Understanding the relationship between animal behaviour and morbidity in feedlot calves - Implications for Industry

K. Schwartzkopf-Genswein, T. McAllister, M. Streeter, M. Branine, S. Swingle, M. Shah, L. Thompson and B. Genswein

Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

Canada

Economics of disease

- Economic loss associated with BRD large
- BRD accounts for:
  - 65-77% morbidity
  - 44-72%mortality

(*Quimby et al., 2001;USDA 1994*)

- Cost of treatment
- Labour and lost production (*Galyean et al. 1999*)

Detection of sick

- Lung lesion data (Wittum et al., 1996)
  - 68% never treated for BRD
  - Visual appraisal not always effective
  - Mass medication
- Behaviour patterns and physiology
- predict onset before clinical signs
- Early intervention (early detection) more effective

Antibiotics

- Reduction of antibiotic use
  - Drug cost
  - Public concern for antibiotic resistance
  - Trade issue?
- Targeted discriminatory use of antibiotics

Objectives

- Use feeding behaviour to:

1) Detect morbidity earlier than conventional methods
2) Efficacy of new drugs
3) Timing of treatment
4) Drug combinations
5) Pre-shipping management

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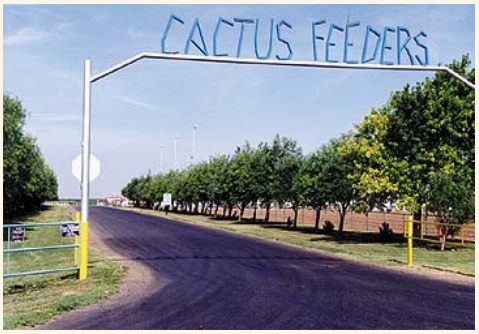
- Large data sets
- Weather, feed, history, breed



Effect of Pasturella Vaccine on Feeding Behaviour of healthy and morbid cattle

- How did feeding behaviour differ between sick and healthy cattle?
- Did cattle with or without lung lesions have different feeding durations and visits overall?
- Did outcome groups based on bunk attendance have different levels of a) BRD b) presence of lung lesions?

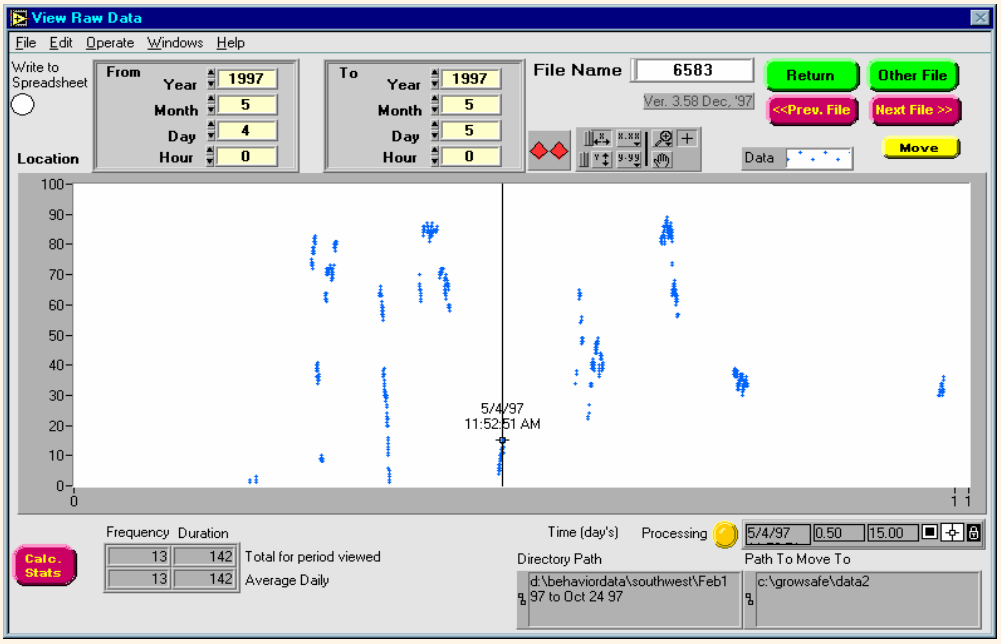
- Did sick calves administered the Pasturella vaccine have different feeding behaviour than sick calves not give the vaccination?

