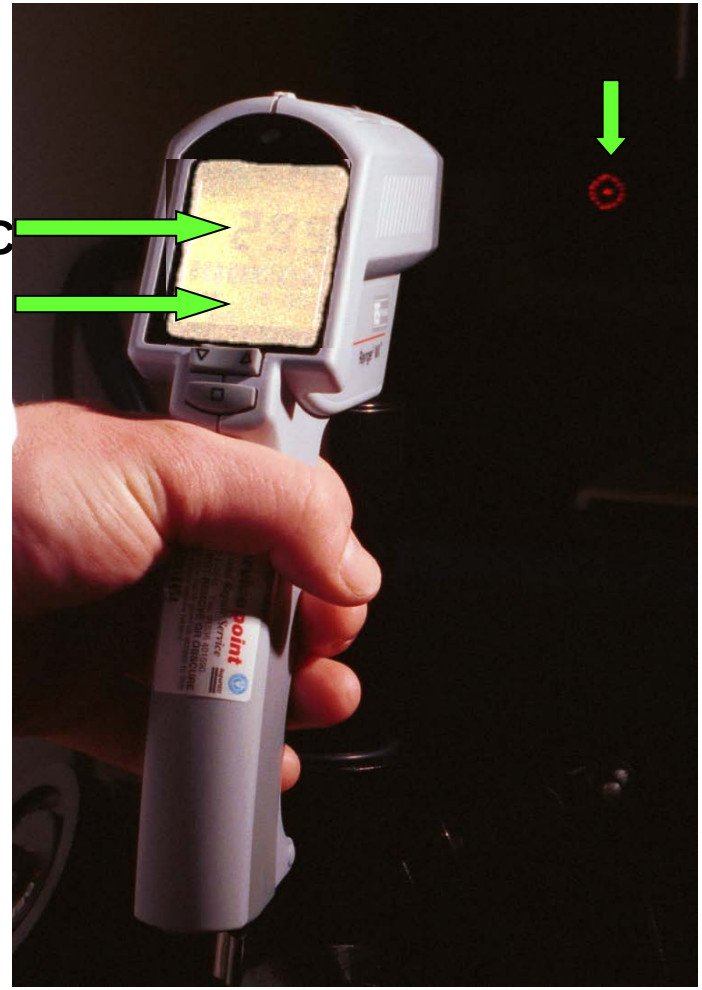
- **Each surface temperature correlated with corresponding body temperature and environmental temperature**

- **Mean surface temperature correlated with corresponding body temperature and environmental temperature**

