January, 2004

New Technologies: Early Disease Detection

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[1] AAFC, [2] AAFRD, [3] Pulmonox Comp, [4] Olds College, [5] Olds Agri-Tech Comp.

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Acknowledgements

-AAFRD

-AFAC

-AAFC

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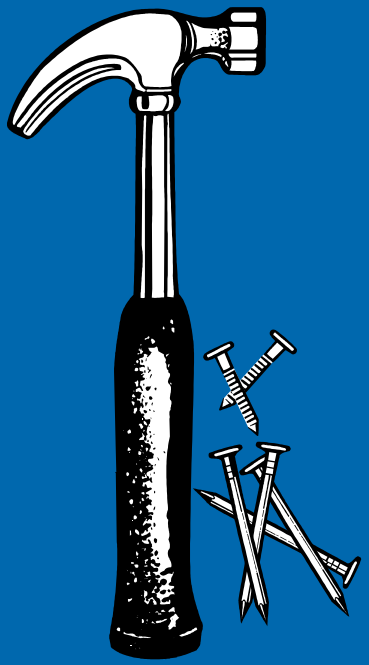
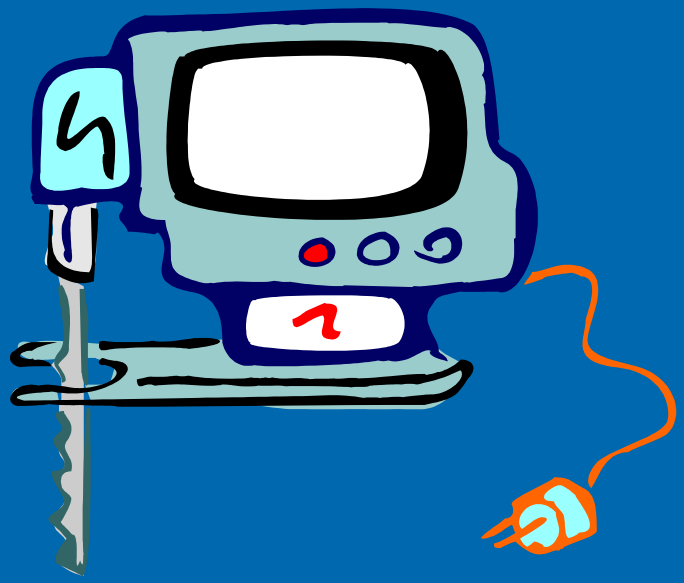
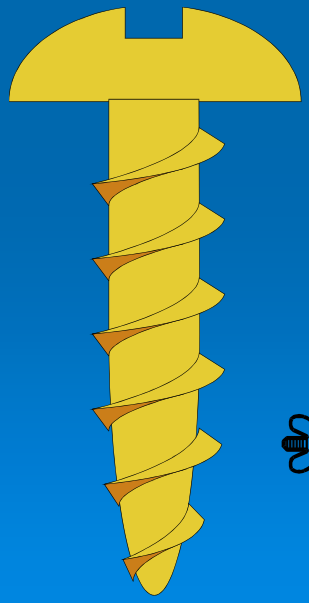
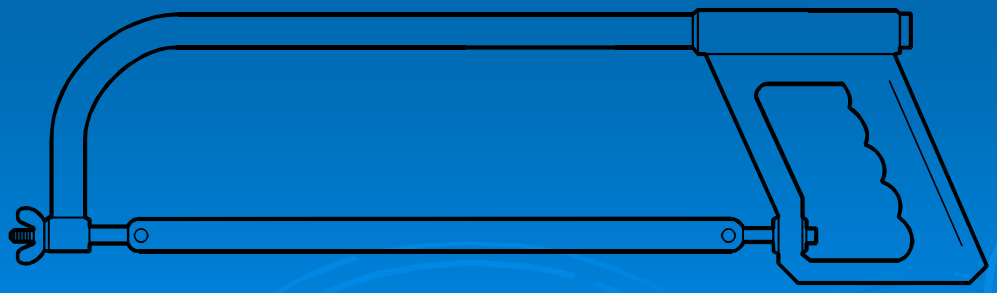
-Veterinary Agri-Health, Airdrie
-Penridge Feeders, Acme
-Olds Agri-Tech, Olds
-Olds College
-Pulmonox Comp. Edmonton
-ACAWRP, Lacombe

Enabling Technology









RFID

Disease Profile

-Healthy Calves on Pasture

-Weaned, Social disruption

-Transported

-Co-mingled, Auctioned

-Off feed/water

-Novelty / Stress

-Clinically Ill

Weaned / Receiver Transition

-diet change
-social bond changes

-transport
-handling
-co mingling - exposure

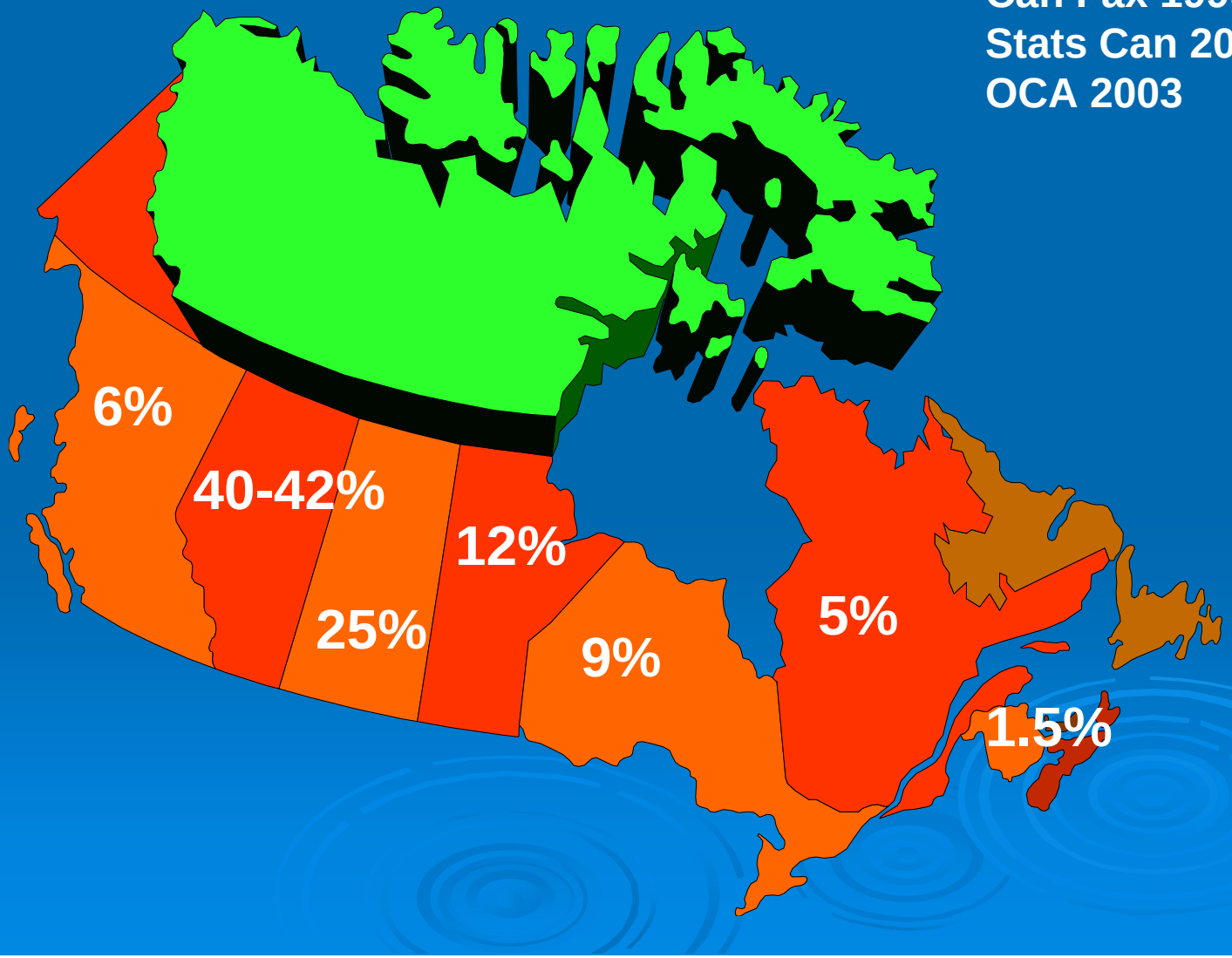
-off feed
-off water
-multiple source

-illness (10 - 40%) BRD
-antibiotic use ($15)
-reduced performance
-reduced yield / grade / efficiency
-antibiotic resistance

National Distribution of Canadian Cow Herd

4.6 million cows

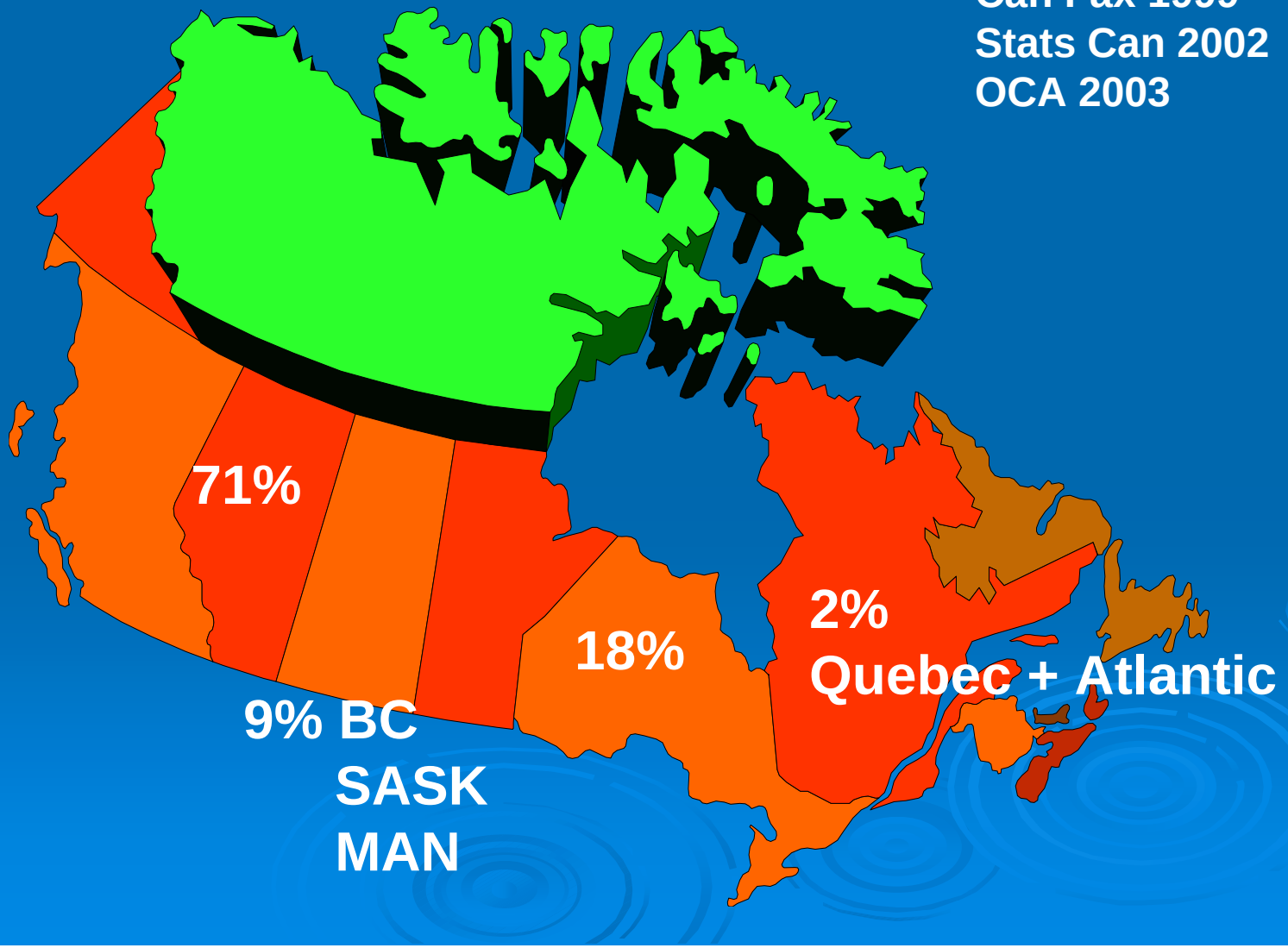
Can Fax 1999
Stats Can 2002
OCA 2003



National Distribution of Feedlot Cattle

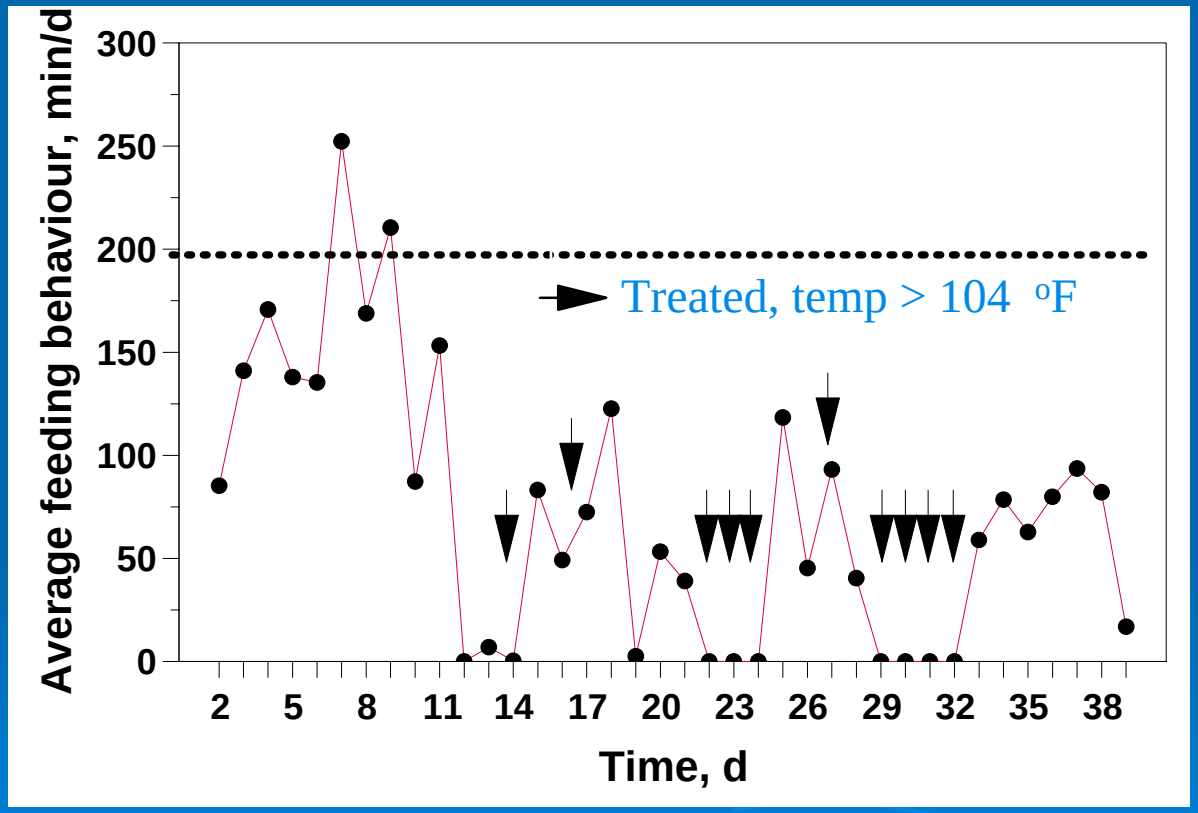
3.4 million

Can Fax 1999
Stats Can 2002
OCA 2003



Cost of Morbidity

Daily pattern of feeding behaviour for steer 16941096



620 lb initial weight
Carcass weight=527 lb; B1; < 4 mm bf; 54.7 sq cm;
-$252.15 net return