Study Design

- 1857 auction market heifers (572 +/-32 lb)
- Processed, mass medicated on arrival; non-preconditioned
- 20 pen 91-97/hd/pen
-
- Pasturella Vaccine/ No vaccine
- Corn/corn silage
- 215 days on feed
  - 4 GrowSafe pens
  - 380 95/pen

Variable Measured

- Performance
- Feeding Behaviour
- Lung Lesions
- BRD severity score
- Carcass


View Raw Data
File Edit Operate Windows Help
Write to Spreadsheet
From
Year 1997
Month 5
Day 4
Hour 0
To
Year 1997
Month 5
Day 5
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File Name 6583
Ver. 3.58 Dec, '97
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Other File
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Move
Data
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100
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11:52:51 AM
Frequency Duration
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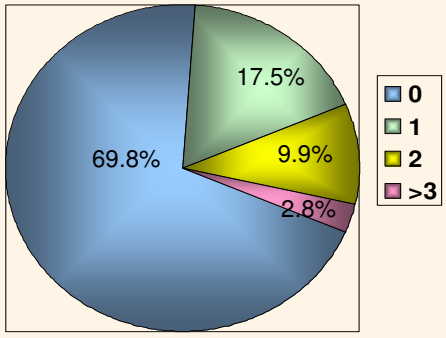
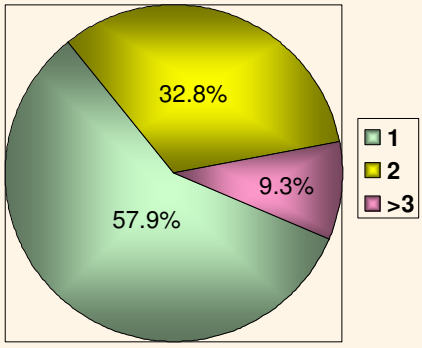
13 142 Total for period viewed
13 142 Average Daily
Time (day's)
Processing
5/4/97 0.50 15.00
Directory Path
d:\behaviordata\southwest\Feb1 97 to Oct 24 97
Path To Move To
c:\growsafe\data2

Methods

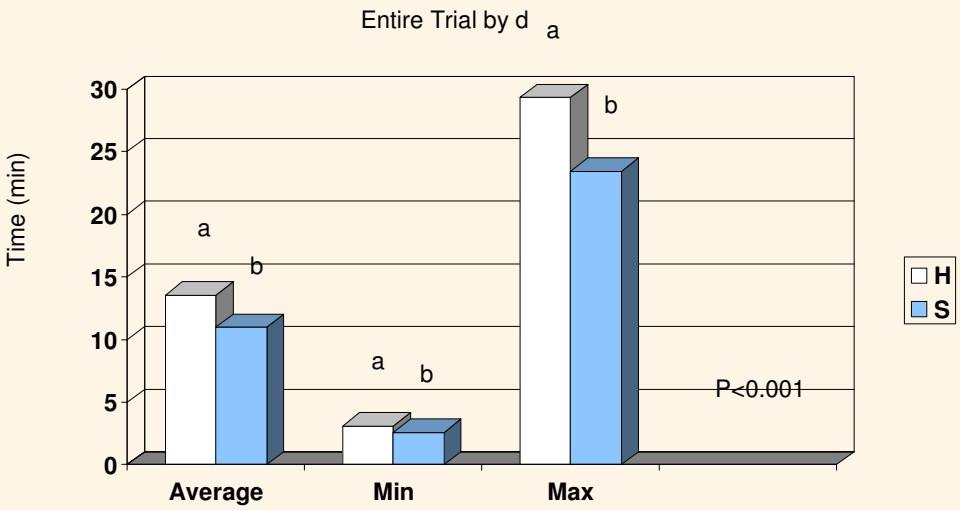
- 176 total pulls (174 BRD diagnosis)
- Sick and healthy matched 1:1 by pen and day
- Data analyzed for entire trial and 4 d prior to being pulled
- BRD severity based on # of treatments
- Lung lesion data Y/N

176 Total Pulls=116 Heifers





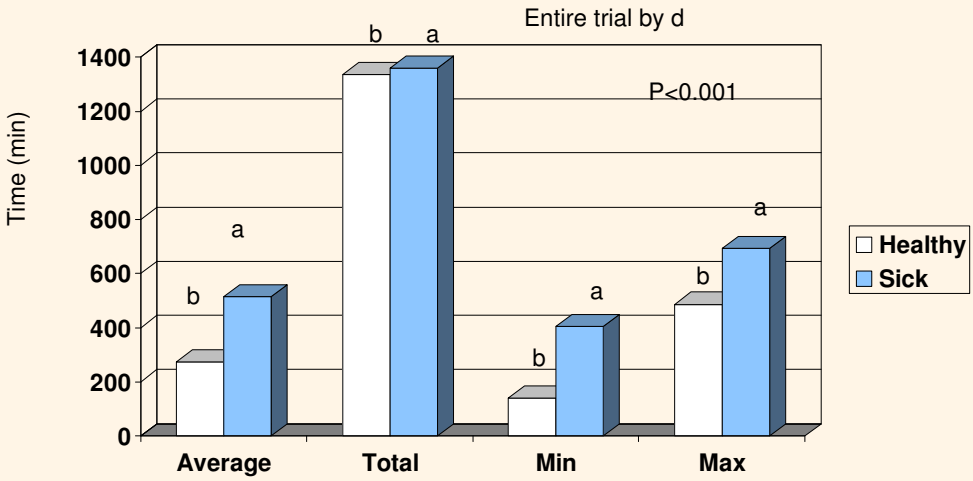
Did bunk attendance duration differ between sick and healthy cattle?