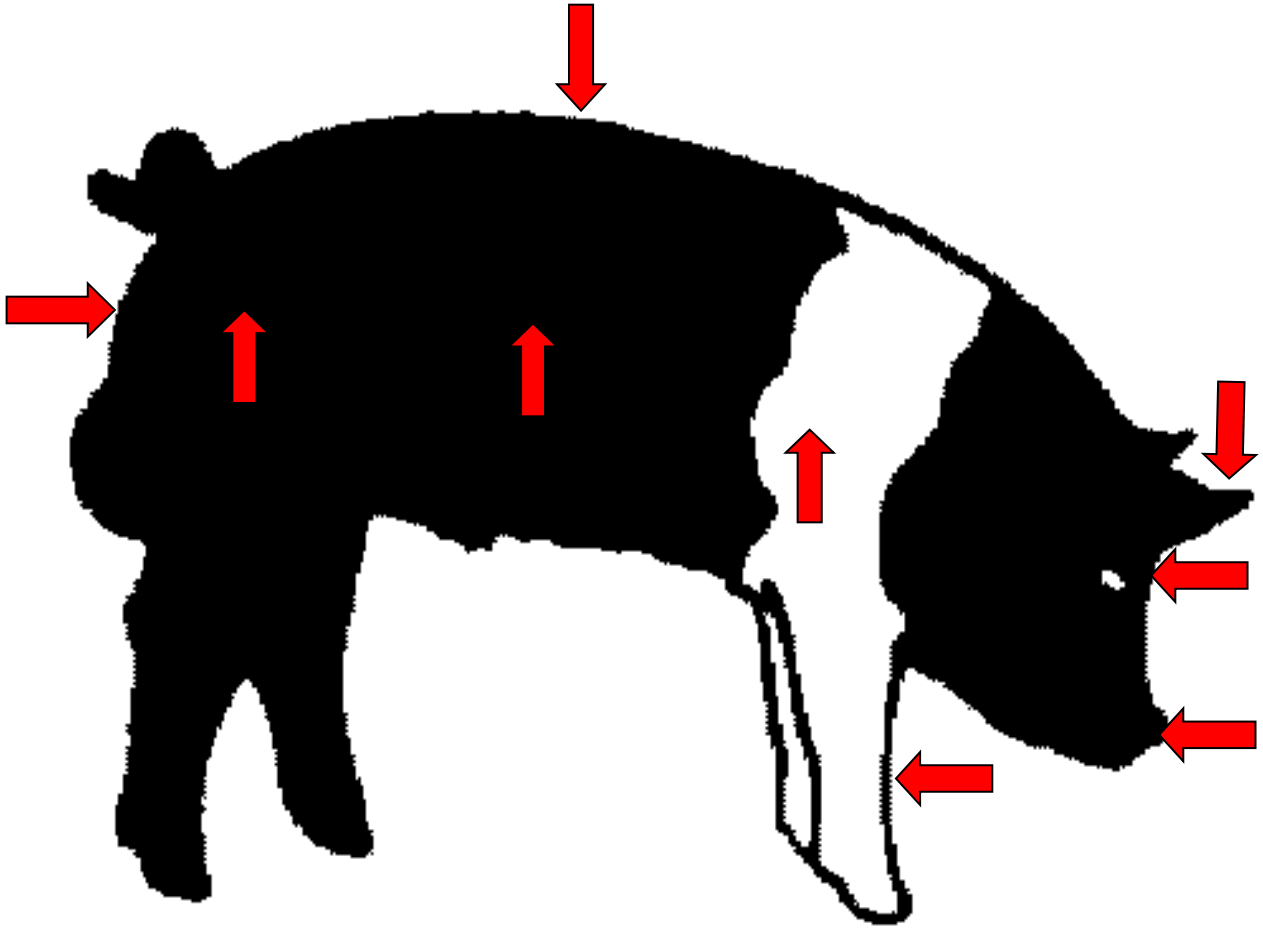
RAYTEK MX-4

Average surface temperature (° C

Emissivity



1 Snout
2 Forehead
3 Ear
4 Foreleg
5 Side – foreleg
6 Side – middle
7 Back – middle
8 Side – hind leg
9 Rump



PIGS SURGICALLY IMPLANTED WITH RADIOTELEMETRY PACKAGES

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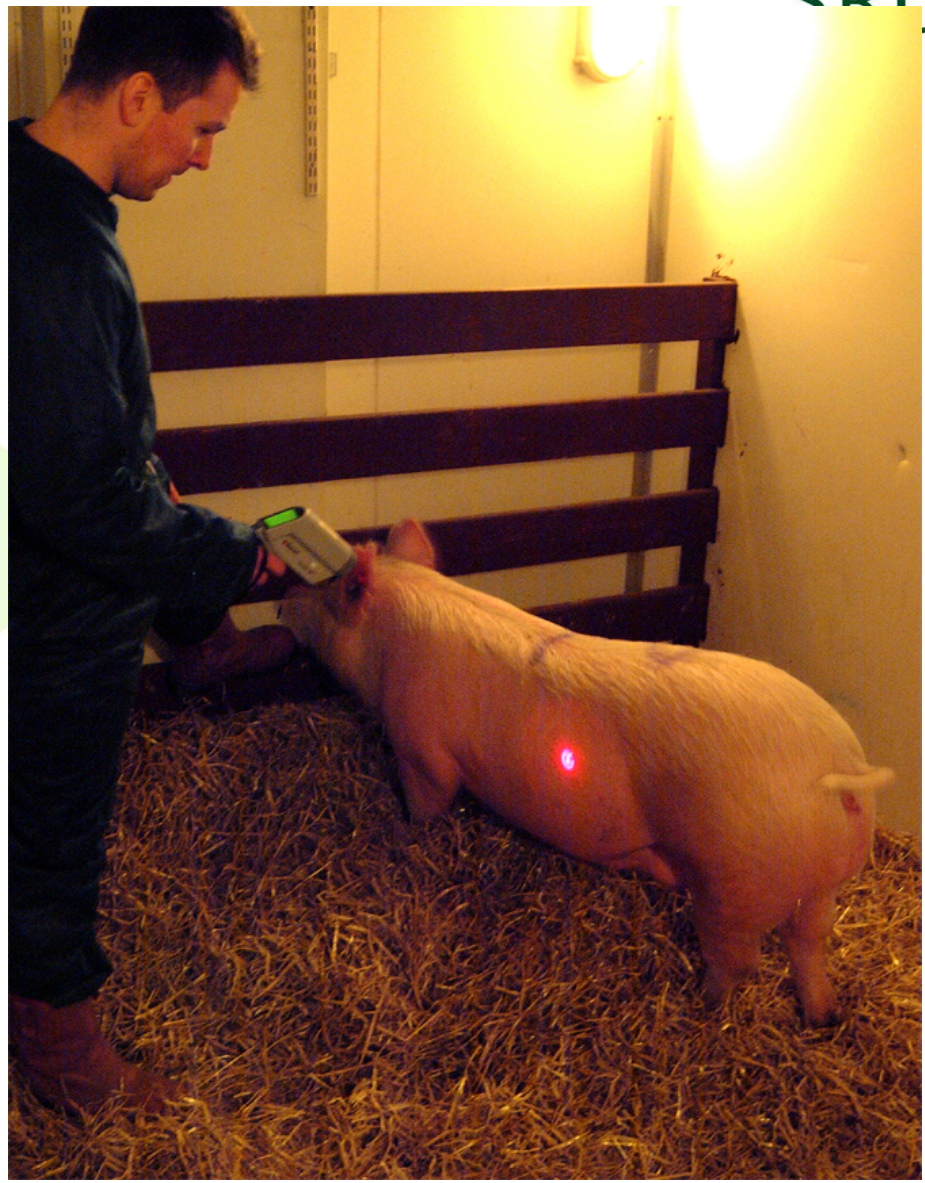
Remote measurement of surface temperature