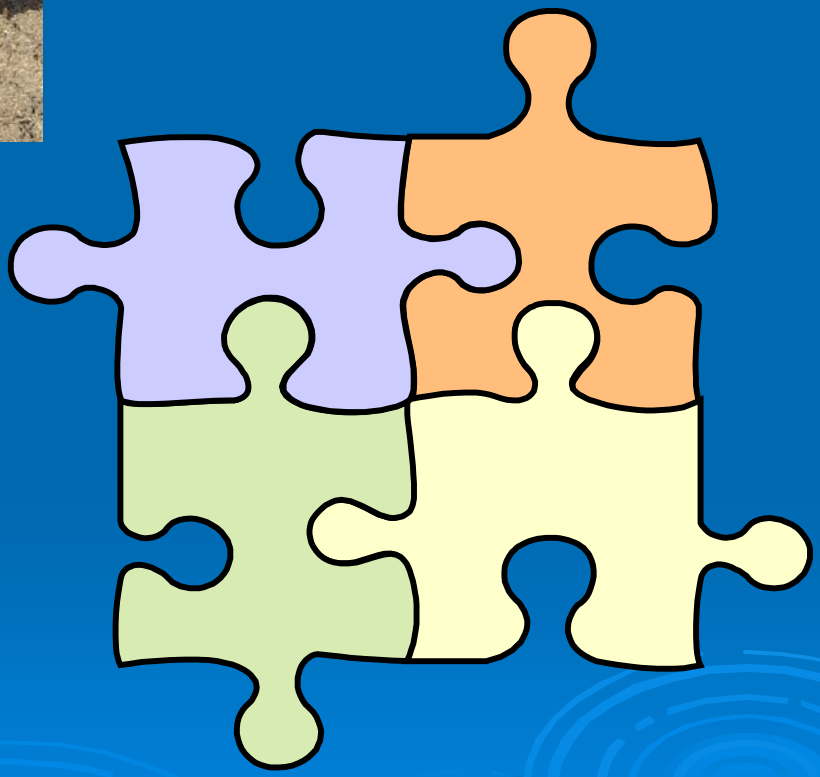
-Drug Treatment Cost > $70

Basarab et al. 1997, Can. J. Anim. Sci.77: 554; Sowell et al. 1999, J. Anim. Sci.77:1105

Reasons to Early Detect

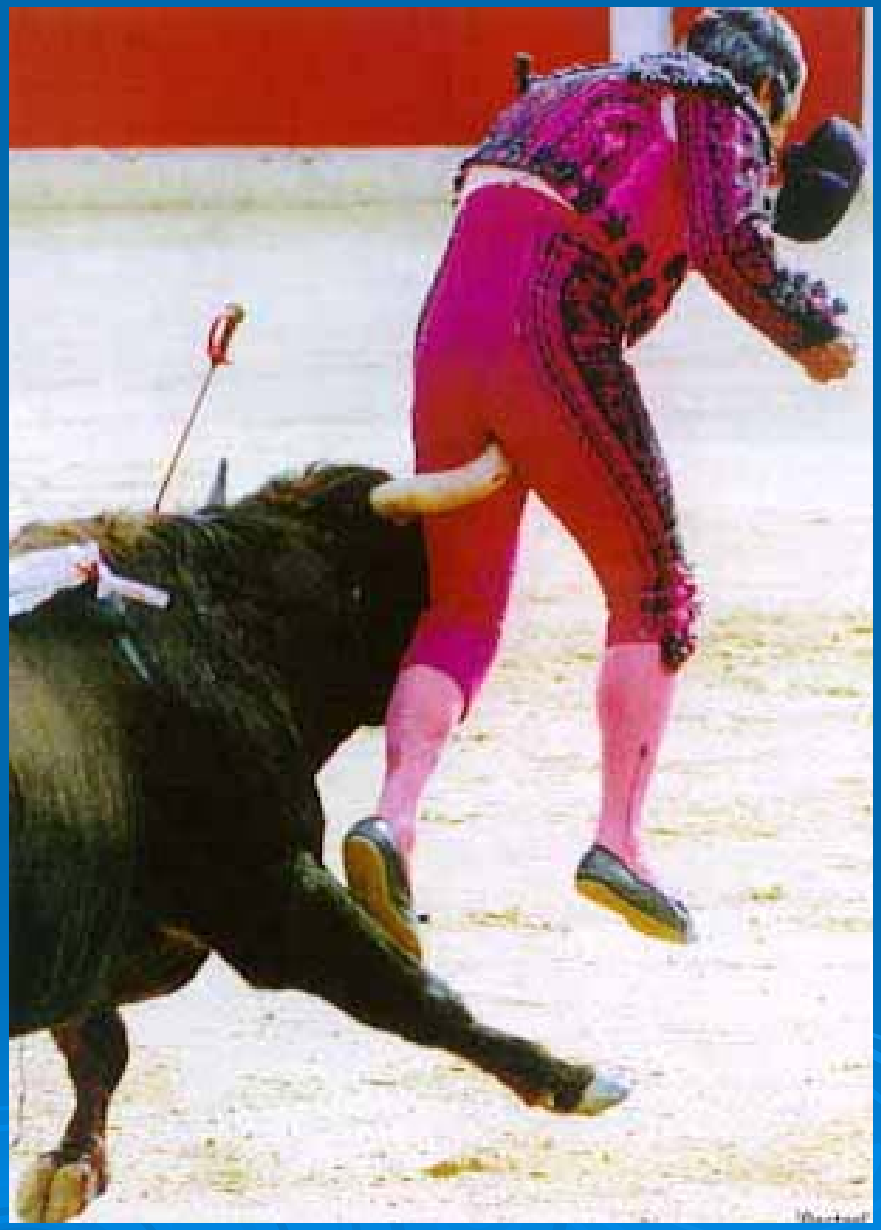
1. Reduced Treatment Costs
2. Improved Efficacy of Treatment
3. Reduced Morbidity Period
4. Reduced Risk of Antibiotic Resistant Microbes
5. Improved Animal Performance
6. Reduced Labour for Treatment
7. Improved Animal Welfare
8. Improved Food Safety

-How do you know when an animal is becoming Ill ?



Animal Signals

How They Feel About Our Management



Steady State Stress: Chronology

Alarm → Resistance → Fatigue/Disease

SECONDS → MINUTES → HOURS → DAYS

ENDOCRINE: EP, NEP, CRH, ACTH, Cort, Gluc,Ins., T3,T4, Cyt. GH Sub P

ENZYMATIC: DBH CPK LDH

METABOLIC: ACID-BASE, GLUC, BMR(HP), BHBA, Anion Gap,OSM, LAC, BUN, APP

HEMATOLOGY: Blood Gas, pH, RBC,WBC, Diffs Ig'S

PHYSIOLOGICAL:
EEG,EKG, RR, Blood flow, Blood pressure, GIT Motility, Fluid shifts, Anion Gap, Rectal Temp

MEAT QUALITY: Glycogen change, Ion Changes, Color, FA Oxidation (Marbling), Toughness, Water Holding Capacity , pH Change, Protein Catabolism, Yield

BRD: Disease Chronology

Viral → **Bacterial**

Alarm → **Resistance** → **Fatigue /Disease**

SECONDS → **MINUTES** → **HOURS** → **DAYS** → **WEEKS**

Disease Onset → **Clinical Signs**

-Cytokines

-Antibody Response

-Infrared Response

-Acute Phase Proteins

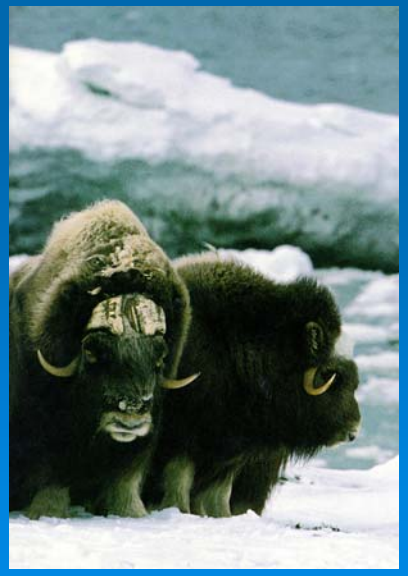
-Behavioural Responses ->Temp

THERMAL SIGNATURES

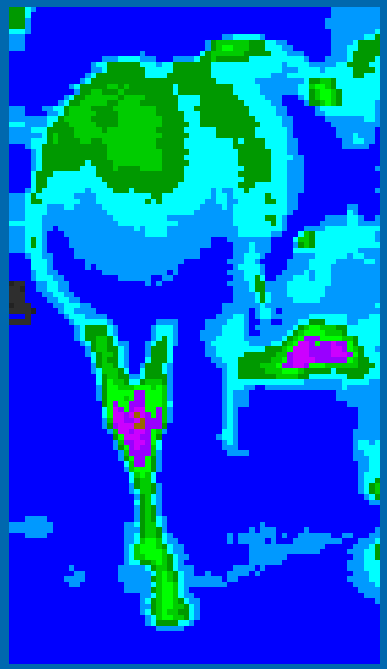
THERMOREGULATION

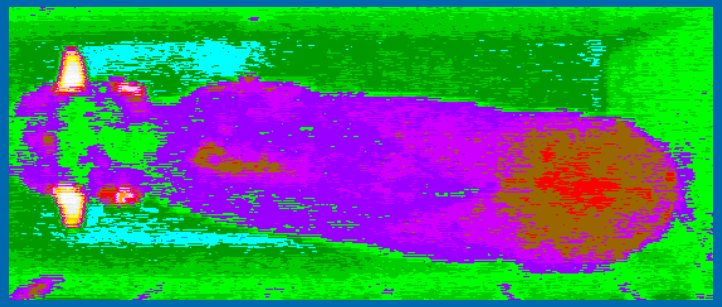
Homeotherm ----------Poikiotherm

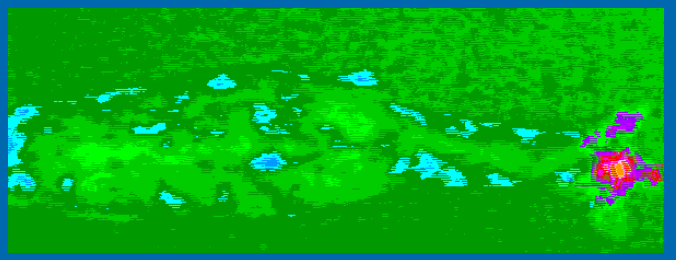
-Jurasic 130-150 MYA
-Some Precursors

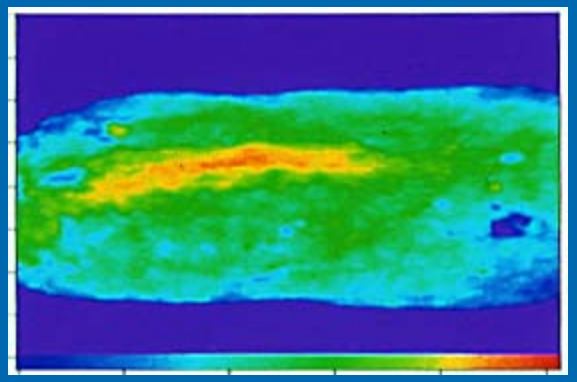


THERMOREGULATORY STRATEGIES

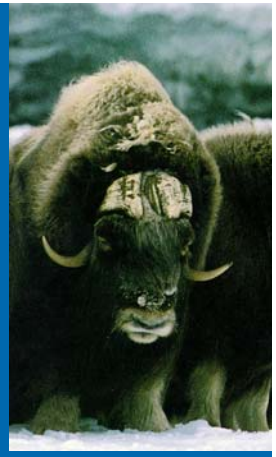




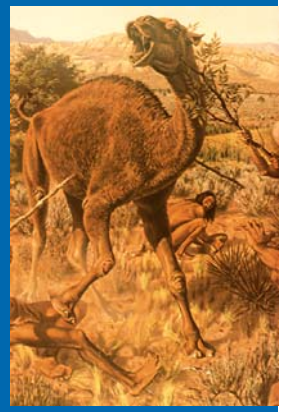




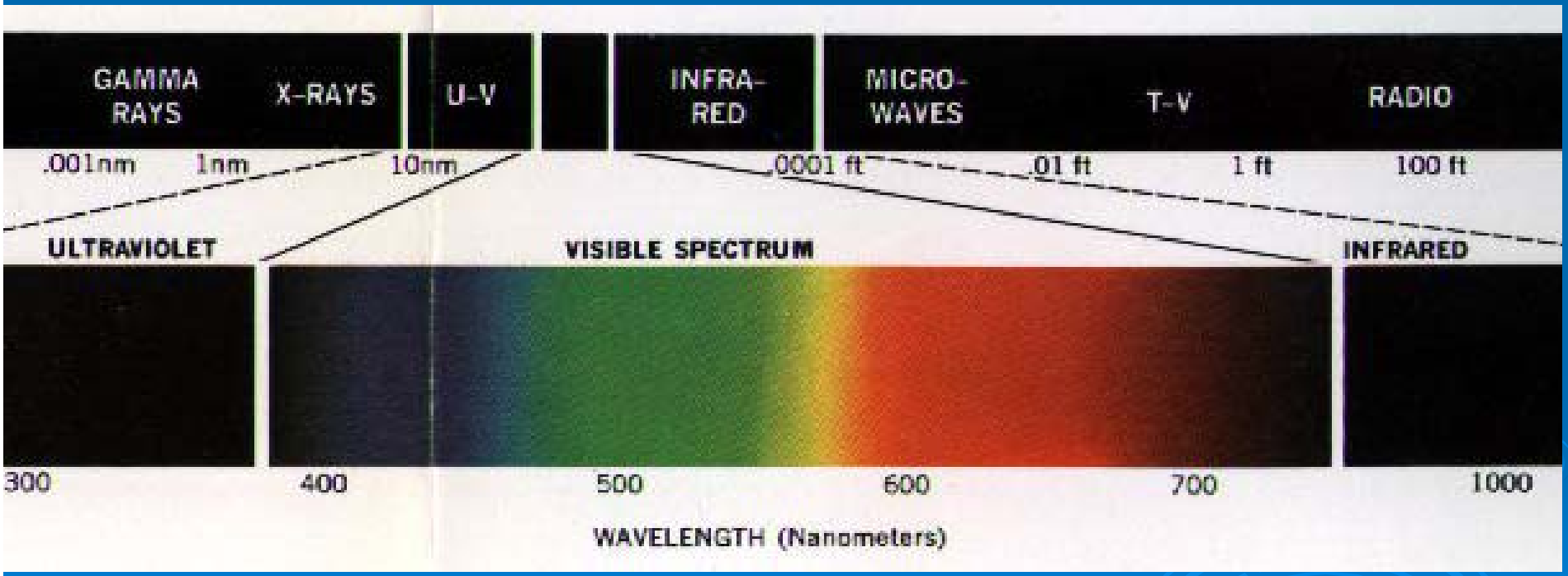
HEAT LOSS



FORM	Kcal/d	% Loss
Respiratory	128	4%
Evaporative	558	21%
Conductive Convective	833	31%
Radiated	1181	44%