Other Studies

- Healthy steers spend 30% more time at the feed bunk than morbid steers (*Sowell et al., 1998*)
- Morbid steers spent 23.7% less time at water than healthy (*Basarab et al.,1996*)

Did time between bunk visits (inter-meal interval) differ between sick and healthy cattle?



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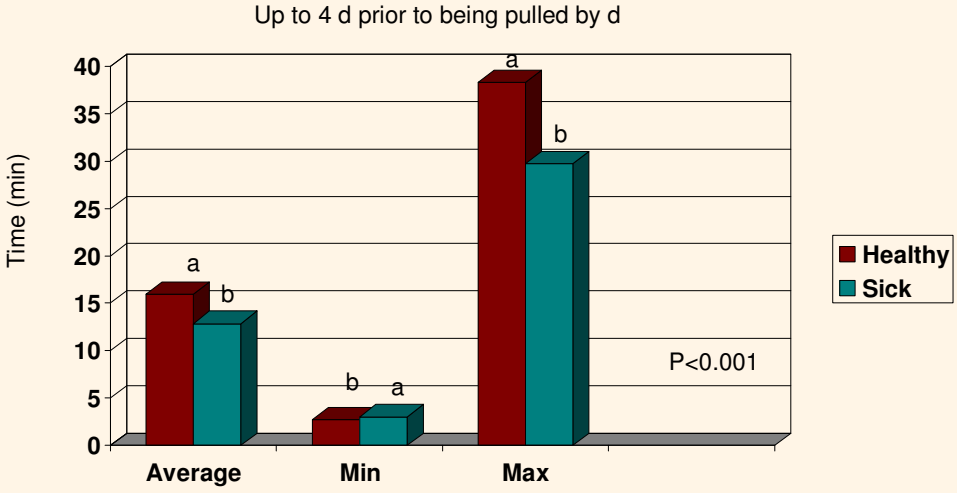

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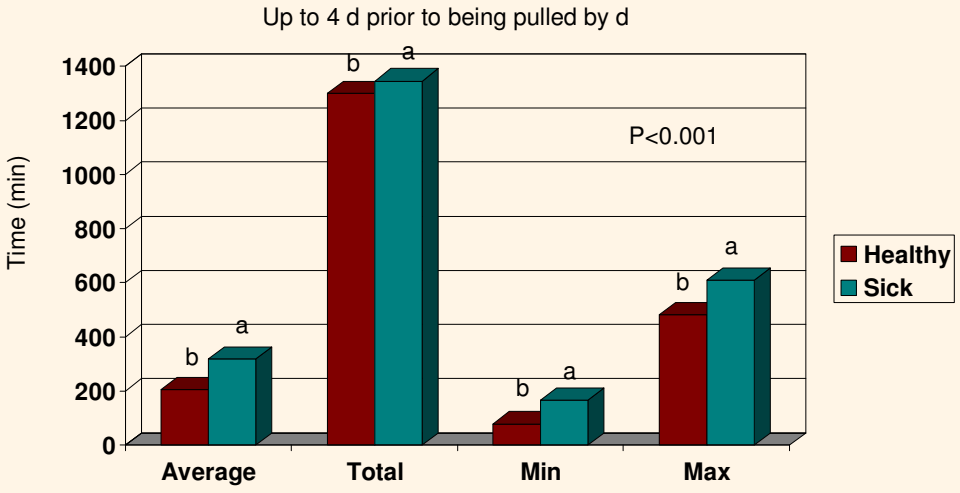
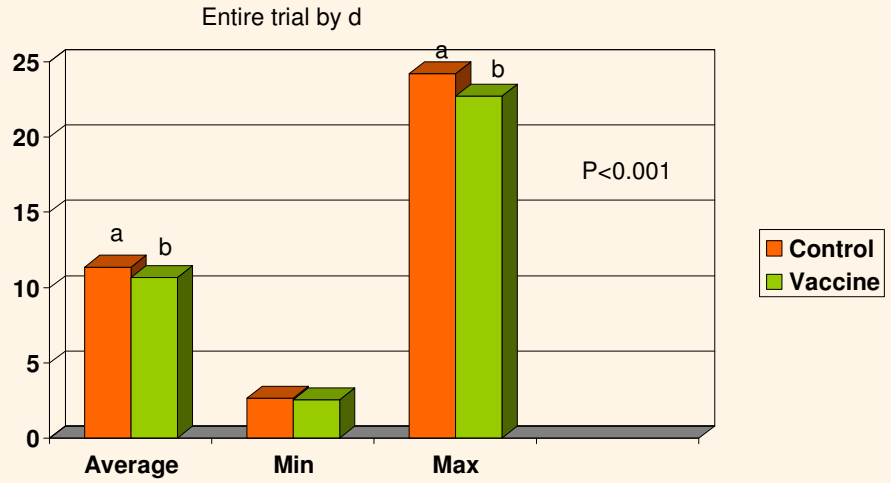


Did sick calves administered vaccine have different bunk attendance durations than sick calves not given the vaccination?