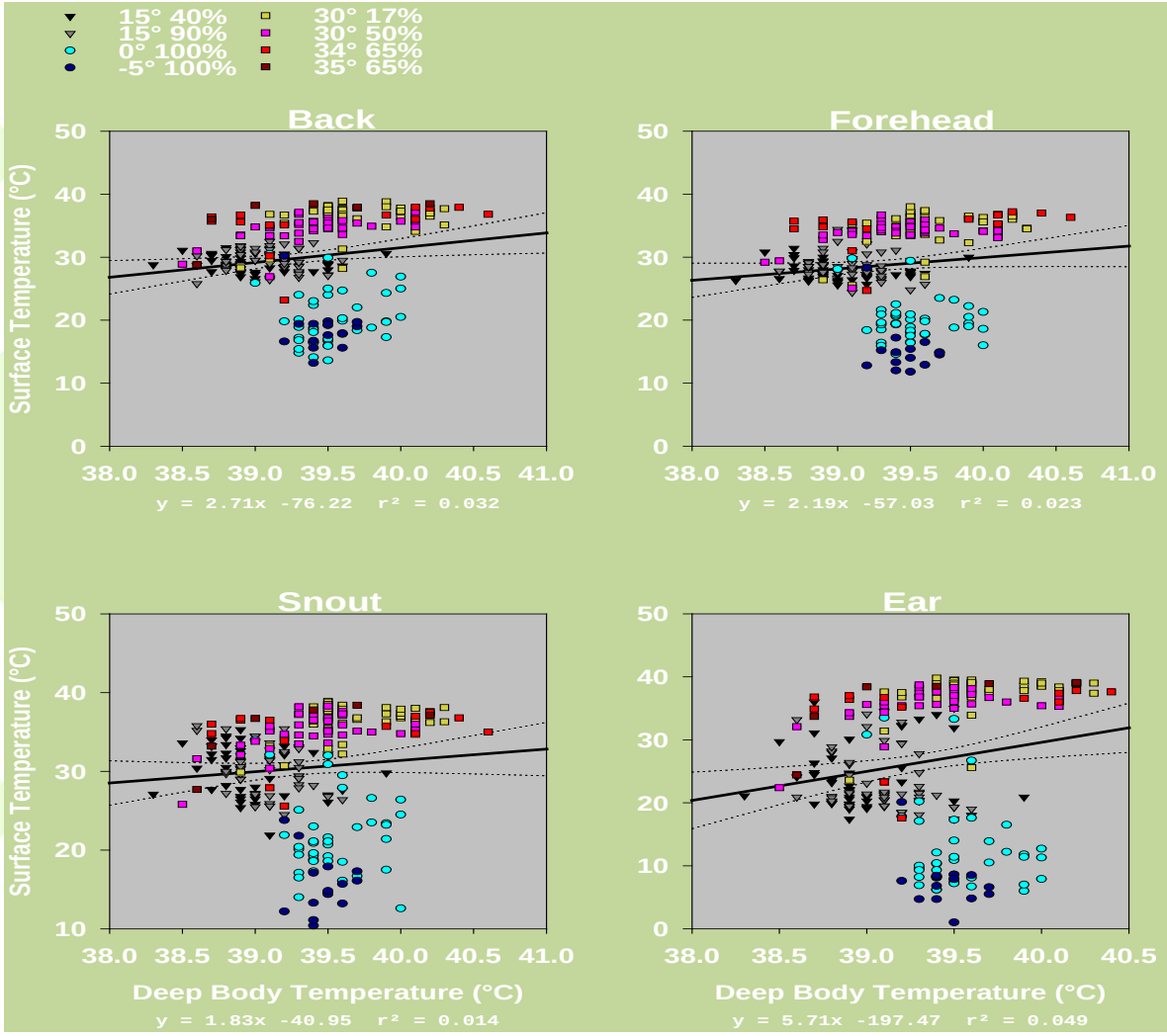


Laser sighting and field size

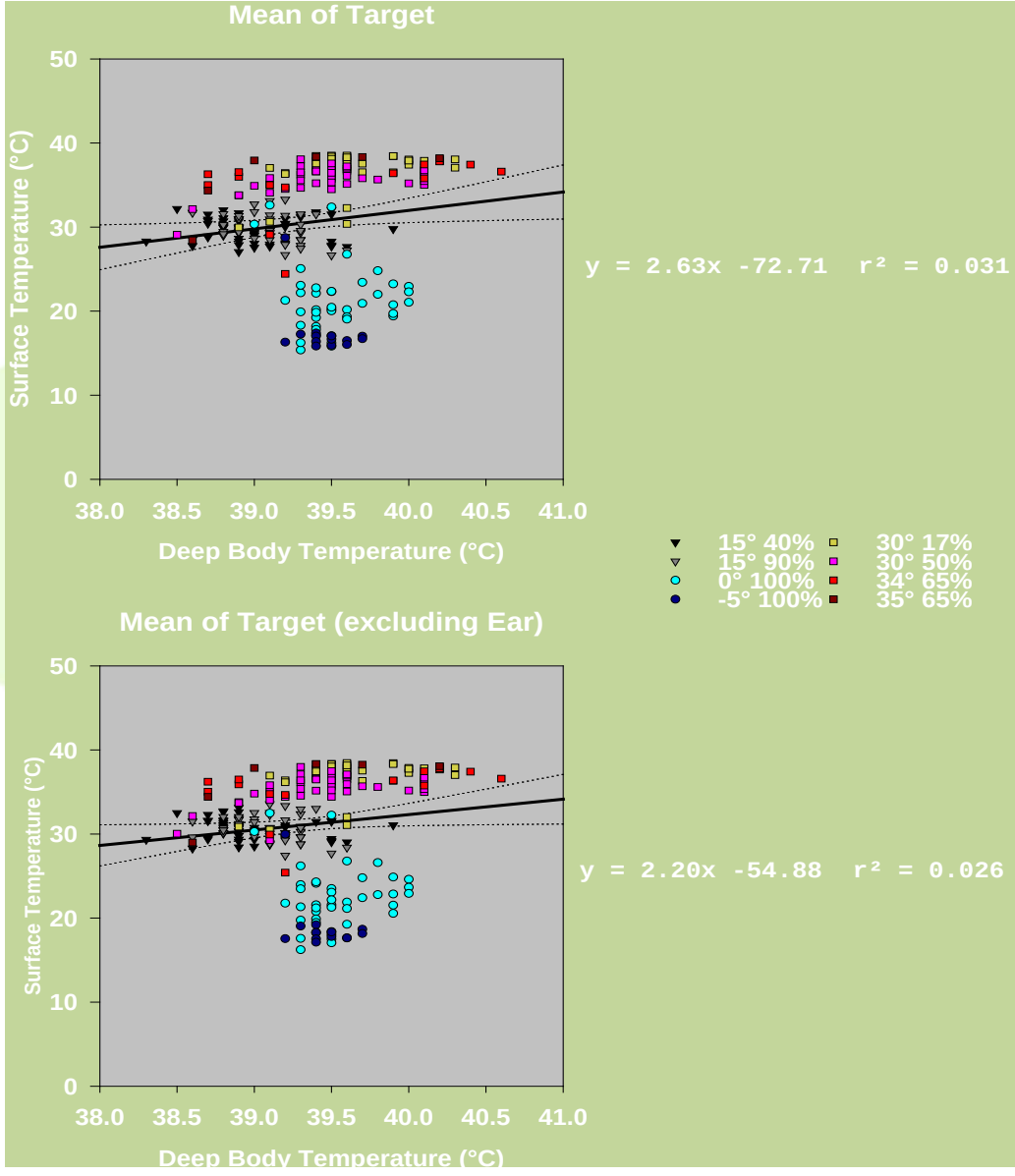
Test Environmental Conditions

Target			Achieved		
Temp (° C)	RH (%)	VD (gm^{-3})	Temp (° C)	RH (%)	VD (gm^{-3})
-5	100	3.41	-5.5	59.6	1.96
0	100	4.85	0.1	63.0	3.10
15	40	5.13	14.9	35.9	4.60
15	90	11.55	16.0	88.9	12.2
30	17	5.16	29.9	23.5	7.10
30	50	15.18	30.1	56.7	17.30
34	65	24.24	33.7		
35	65	25.73	34.7	63.4	24.71