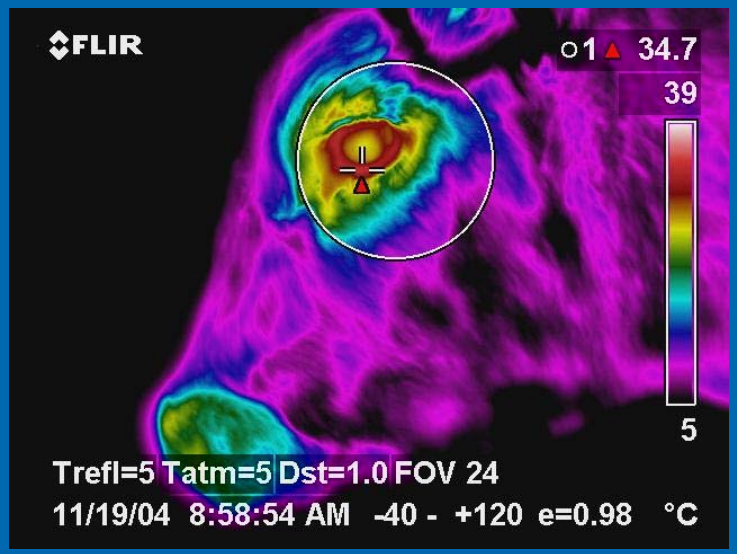


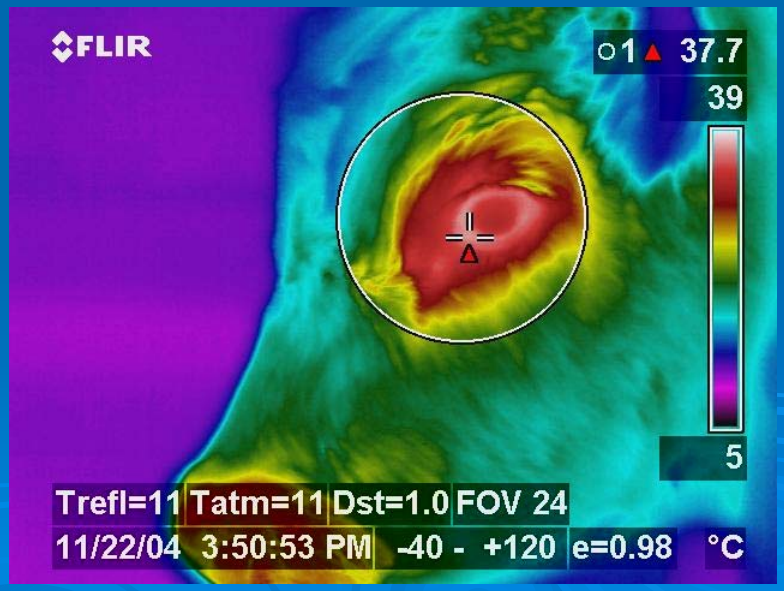
INFRARED THERMOGRAPHY



Receiver Calf Health

Thermoregulatory Strategies and Disease



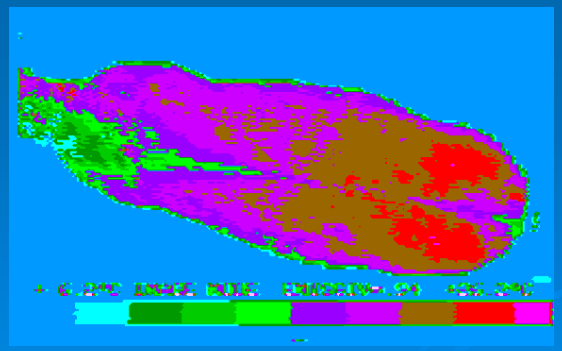


Infrared and Salivary Cortisol Changes Pre and post transport

Salivary Cortisol Pre Transport	Salivary Cortisol Post Transport
2.6 nmol/L	5.2 nmol/L P<0.05

Lacombe Research Centre data on receiver feedlot cattle transported approximately 3h

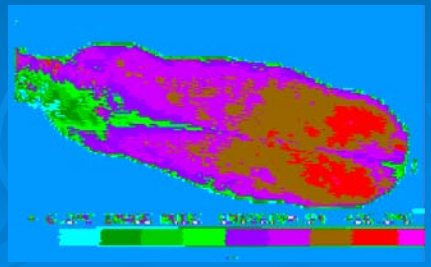
Dorsal Infrared Pre-Transport



Dorsal Infrared Post Transport

Infrared (IRT) and rectal temperatures in receiver calves with two levels of stress

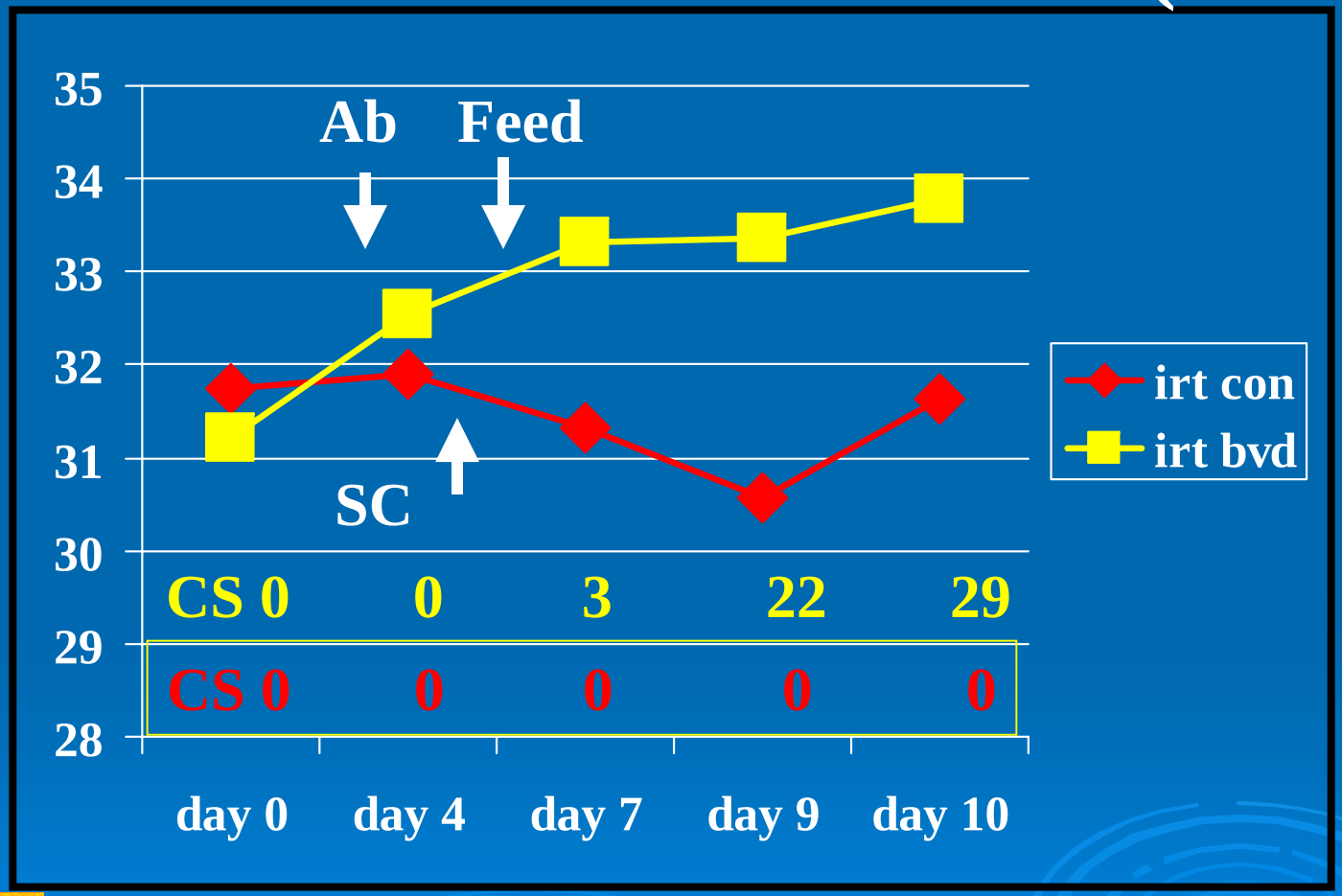
	IRT	RECTAL	C
Commercial Calves (multiple source, commingled. Higher stress)	**21.6**	**39.1**	n=242
Retained Possession (single source, retained possession. Lower stress)	**17.3**	**39.4**	n=296



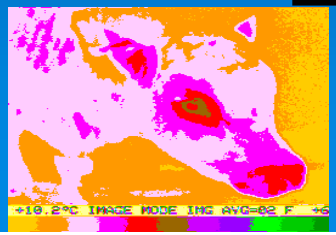
Infrared and Rectal Temperatures in Calves

	Infrared Temp C	Rectal Temp C
Day 1	**21.88 C**	**39.4 C** (103.0)
Day 3	**29.03 C**	**39.9 C** (103.9)
Change	**7.15 C**	**0.5 C**
(n=7)	**33%**	**0.8 %**

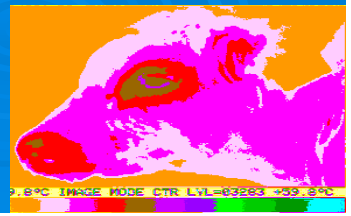
Eye Infrared Values and Clinical Scores BVD Infected Calves (ADRI)



Day 0



Day 10



Schaefer et al. 2004. Can. J. Anim. Sci. 84

Penridge Feeders:
Early Disease Detection Study

2003

Experimental Design

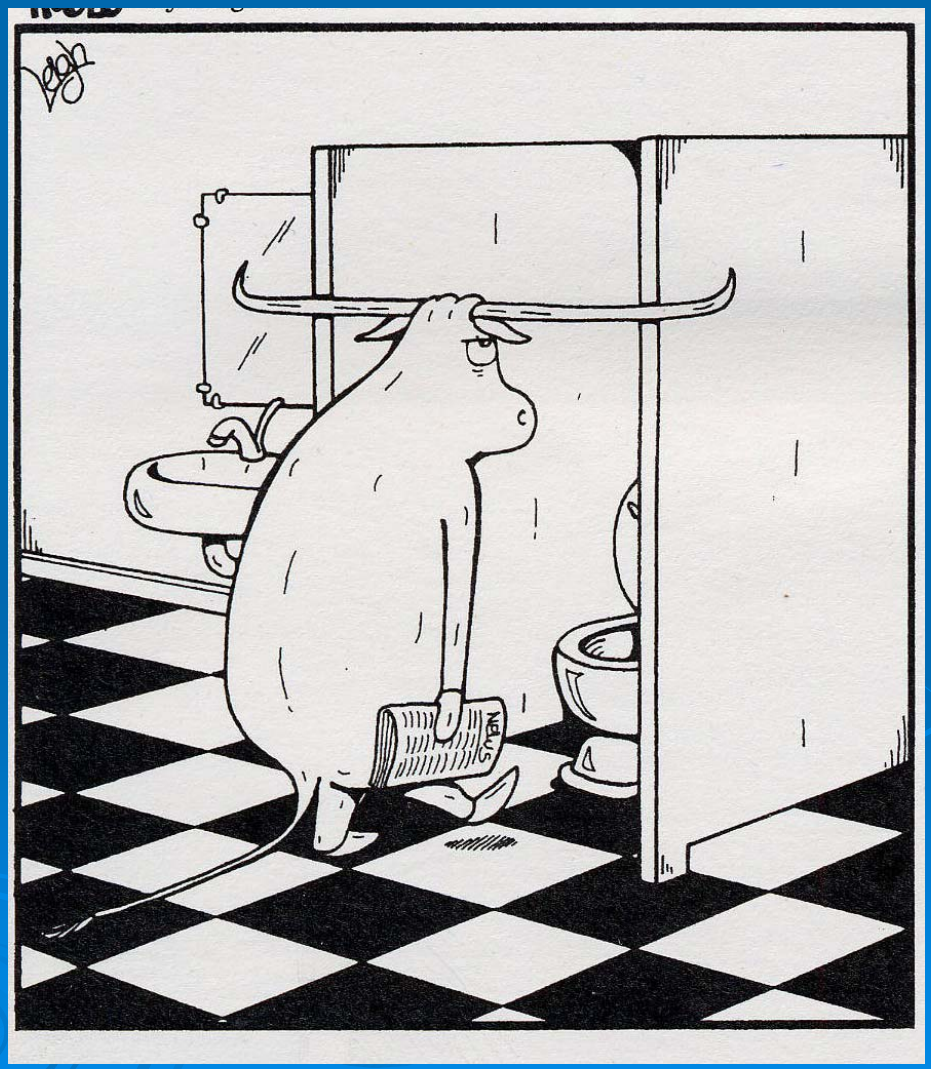
93 multiple sourced (3), commingled, transported weaned calves

Not ill

Might be ill

ill

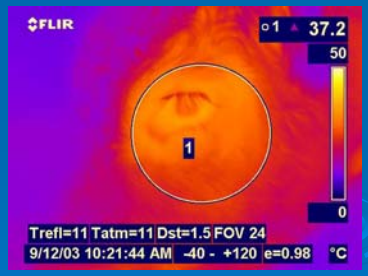
Components of a Disease Early ID Station For Cattle



Monitored Weekly

-body wt
-core temp
-sal cort
-IRT orbital
-hematology/metabolites
-clinical score (ethology)

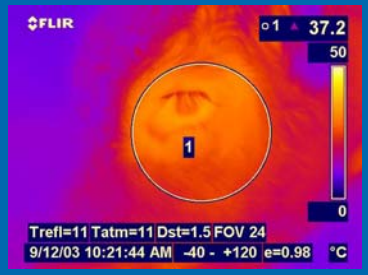
Monitored Daily



-IRT orbital
-behaviour
-feed bunk/water

Health and Treatment Identification: Pulled Calves

ID	FI	PC	RT	IRT	CS
4	A	A	N	A	A
	3		102.2	ΔT	BRD
21	A	A	A	A	A
	?		105.6	39	BRD
24	A	A	N	A	A
	6		101.4	36.9 (low)	BRD
39	A	A	A	A	A
	12		105.5	38.6	BRD
72	A	A	A	A	A
	?		102.2	39.7	BRD
78	N	A	A	A	A
	0		104.1	38.9	BRD



-No calves would be identified early on the basis of RT alone; for PC, -false +vs / - false –vs. A = abnormal, N = normal. Some 56 pulled calves total