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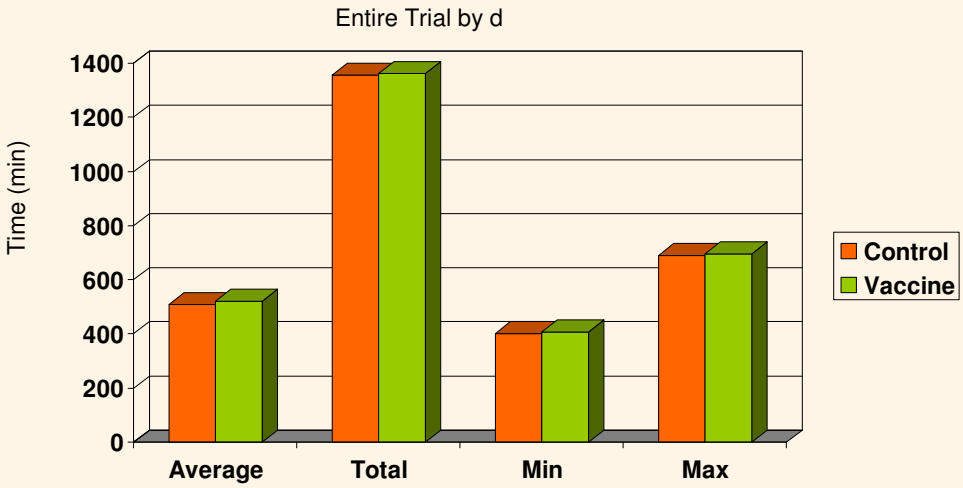

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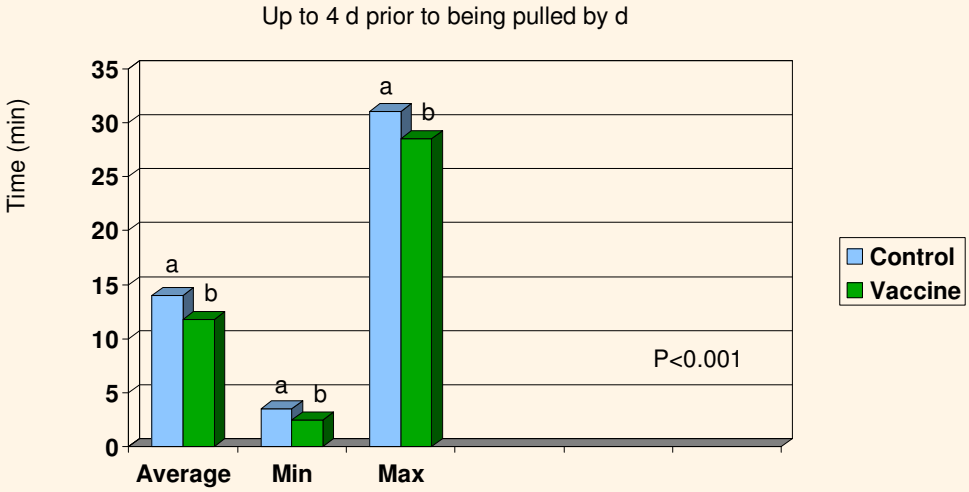