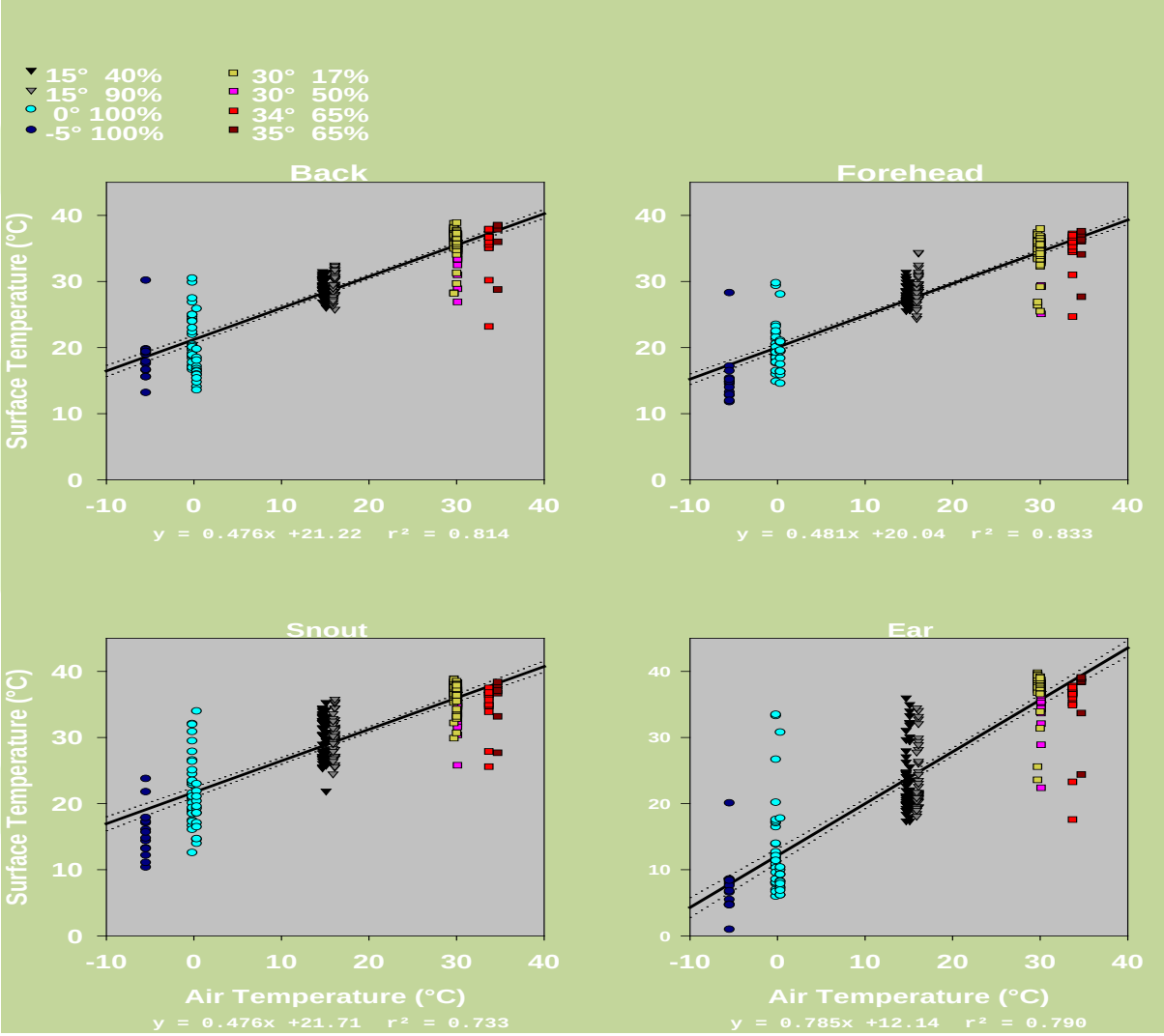
DBT vs Surface T



DBT vs Surface T



Air T vs ST


15° 40%
15° 90%
0° 100%
-5° 100%
30° 17%
30° 50%
34° 65%
35° 65%
Back
Surface Temperature (°C)
y = 0.476x +21.22 r² = 0.814
Forehead
y = 0.481x +20.04 r² = 0.833
Snout
Surface Temperature (°C)
Air Temperature (°C)
y = 0.476x +21.71 r² = 0.733
Ear