Future Focus

-complete analysis

-Prediction Index
= IRT +FI / WI + Biol

-link engineering

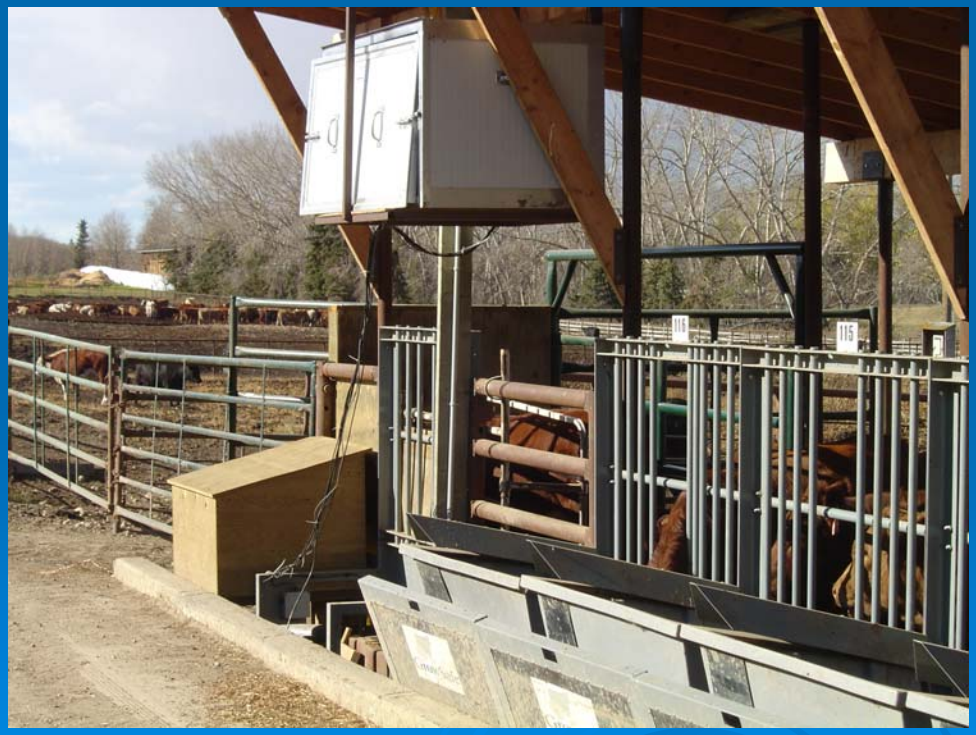
-further research

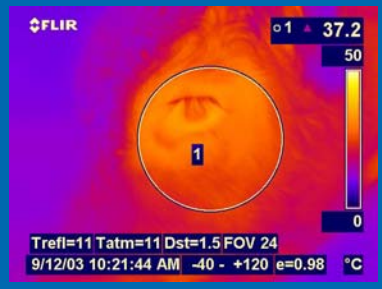
Fence line system

or

Analysis on arrival

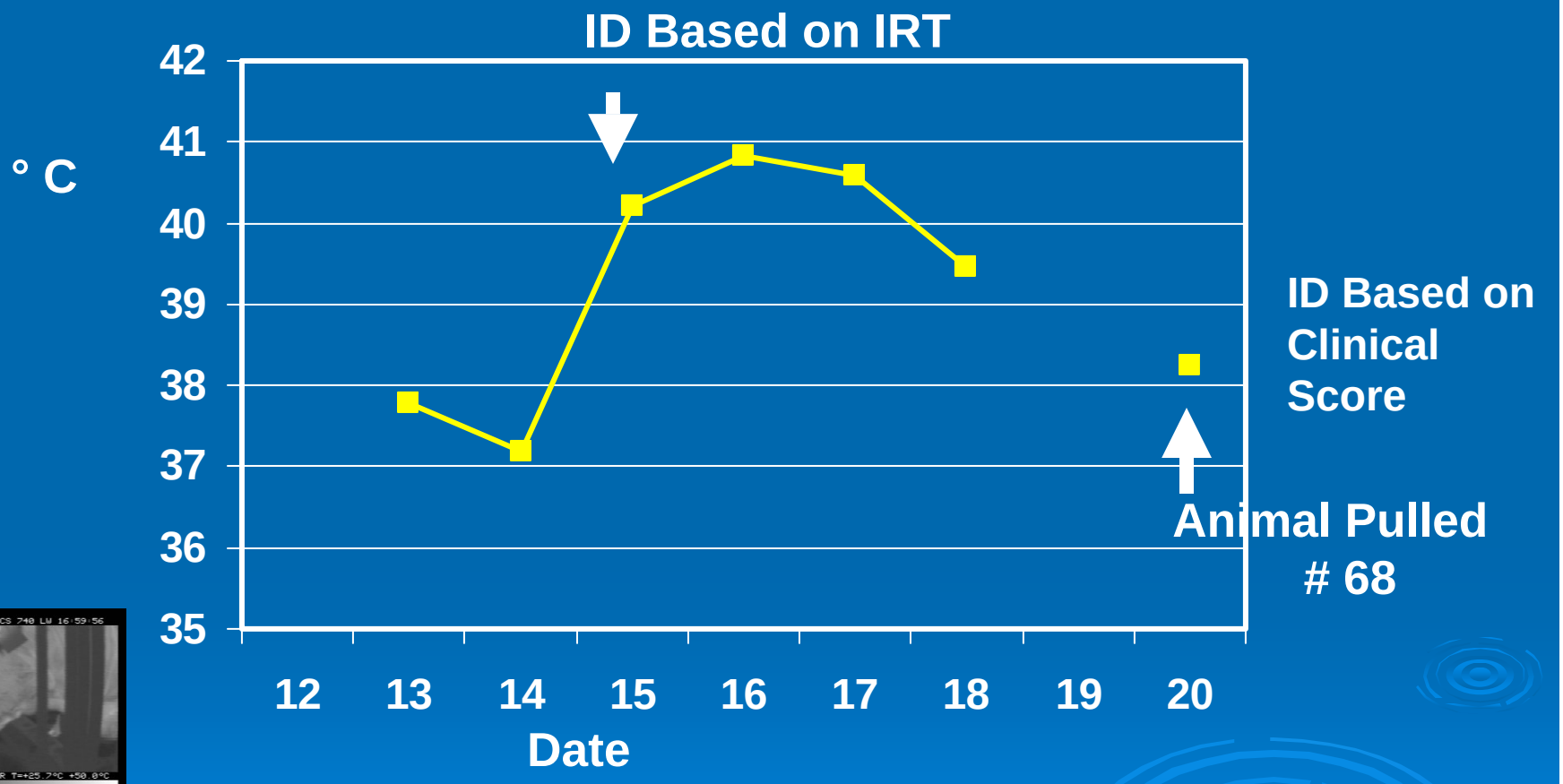
2004
Refining the ID Station

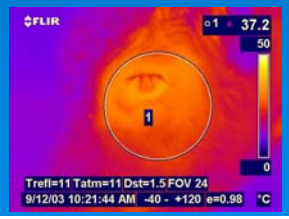



FLIR
1 37.2
50
1
0
Trefl=11 Tatm=11 Dst=1.5 FOV 24
9/12/03 10:21:44 AM -40 - +120 e=0.98
°C

28 SEP 03 INFRAMETRICS 740 LW 16:59:56
+ 0.0°C IMAGE MODE CTR T=+25.7°C +50.0°C

Orbital Max IRT Remotely Captured at Water Station

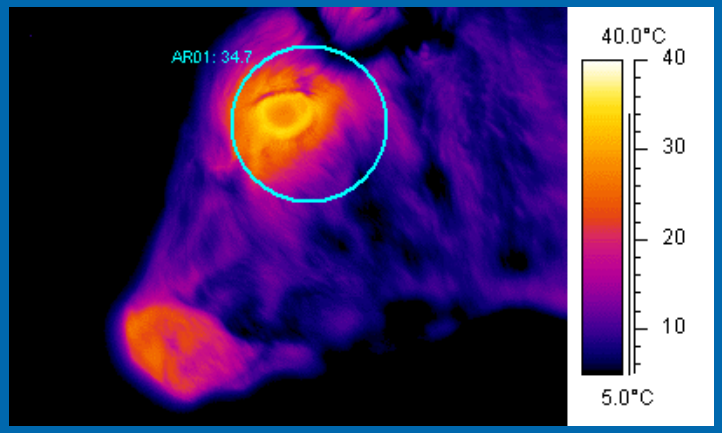




Mean # days identified earlier than clinical signs, 7 (Range 1-23)

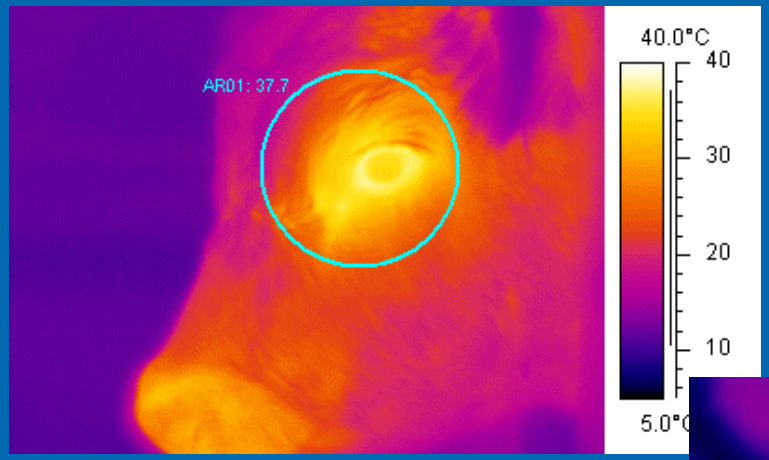
BRD Progression

Day 1



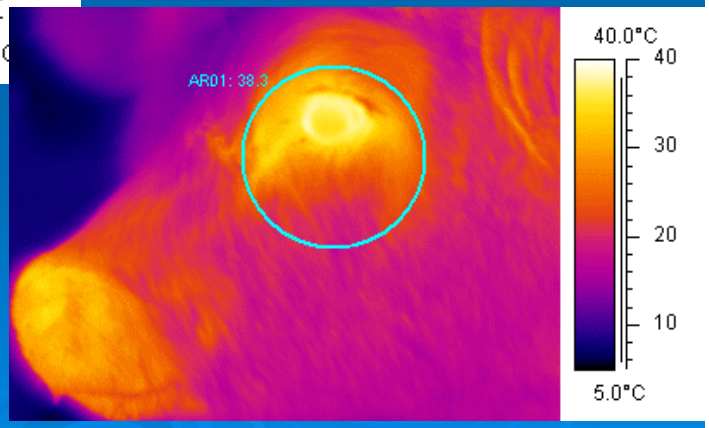
35.1 C

Day 4



37.7 C

Day 8



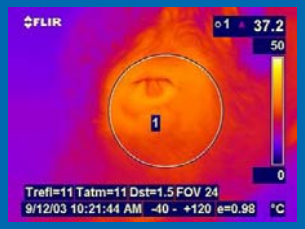
38.4 C

Early Diagnostics:

Non-Invasive Infrared vs Conventional Clinical Score

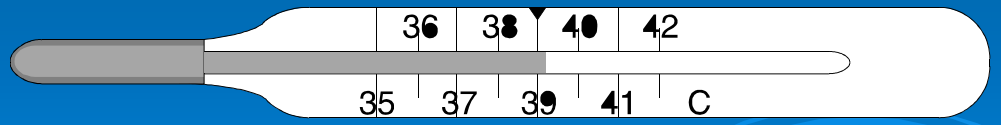
-Example ED04, 21 head of MSCMWTA calves (North Alta)

Using IRT:



-On arrival 10 ID'ed as suspect BRD using IRT
-Of these, 8 subsequently contracted BRD within 1-10 days (🗀 of 3 days) ; - 2 false +ve and 5 false –ve

Using Clinical Signs:



-On arrival 2 animals ID'ed as suspect BRD using clinical signs (≥ 104 ° F); - no false +ve, 13 false –ve

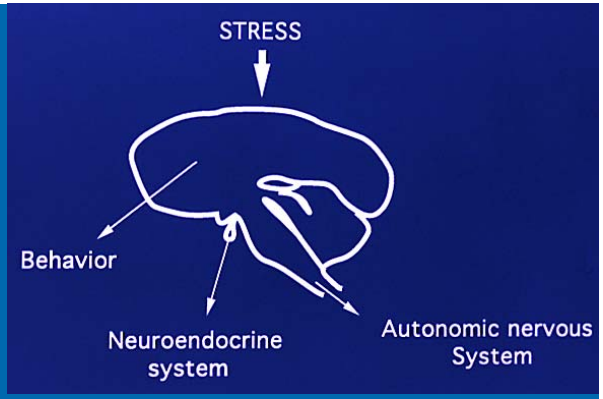
Alternative Strategies for Treatment
(Combing Detection and Correction)

Nitric Oxide

Humane Hay

Humane Hay Trial

-Manipulating Amino Acid Precursors -Stress Management



- 186 Weaned, Transported Calves (ave 668 lb)
- 4-5 h Transport (Pincher Creek to Olds College)
- Overall loss of liveweight 46 lb or 6.9%

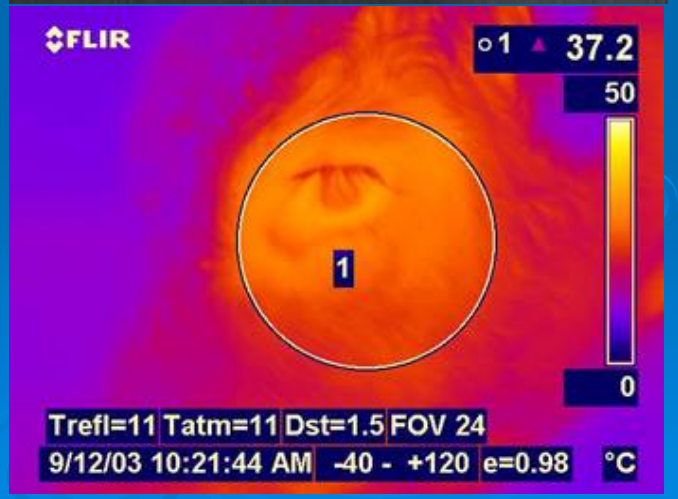
-Control – normal grass hay 3-4 lb/head for 12h
-Humane Hay Treated 3-4 lb/head for 12 h

Control (n=89) lost 47.9 lb ±9.5
Humane Hay group (n=97) lost 42.8 lb ±10.8 (P<0.001)

Olds Agri-Tech

Pilot Bovine Respiratory Disease Study

- Shipping Disease in Cattle clinically mimics URTI in humans
  - Malaise/Lethargy
  - Fever
  - Loss of appetite
  - Inflamed sinuses
    - Early Thermal Detection
  - Nostril discharge
  - Usual duration of 14 days



Pilot Bovine Respiratory Disease Study

- Four Small Pilot Groups of Naïve Calves
  - Prophylactic treatment
  - Thermal detection treatment (early)
  - Clinical detection treatment (late)
  - Placebo Control treatment (uninfected)
- Infected Herd Exposure
- Treatment and Response Measurements

Pilot Bovine Respiratory Disease Study

- Inhaled NO
  - 100,000 ppm source tank
  - Breath actuated delivery
  - “J”-tube delivery line
  - 8.27 mL pulse dose per breath
  - 300 pulses/nostril
  - 600 breaths during 20-30 minutes
  - Estimated dose ~160 ppm

Pilot Bovine Respiratory Disease Study

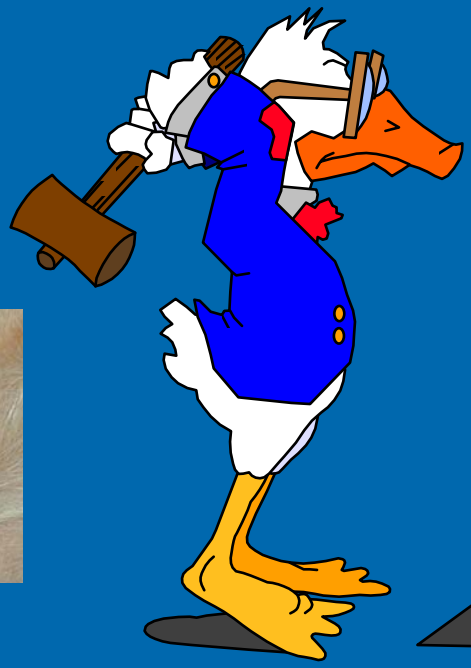
- Inhaled NO
  - 100,000 ppm source tank
  - Breath actuated delivery
  - “J”-tube delivery line
  - 8.27 mL pulse dose per breath
  - 300 pulses/nostril
  - 600 breaths during 20-30 minutes
  - Estimated dose ~160 ppm