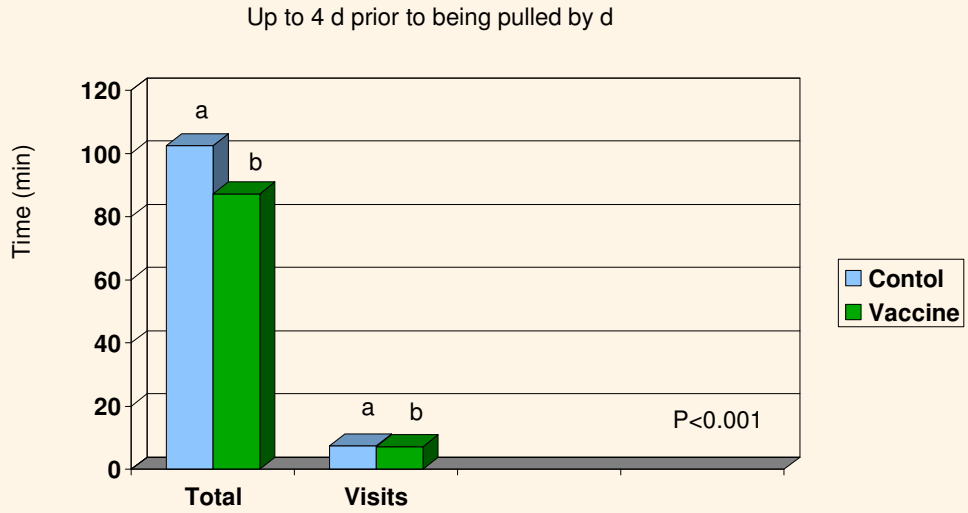

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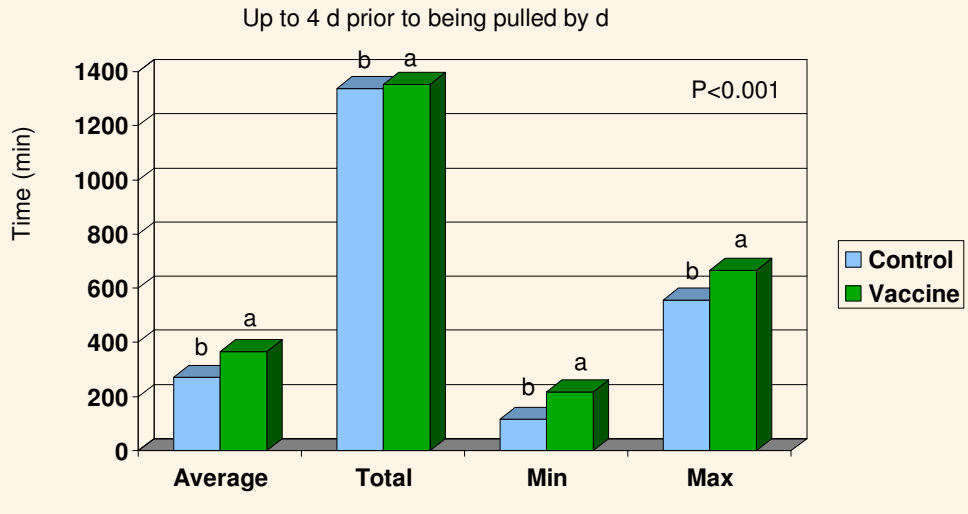
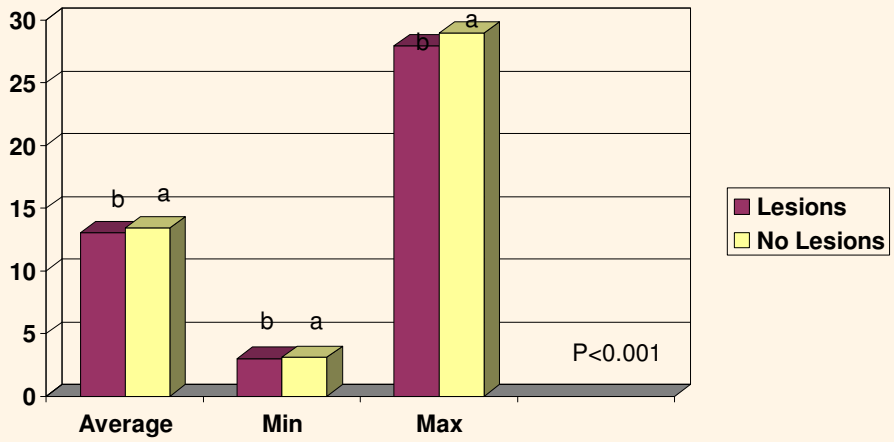


Did cattle with or without lung lesions have different feeding durations and visits overall?



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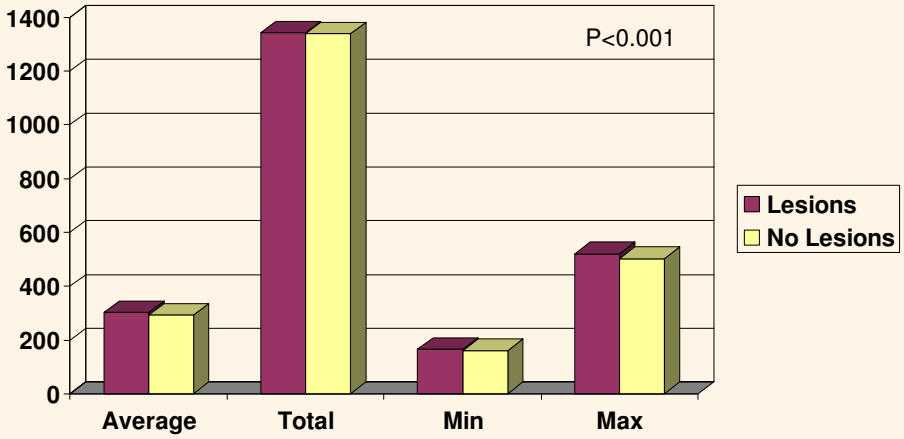
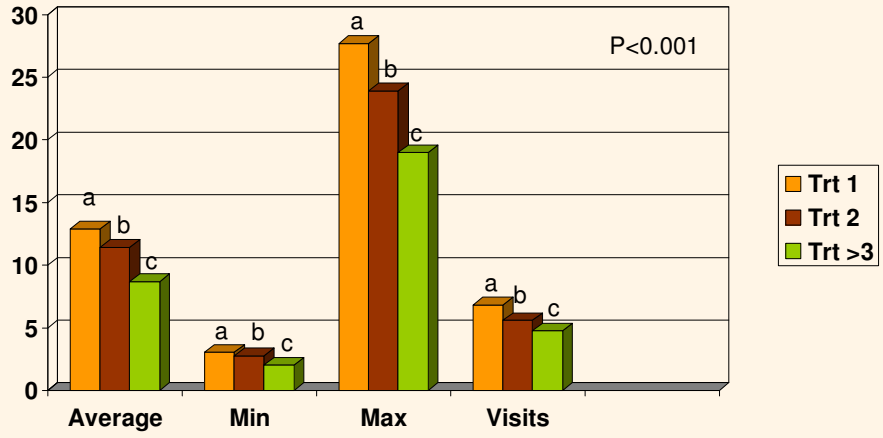