Air Temperature (°C)
y = 0.785x +12.14 r² = 0.790

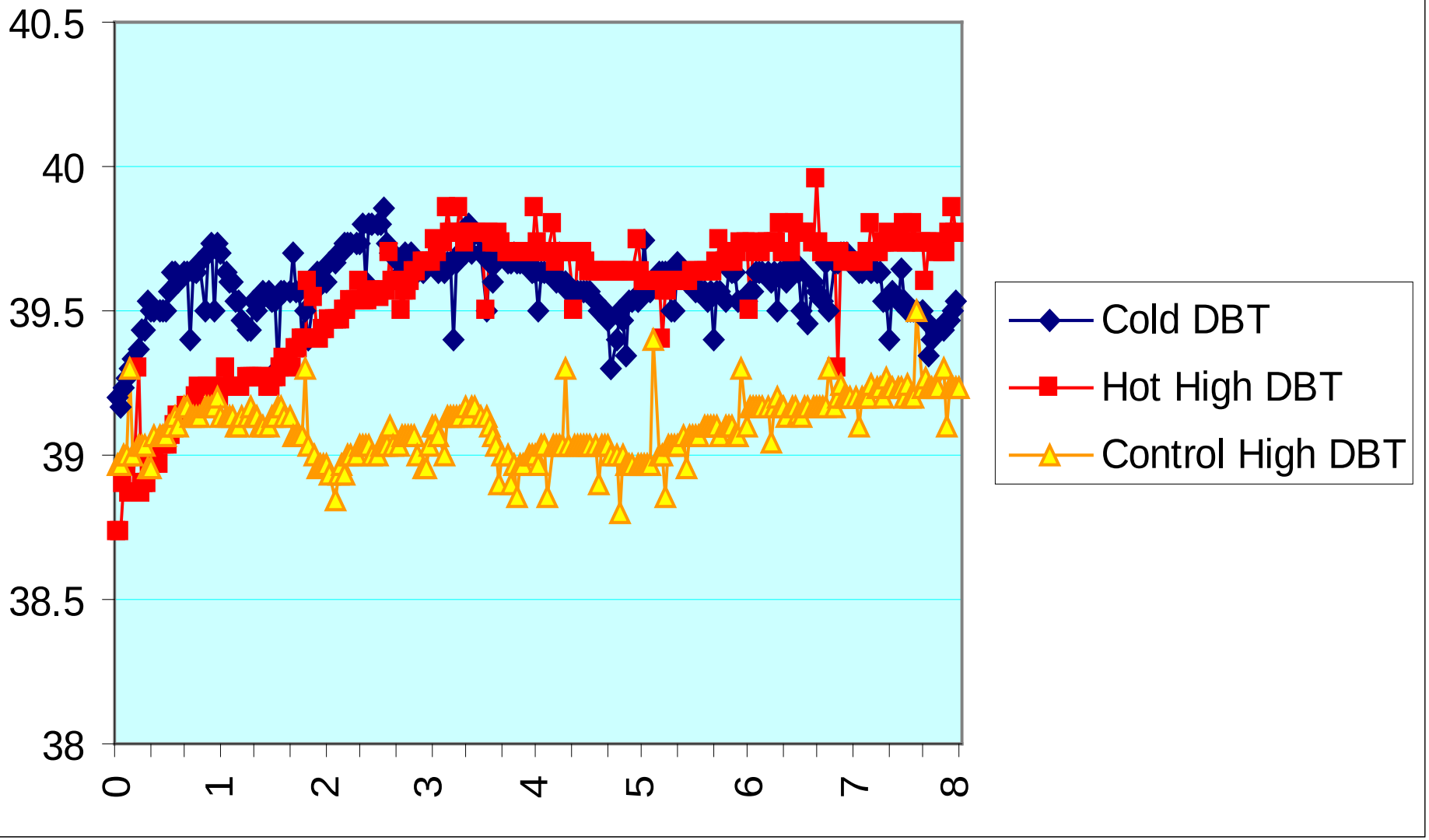
Correlation coefficients for AT and DBT against ST

Target	vs AT	vs DBT
Back	0.902	0.149
Forehead	0.913	0.115
Snout	0.856	0.086
Ear	0.889	0.179
Shoulder	0.858	0.131
Side	0.863	0.146
Hip	0.881	0.121
Buttock	0.870	0.115
Mean	0.912	0.138
Mean(ear)	0.907	0.127