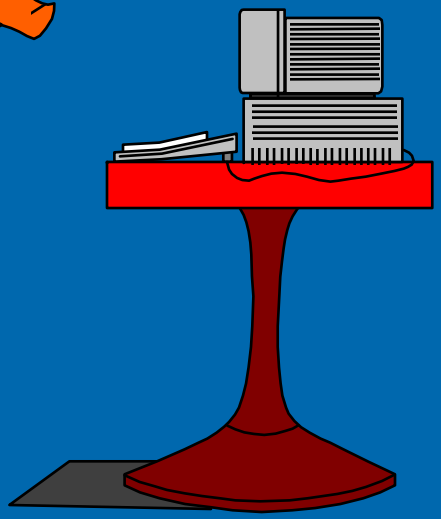
-None of the calves early identified with IRT and then received a NO treatment developed clinical BRD

Summary: Reasons to Early Detect

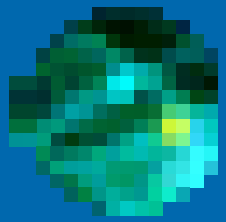
1. Reduced Treatment Costs
2. Improved Efficacy of Treatment
3. Reduced Morbidity Period
4. Reduced Risk of Antibiotic Resistant Microbes
5. Improved Animal Performance
6. Reduced Labour for Treatment
7. Improved Animal Welfare
8. Improved Food Safety

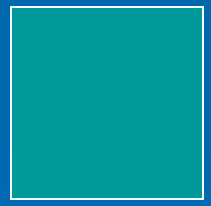
Summary





Rx





Criteria For Illness

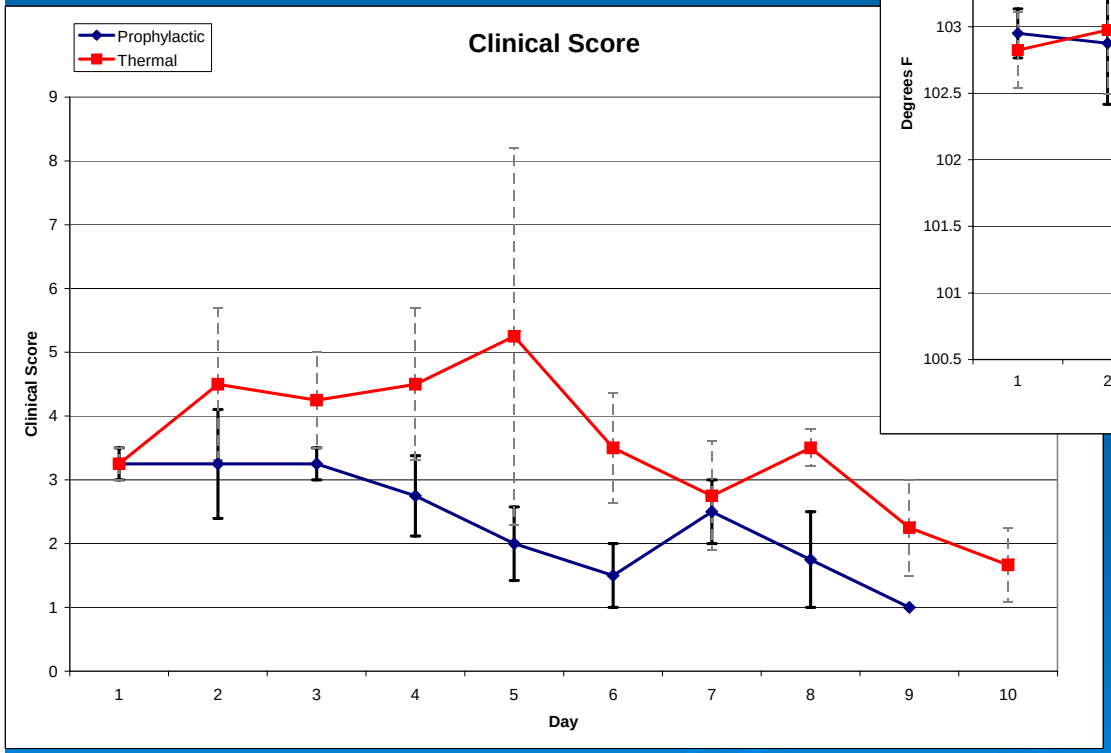
1. -behaviour suspect by pen checker
2. -suspect animals sampled for abnormal hem
3. -core temp was > 40 C
4. -verification of illness by veterinarian

-Criteria for Wellness

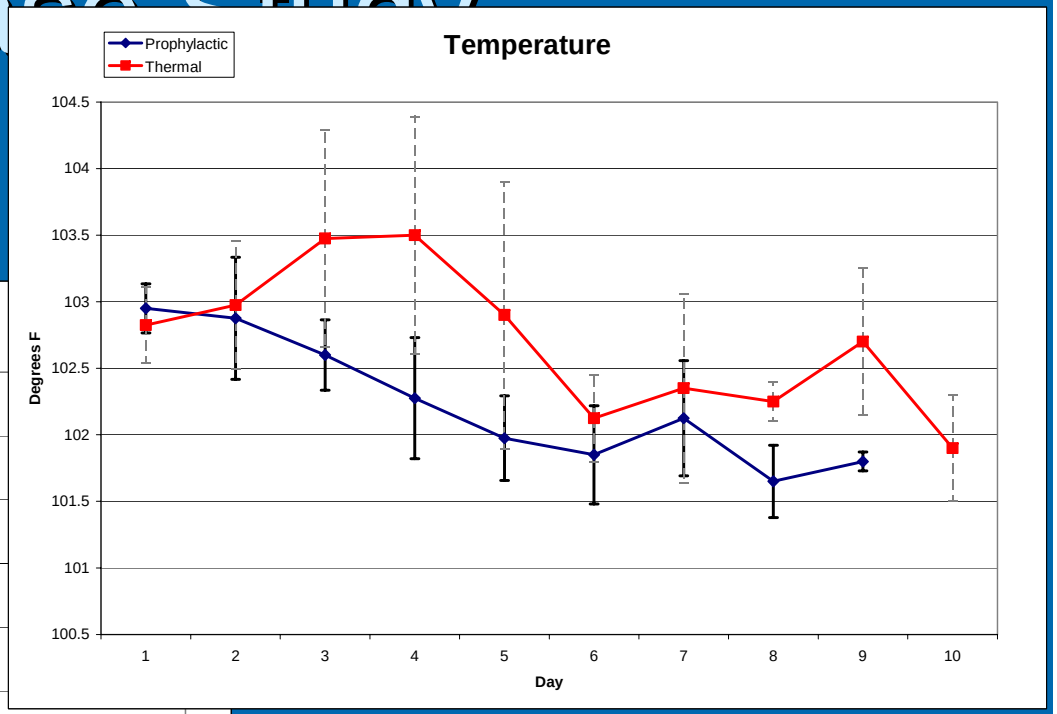
1. -None of the above symptoms

Pilot Bovine Respiratory Viral Disease Study

Prophylactic vs Thermal Detection Groups



Paired t-test p < 0.01



Paired t-test p < 0.01

Values Used for Normal Ranges
(Blood Radostits and Henderson, 1983)

Pen Check	See Sheet
Rectal Temp	>40 C or 104 F
IRT (mean ±1SD)	37.26 – 38.04(37.6)
WBC	4-12 X 10(9)/L
RBC	5-10 X 10(12)/L
Hg	8-15 g/dl
HCT	24-46 %
Clinical Score	Veterinarian

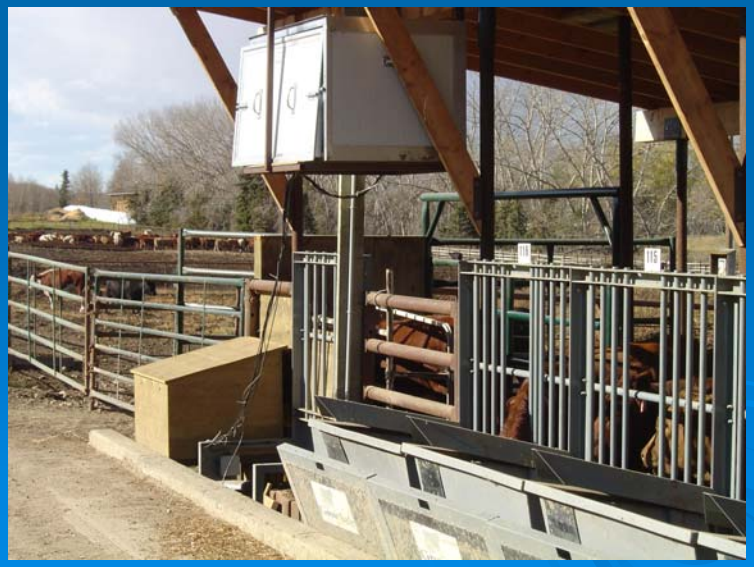
Interesting Stuff:

-On pull day, 51 of 56 calves (91%) would have been identified on the basis of IRT eye temp. (either absolute IRT or Δ T/d)

-Of these calves, approx 2/3 were hot and 1/3 cold

-On the basis of > 0.1 C Δ/d IRT, >80% identified

-If RT was used to pull calves, 36% false +ve and some false -ve



57 calves Identified as Possibly ill

35 verified ill

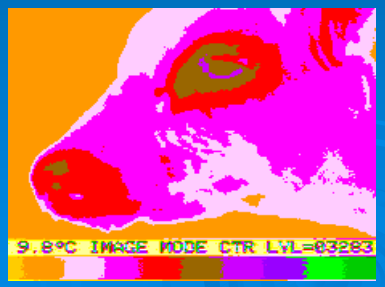
22 verified not ill

IRT Orbital Temps

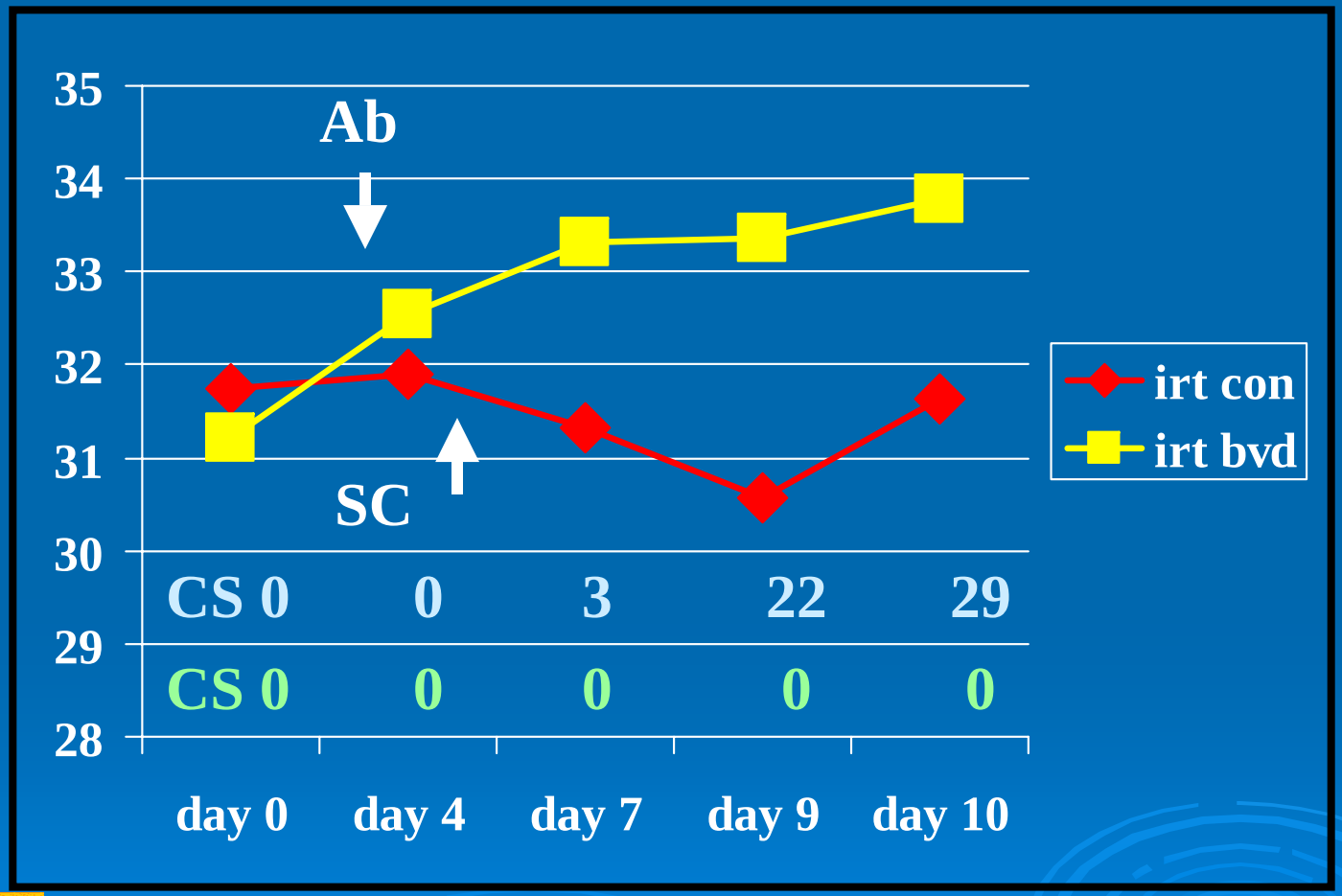
38.5 C

37.6 C (P<0.001)

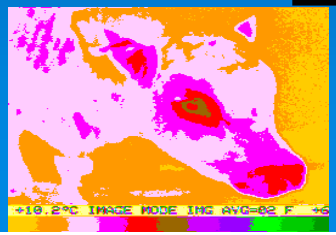
>0.1 C/d



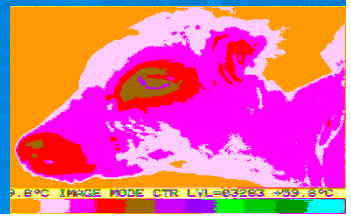
Eye Infrared Values and Clinical Scores
BVD Infected Calves



Day 0



Day 10



ADRI Trial

Pilot Bovine Respiratory Viral Disease Study

- Inhaled NO
  - 100,000 ppm source tank
  - Breath actuated delivery
  - “J”-tube delivery line
  - 8.27 mL pulse dose per breath
  - 300 pulses/nostril
  - 600 breaths during 20-30 minutes
  - Estimated dose ~160 ppm