Relationship between times treated and bunk attendance



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Cat. by feeding duration	# Trts	ADG	Liver Score	Lung Score
Low category				
Control	2.97a	2.54c	.67a	.18a
Vaccine	2.21b	2.64a	.44b	.08b
Med category				
Control	2.31c	2.57b	.49b	.17a
Vaccine	1.78d	2.63a	.46b	.08b
High category				
Control	2.32bc	2.61a	.38bc	.14a
Vaccine	1.81d	2.61a	.54ab	.08b

P value = 0.001

Other Questions

- When do sick eat relative to healthy?
- Do sick maintain diurnal pattern?
- Feeding pattern related to truck delivery?
- Where there are differences can activity during specific periods of the day explain those obtained over a 24 h period?

Conclusion and Implications

- Feeding behaviour has use in:
  - Screening for the early detection of animals in need of therapeutic treatment
  - Assessment of antimicrobials
  - Drug treatment regimes
  - Animal management

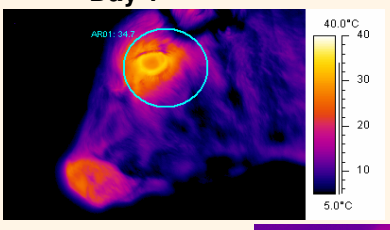
Future

- All other studies retrospective
- Define behaviour
- Test criteria on “new” studies
- Correlation to physiology (IRT, immune status)
- Other behaviour

BRD Progression

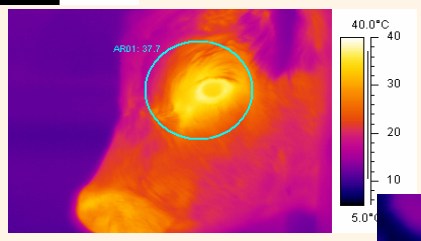
Multiple Sourced Calves
Co-mingled, 8h transport

Day 1



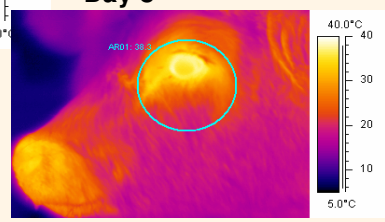
35.1 C

Day 4



37.7 C

Day 8



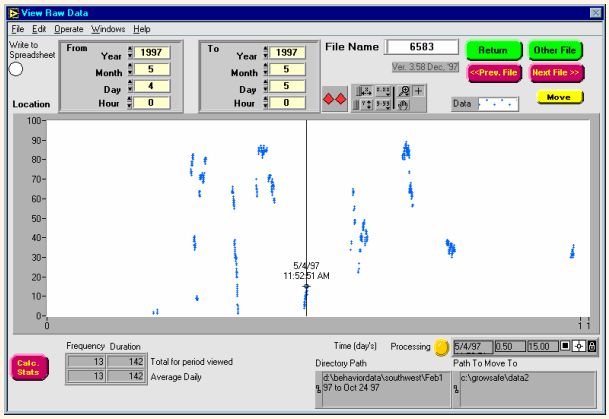
38.4 C

Stewart et al. 2005
Animal Welfare 14:319


GrowSafe

Computer modelling ?

- Neural network
- Pattern recognition



Use of pattern recognition to develop an automated animal health classification system

R. Silasi, K.S. Schwartzkopf-Genswein,
B. Genswein, T.A. McAllister, and T.G. Crowe

Traditional methods for identifying morbid animals

- Pen checker looks for symptoms of BRD progression (subjective in nature)
  - Thick nasal discharge
  - Difficulty breathing
  - Discharge from eyes
  - Red, peeling muzzle
  - **Listless behavior**
  - Elevated temperature

Of those cattle identified as having lung lesions at slaughter only 68% were treated for BRD

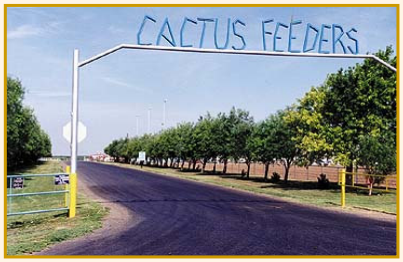
→ Visual appraisal not effective

Objectives

- Identify and define sick feeding behavioral patterns prior to pull date

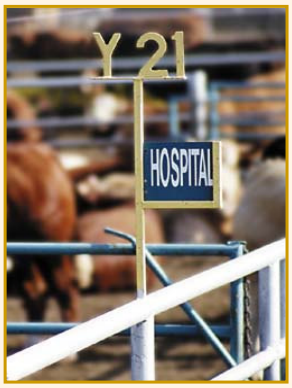
Animals and measures

- Behavior data collected at Cactus Feeders (Texas)
- 376 newly arrived beef cattle in 4 pens equipped with GrowSafe – Model Dataset (2002)
- 383 animals – Test Dataset (1998)
- Variables measured:
  - Performance
  - Feeding behavior
  - Lung lesions
  - BRD severity score
  - Carcass information