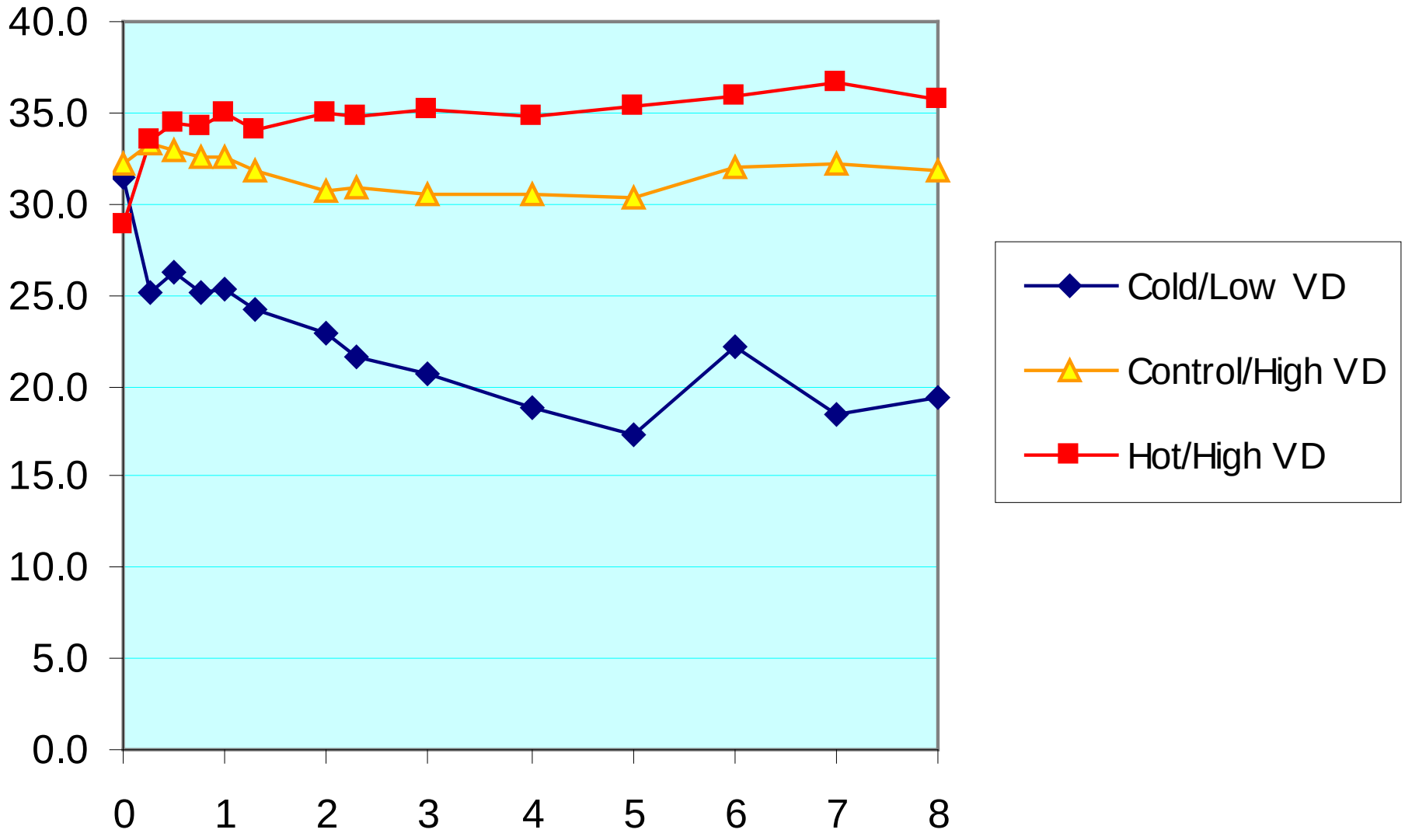
Correlation coefficients for AT and DBT against ST: >29° C only

Target	vs DBT
Back	0.581
Shoulder	0.624
Side	0.601
Hip	0.557
Buttock	0.440
Mean	0.561