Early Disease Detection in

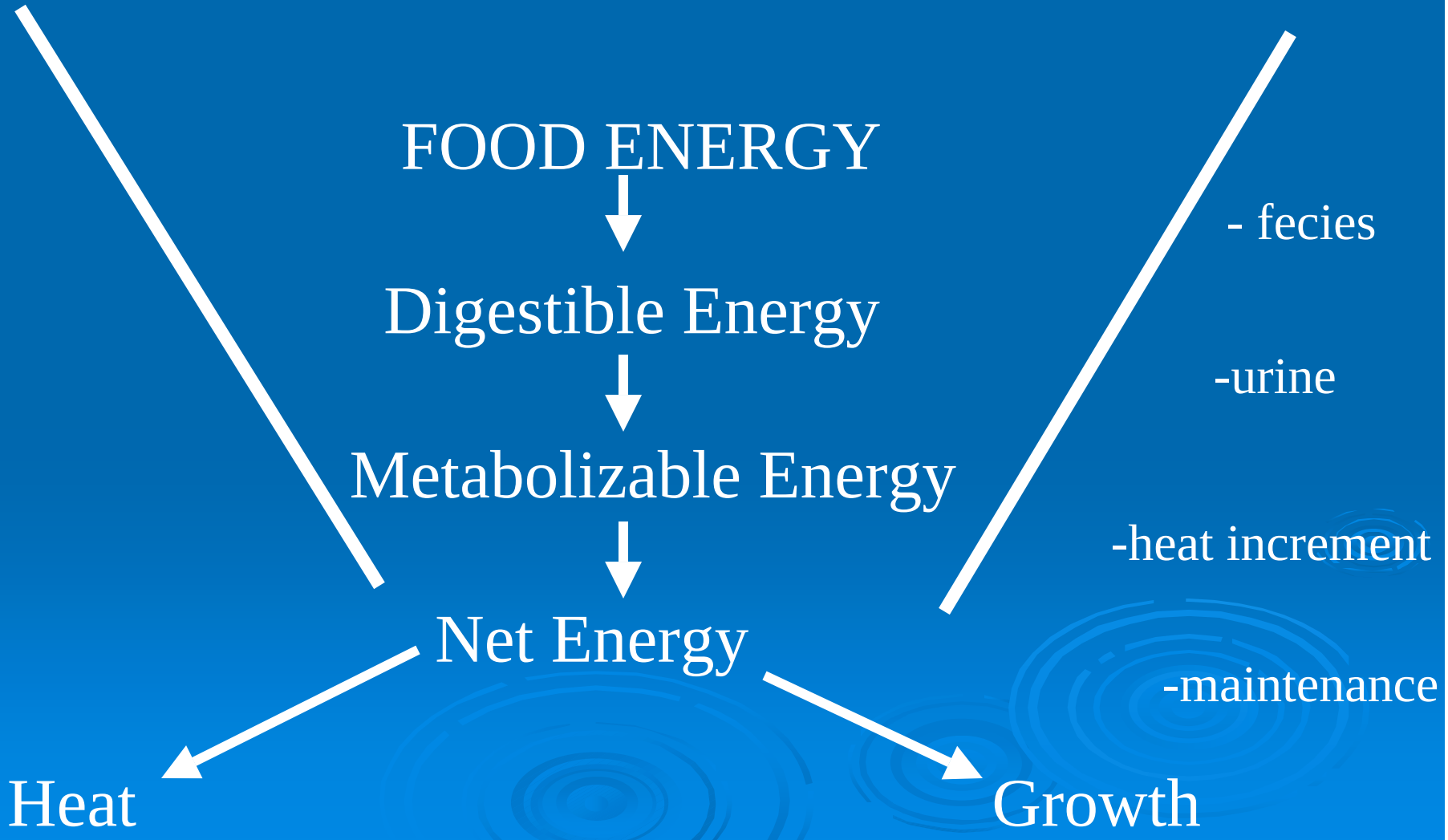
Weaned and Receiver Calves

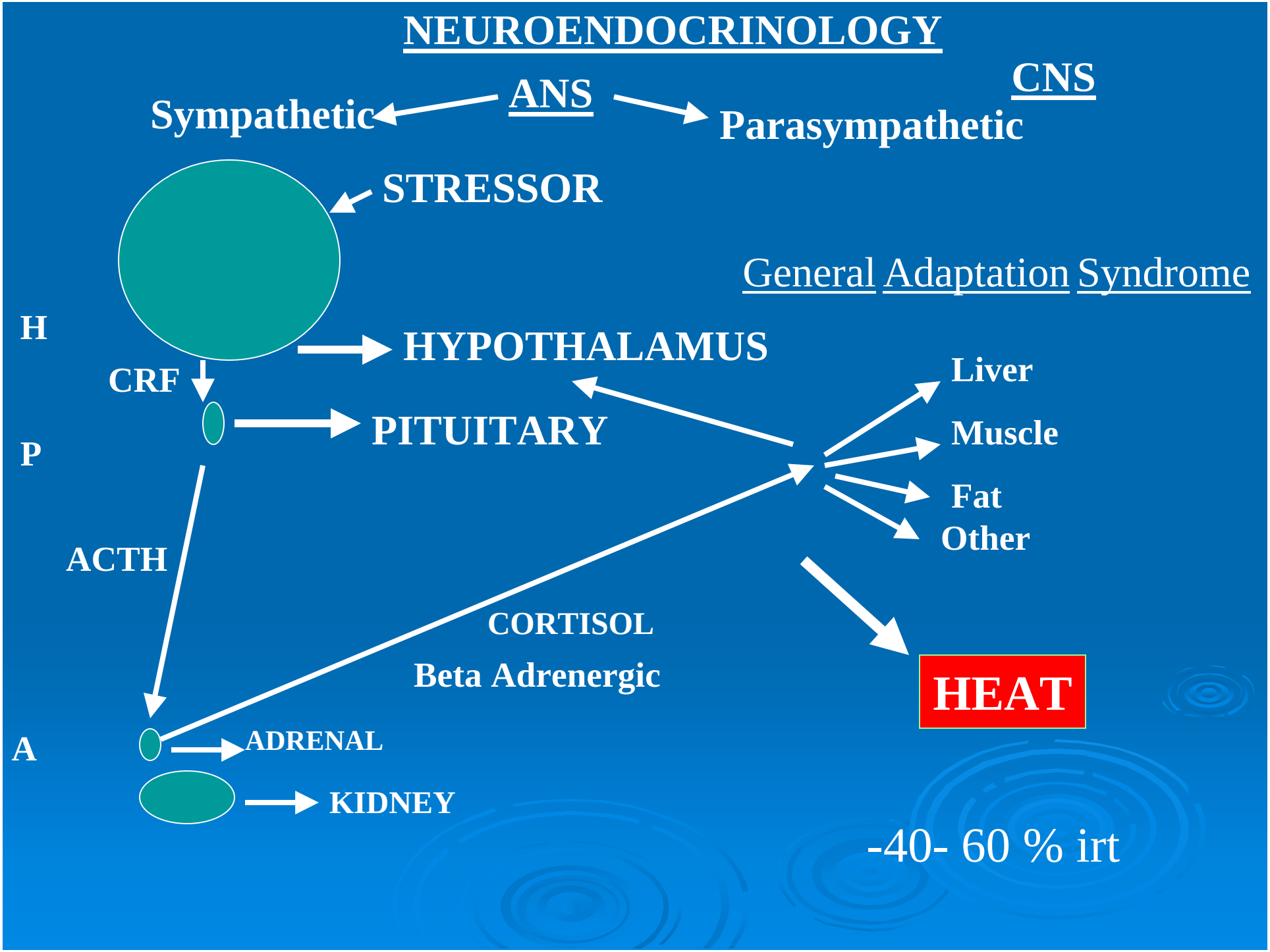
-AAFRD, N. Cook, J. Church, D. Milligan, J. Basarab
-AFAC
-Penridge Feeders
-Veterinary Agri-Health Airdrie

HEAT PRODUCTION

Oxydative Phosphorylation - Catabolism

(blood flow)

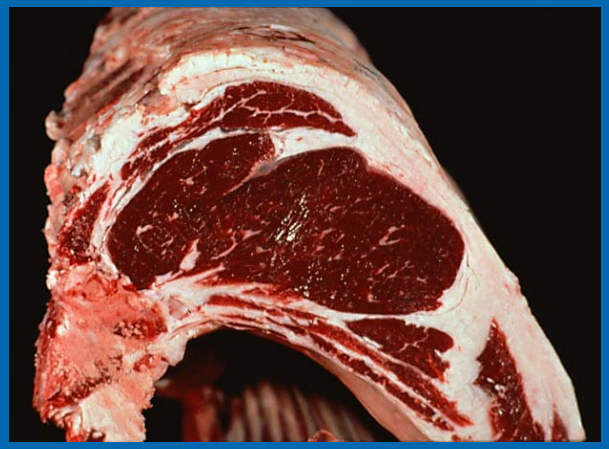



NEUROENDOCRINOLOGY
ANS
CNS
Sympathetic
Parasympathetic
STRESSOR
General Adaptation Syndrome
H
HYPOTHALAMUS
CRF
Liver
PITUITARY
Muscle
P
Fat
Other
ACTH
CORTISOL
Beta Adrenergic
HEAT
A
ADRENAL
KIDNEY
-40- 60 % irt