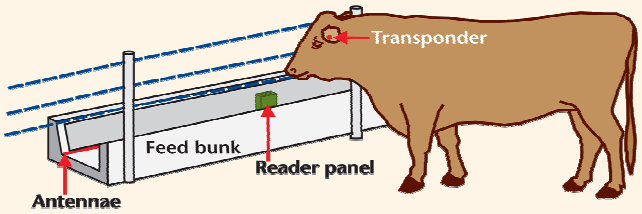


Proposed method for identifying morbid animals

- An analytical method for the early identification of morbid animals
  - Combine feeding behavior data with morbidity data
  - Use pattern recognition techniques to identify feeding behavior differences between sick and healthy cattle

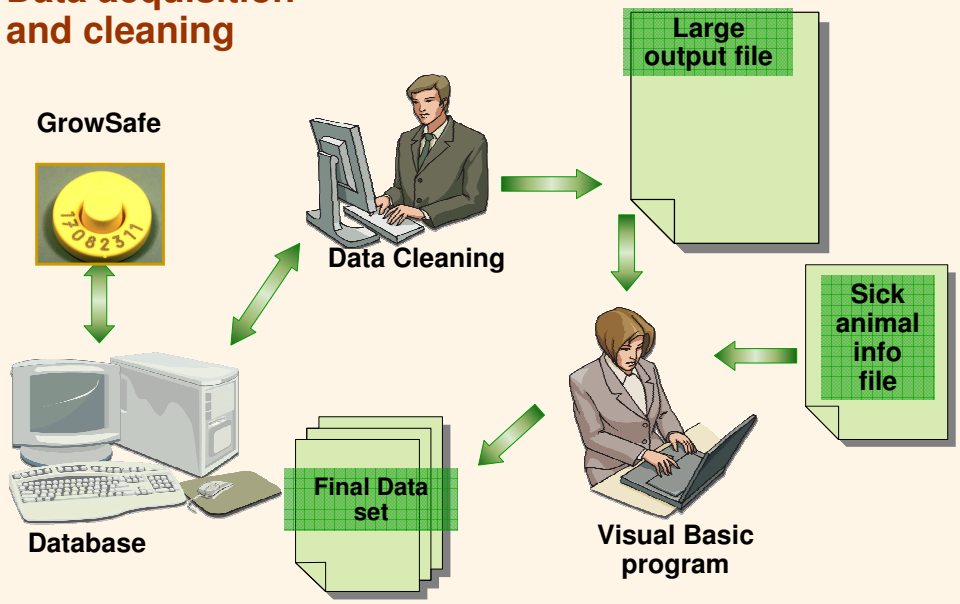


GrowSafe feedbunk monitoring system

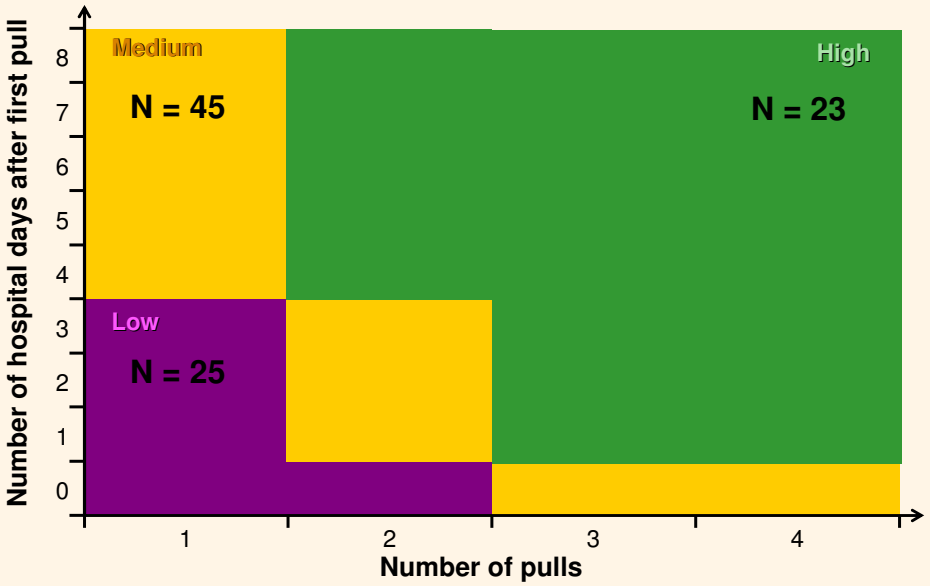


- Feeding behavior data collected every 5.6 s over a 24 h period for up to 210 d on feed for every animal within a pen