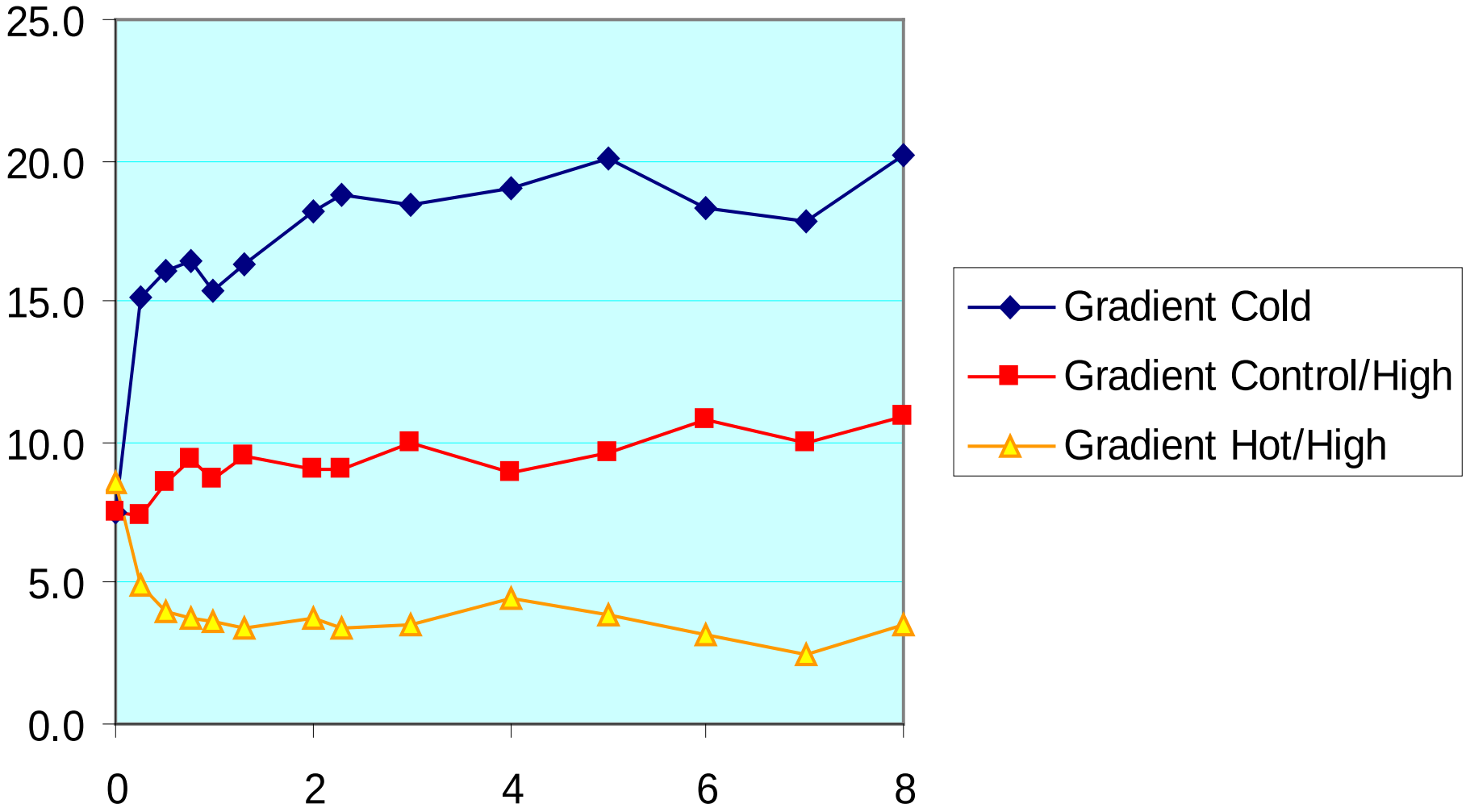
Deep body temperature – high humidity



Surface temperature – high humidity



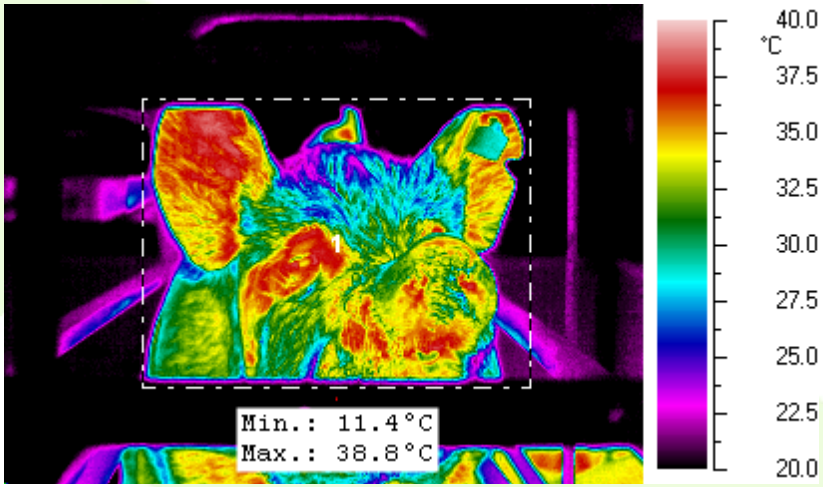
Temperature gradient – high humidity

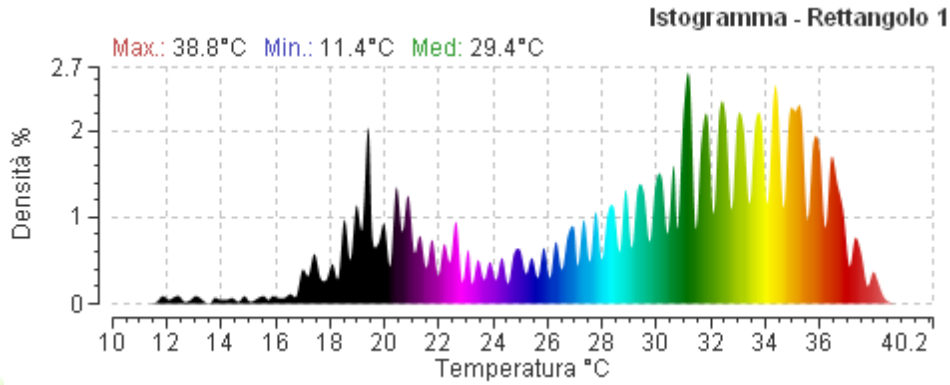


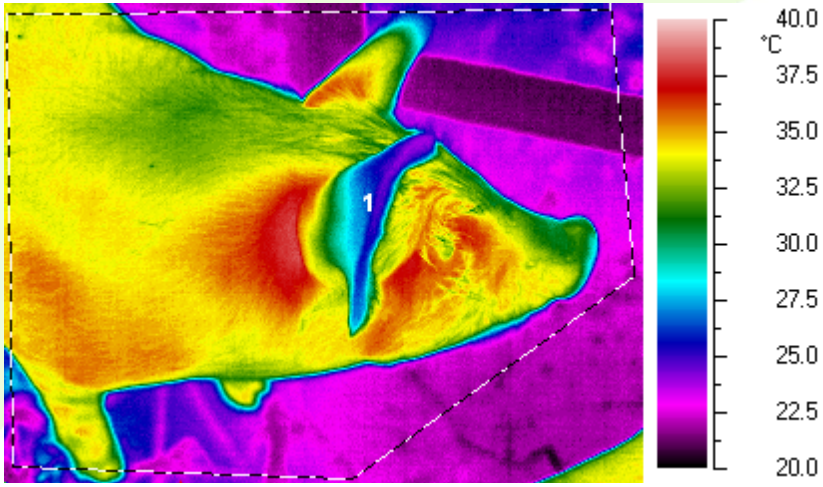
IR Thermometry

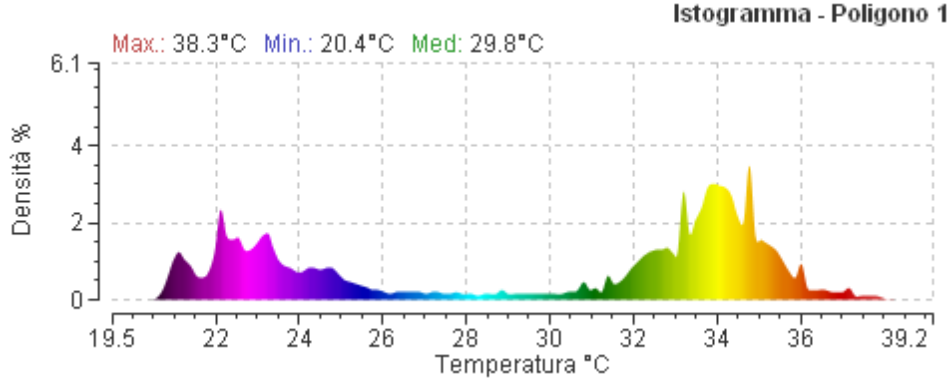
- Surface (skin) temperature is not a good predictor of body core temperature across the wide range of Ta
- At elevated environmental temperatures surface temperature is a better indicator of core temperature