INFRARED AND BEEF QUALITY

30.1

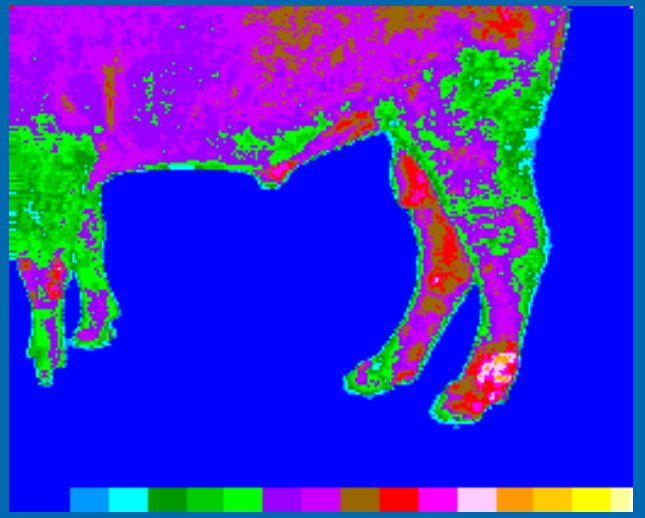
33.0

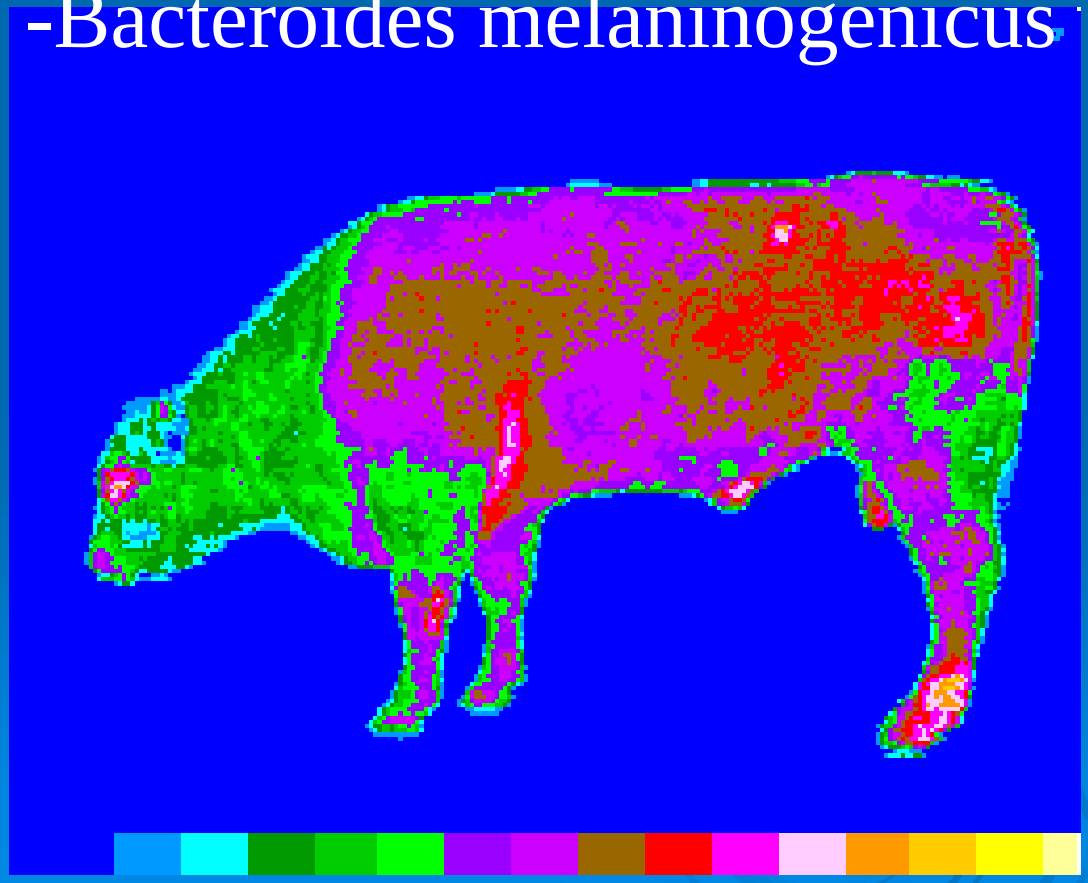


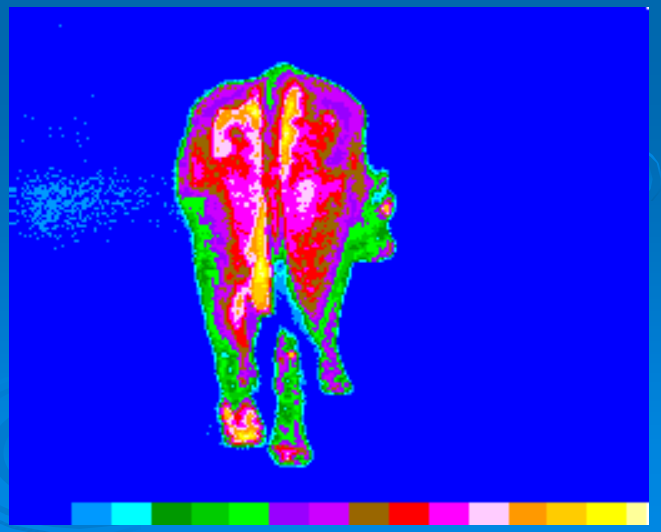
Infectious Pododermatitis

Foot Rot

-Fusobacterium necrophorum
-Bacteroides melaninogenicus

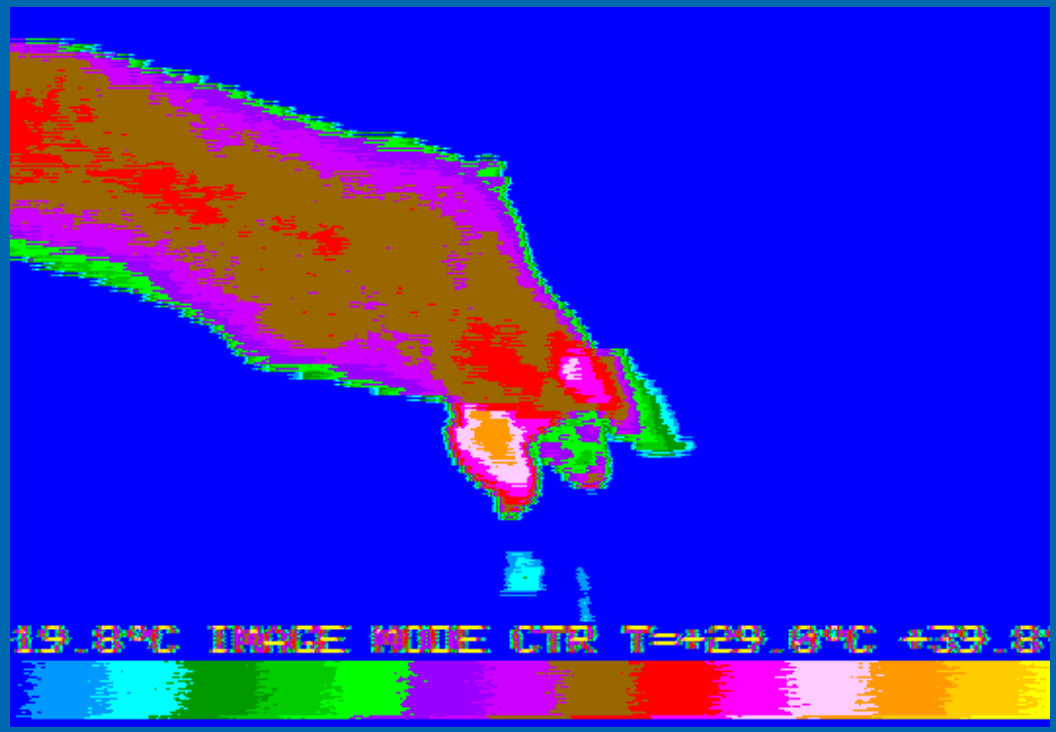


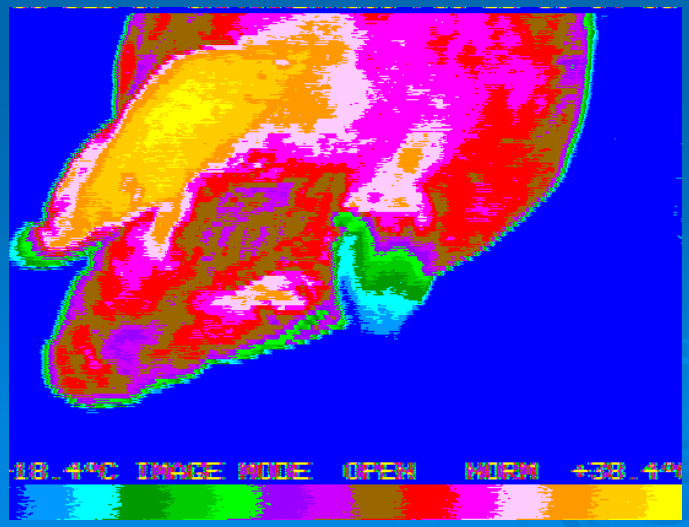




INFECTED EAR

PIG





CLOSTRIDIUM VACINE: VIRAL MODEL

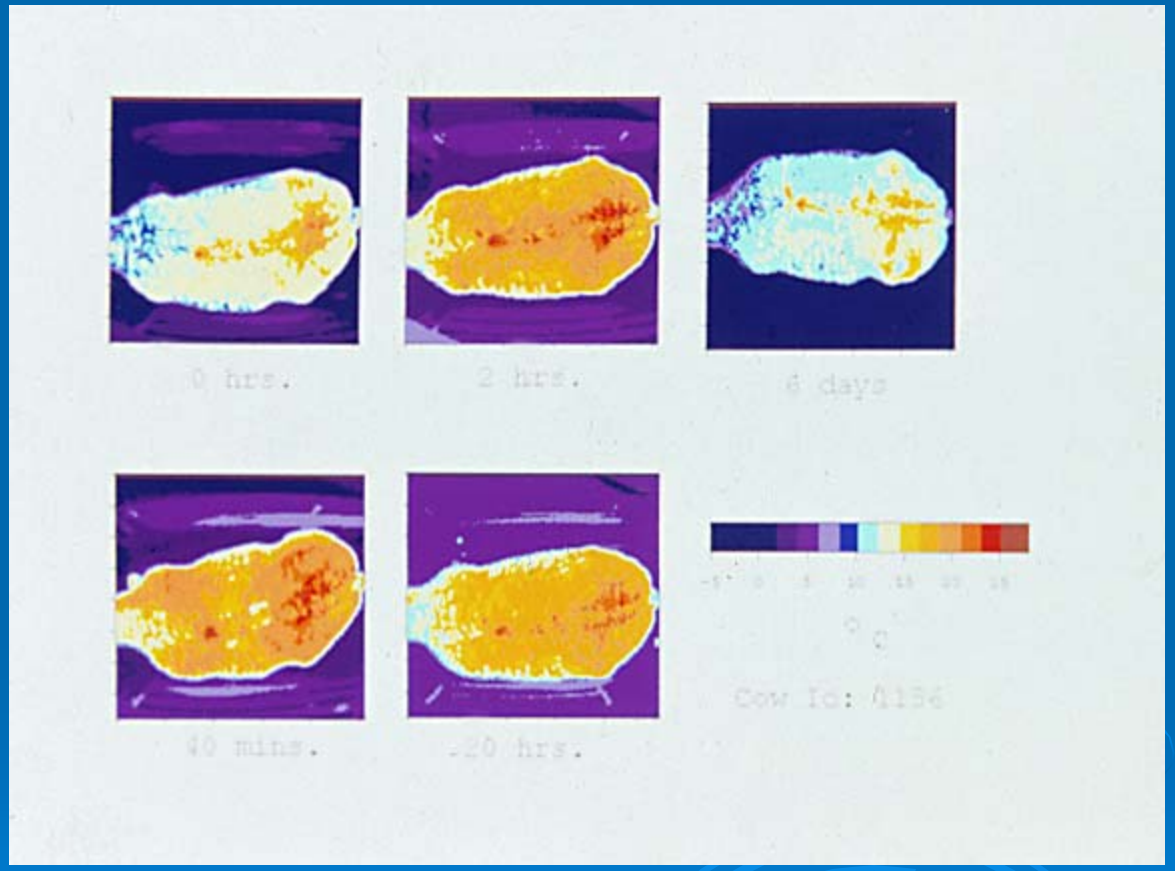
0h ------13C

40 min -- 16C

2h -------18C

20h ------18C

6d -------11C



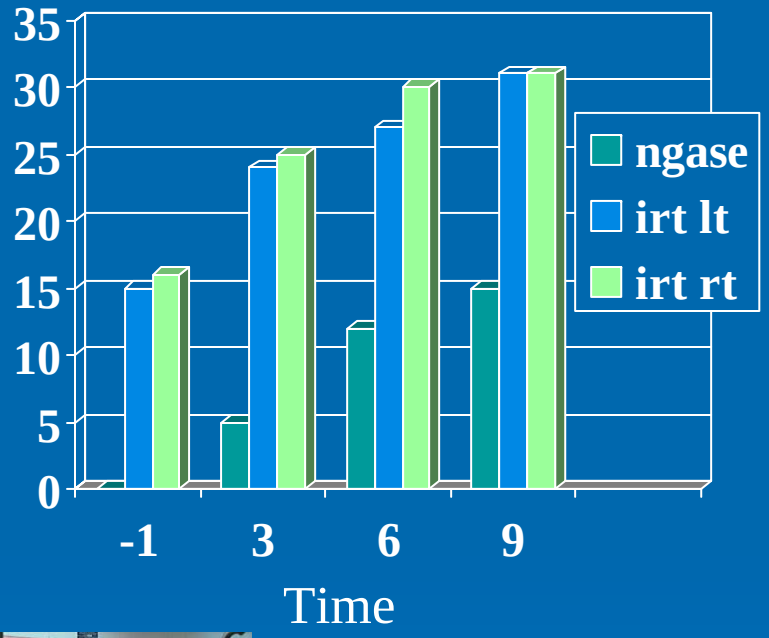
Cow 1156

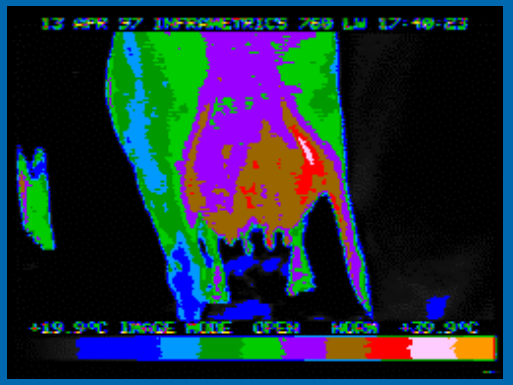
DAIRY CATTLE
IRT Mastitis

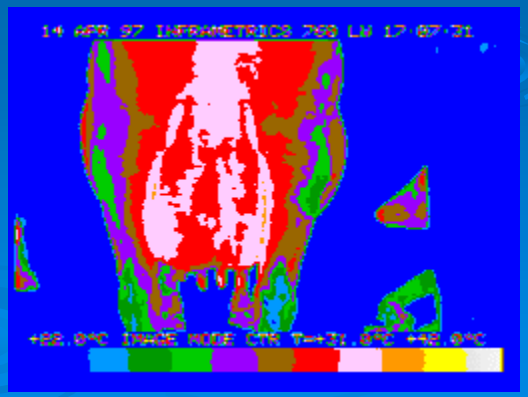
IRT Temp

C

Ngase ug/ml



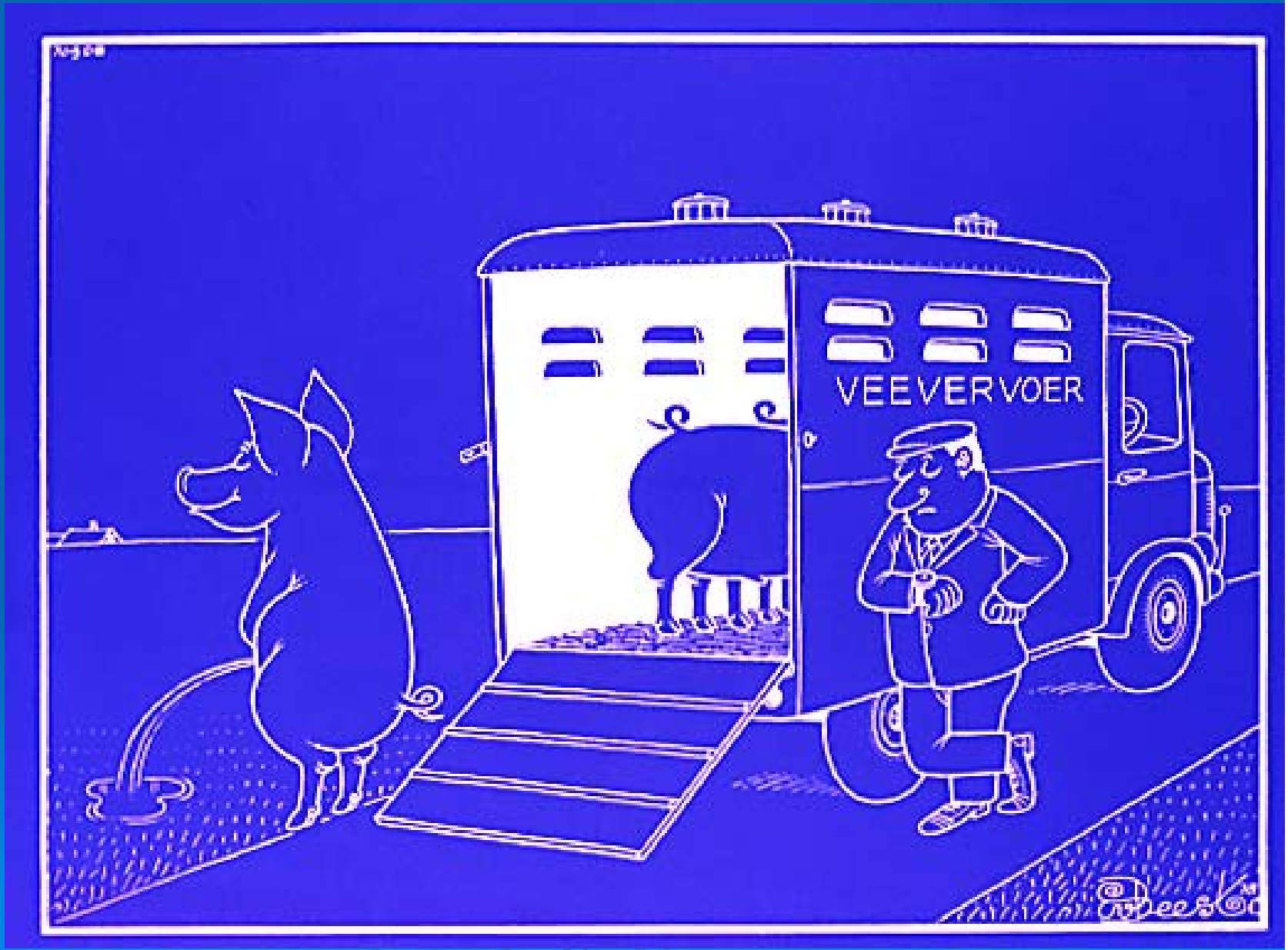




Transport and Handling Stress

-loss of grade
-loss of yield
-DFD /PSE
-toughness

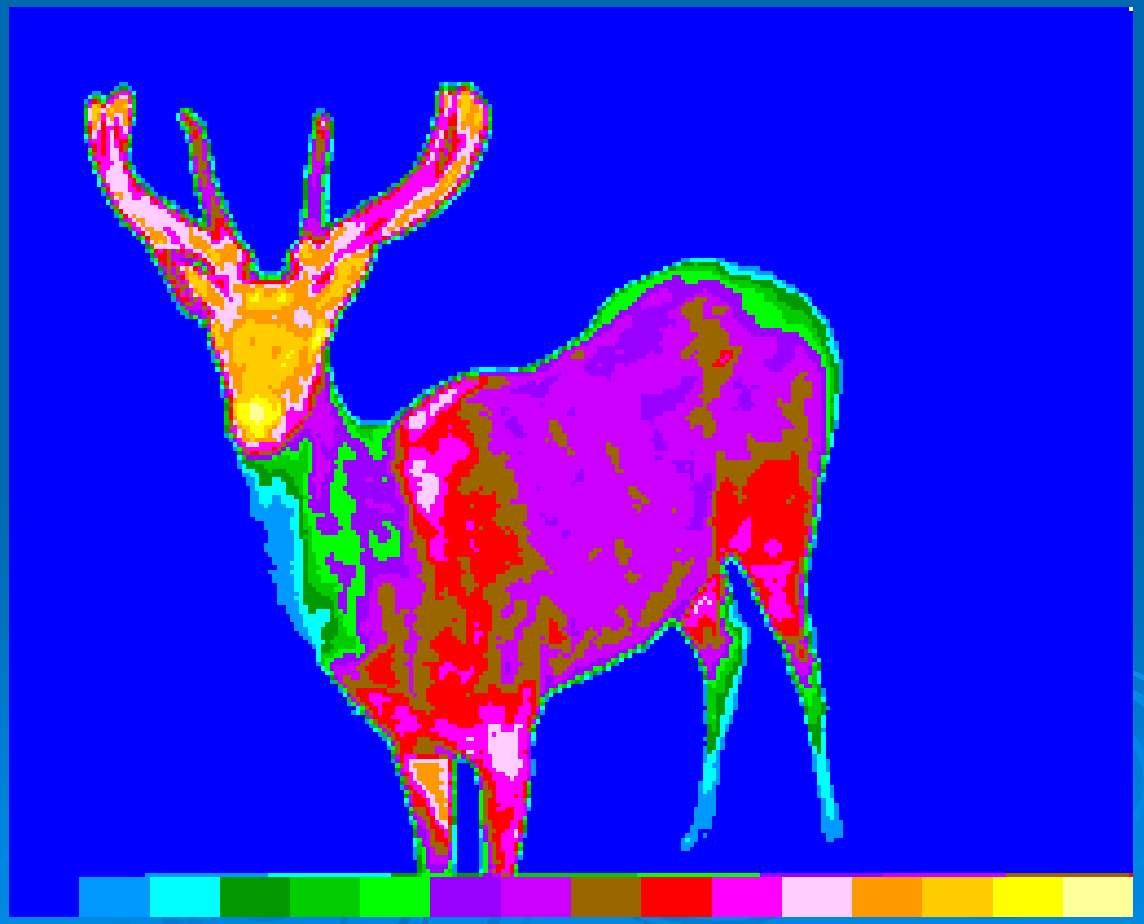
Area of Discipline: Physiology



28 SEP 03 INFRAMETRICS 740 LW 16:59:56
+ 0.0°C IMAGE MODE CTR T=+25.7°C +50.0°C

INFRARED THERMOGRAPHY

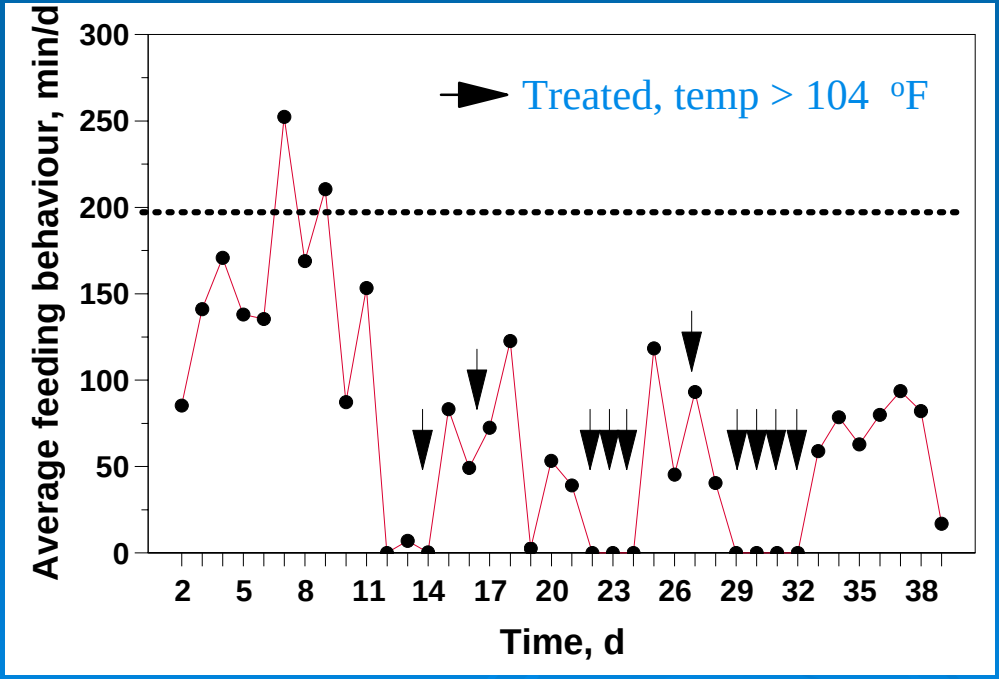
AN INDICATOR OF STRESS



Background:

- Reduced feeding behaviours are linked to early detection of morbidity, reduced performance and poor carcass quality in feedlot cattle (Basarab et al. 1997; Sowell et al. 1999)

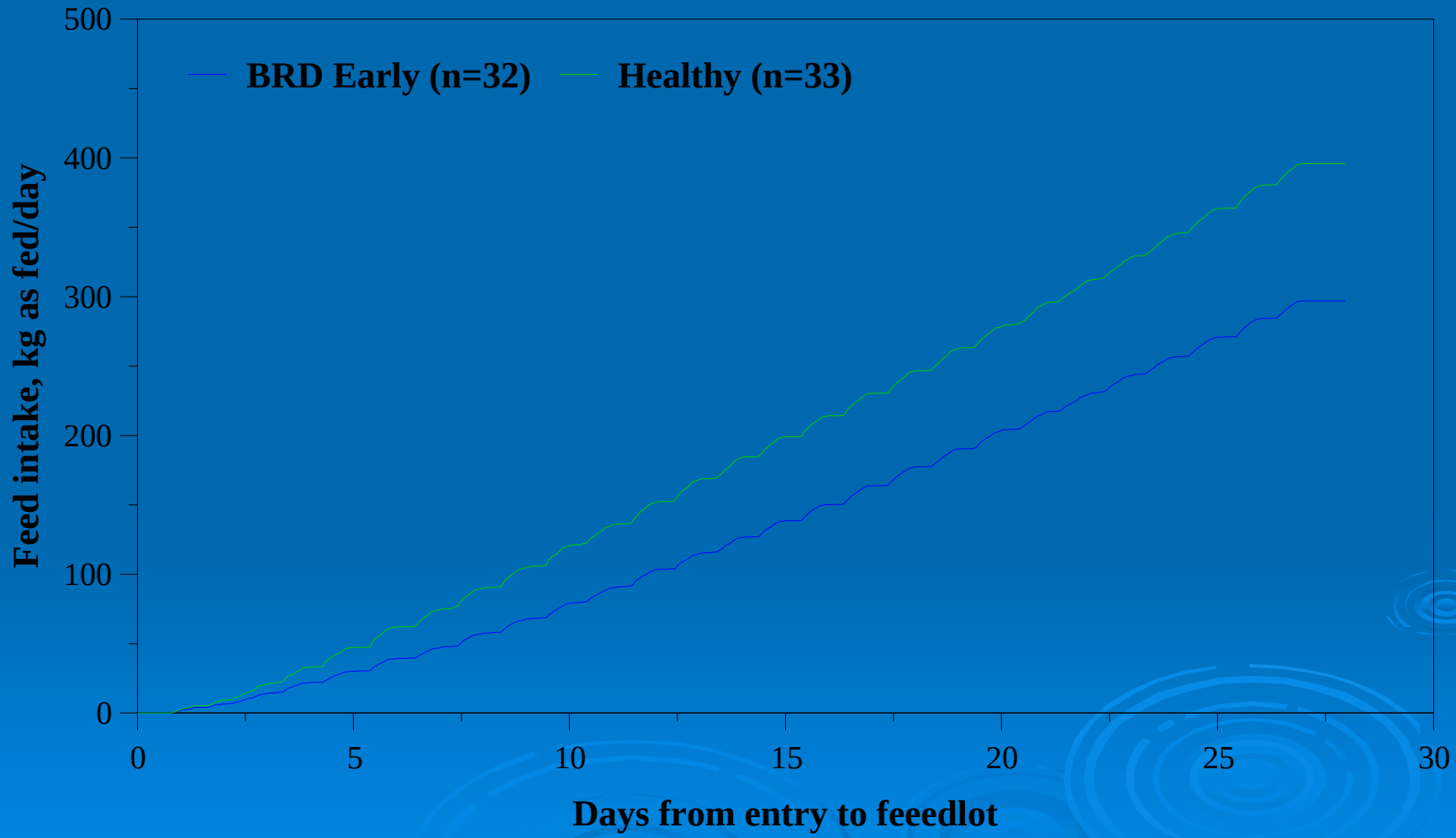
Daily pattern of feeding behaviour for steer 16941096



620 lb initial weight
Carcass weight=527 lb;
B1; < 4 mm bf;
54.7 sq cm;
-$252.15 net return

(Basarab et al. 1997, Can. J. Anim. Sci. 77: 554; Sowell et al. 1999, J. Anim. Sci. 77:1105)

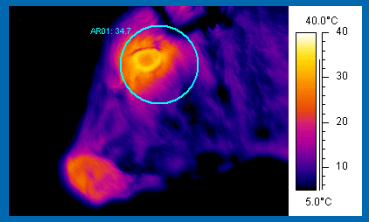
Cumulative feed intake for healthy, newly weaned steers and steers diagnosed with BRD on day 4-6 (BRD Early) of the feedlot period

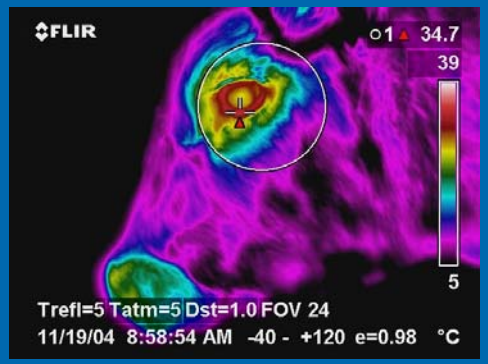


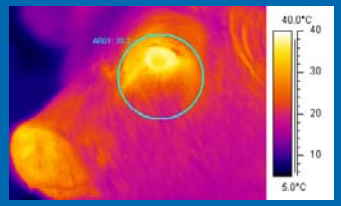
Pilot Bovine Respiratory Viral Disease Study

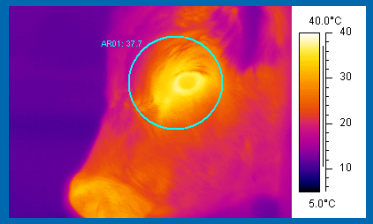
- Monitoring

  - Core Temperature
  - Saliva cortisol
  - Orbital IRT
  - Hematology
  - NO metabolites
  - Clinical score
  - Behavior


40.0°C
40
30
20
10
5.0°C


FLIR
1 34.7
39
5
Trefl=5 Tatm=5 Dst=1.0 FOV 24
11/19/04 8:58:54 AM -40 - +120 e=0.98 °C


40.0°C
40
30
20
10
5.0°C


40.0°C
40
30
20
10
5.0°C

P45

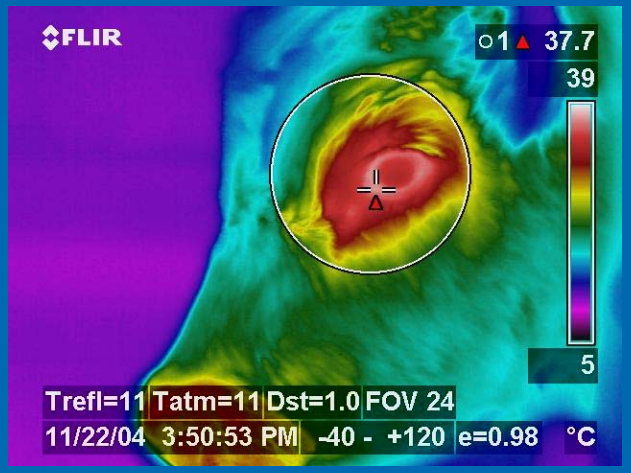
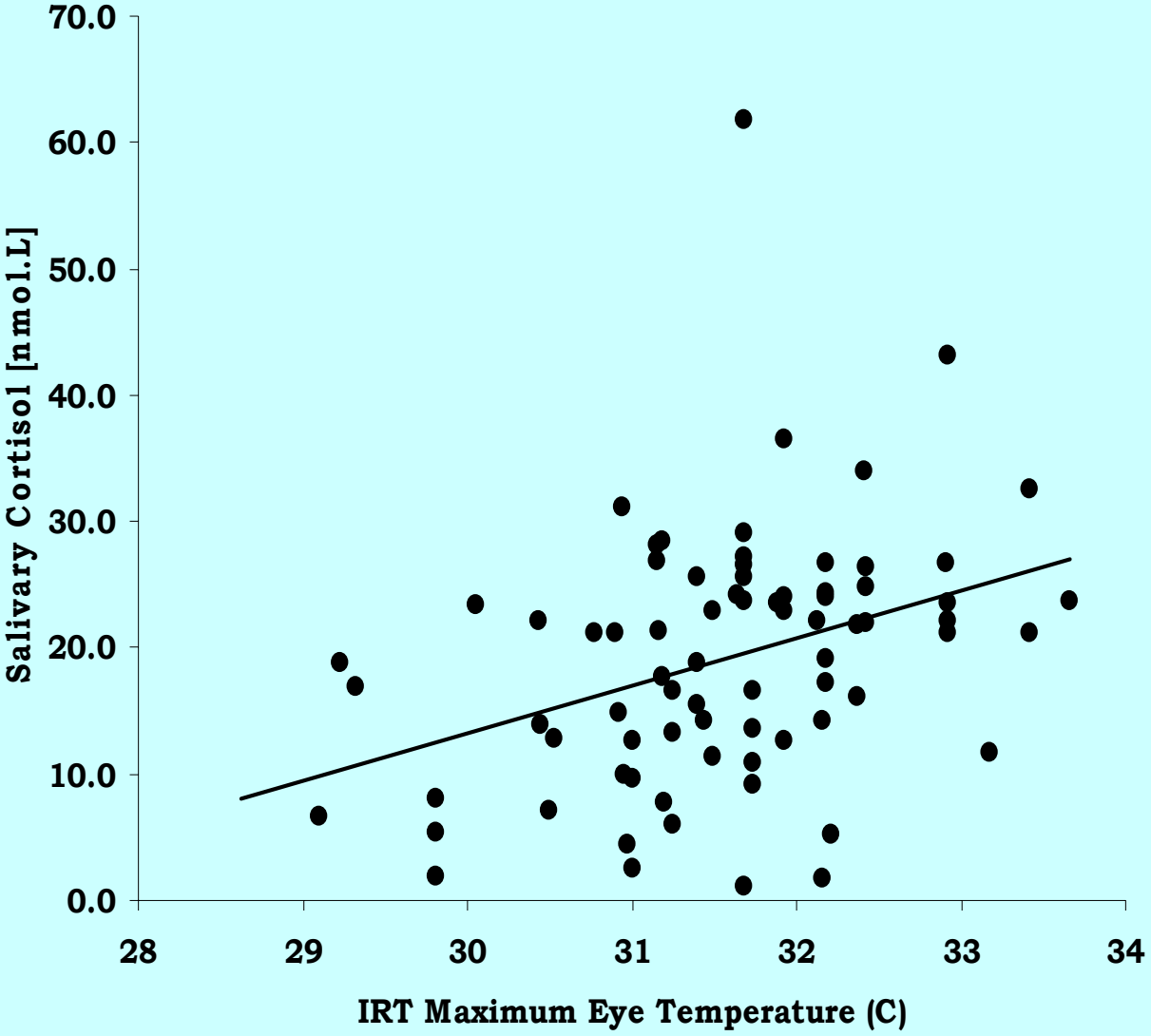
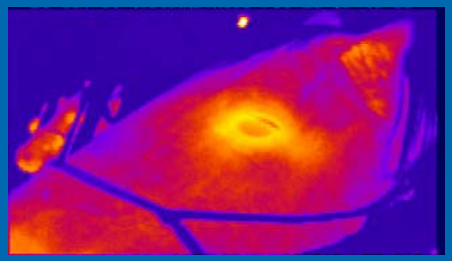

FLIR
1 37.7
39
5
Trefl=11 Tatm=11 Dst=1.0 FOV 24
11/22/04 3:50:53 PM -40 - +120 e=0.98 °C

Fig 6
Salivary Cortisol vs.IRT max Eye Temperature Following ACTH (200IU) Injection in Horses (n = 6)





R sal cort and irt =0.5555 (P<0.05)