- Surface temperature may be used to detect potential heat stress in pigs in practical conditions
- The less labile sites identified (back, flank, side, head) are more useful for this purpose
- Calculation of core-periphery gradients from ST and DBT measurements provides useful information on insulation and heat loss

Thermal imaging



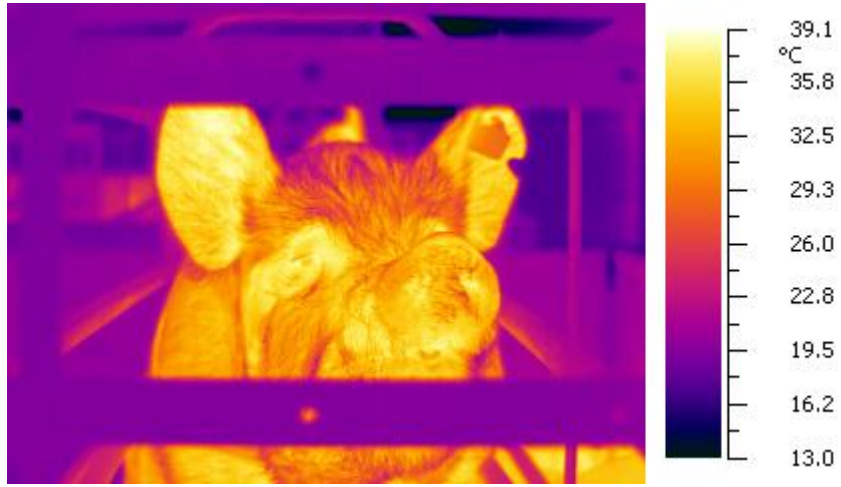


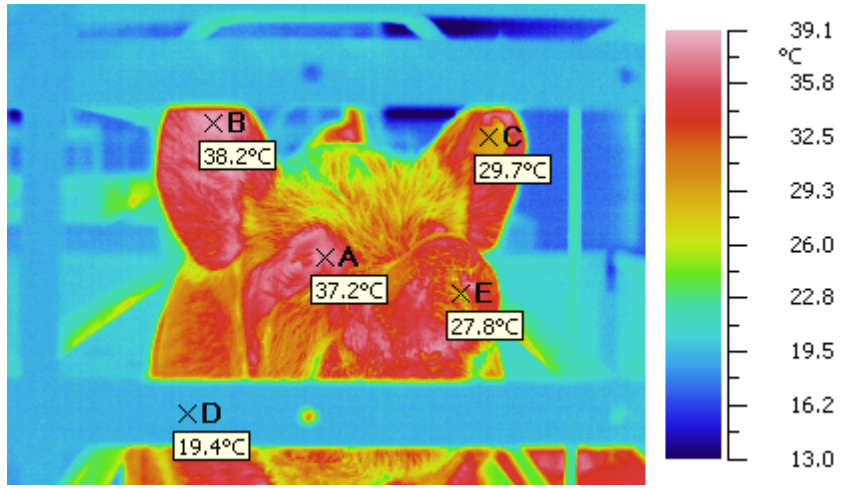




Thermal imaging

Next year in Copenhagen!!!!





Thank you for your attention !