Data acquisition and cleaning



Defining Confidence Level of Sickness (CLS)



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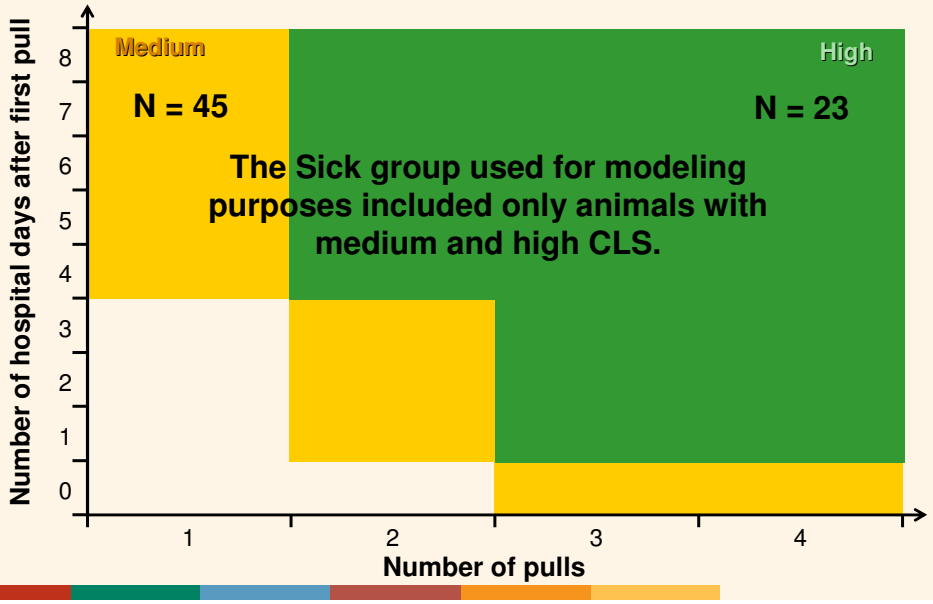
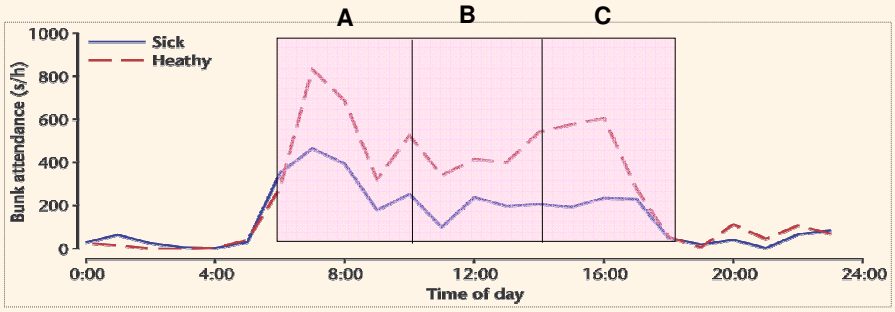


Methods



- Over 10 d, 30 distinct sections were defined

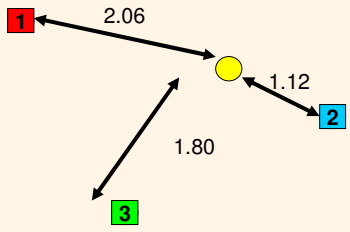
Modeling Procedure

1. Principal Component Analysis
2. Clustering
3. Cluster Analysis / Create binary string
4. Pattern Recognition

Principal Component Analysis (PCA)

- Identification of groups of inter-related variables
- Reduction of number of variables
- Original dataset (13 feeding behavioral variables)
- 5 principal components (99% variation)

K-Means clustering algorithm a 3 cluster example



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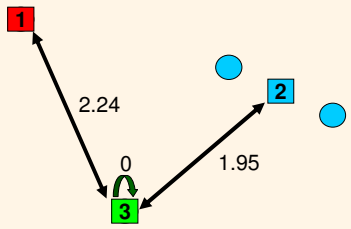

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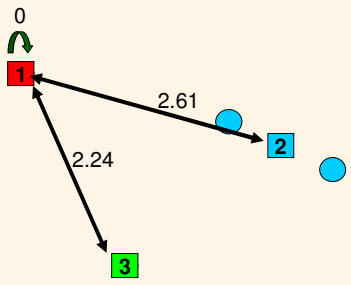

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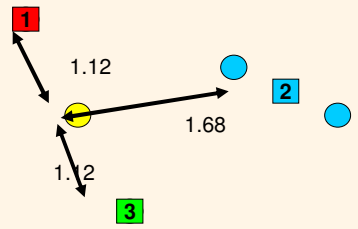

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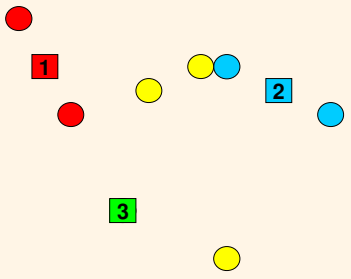

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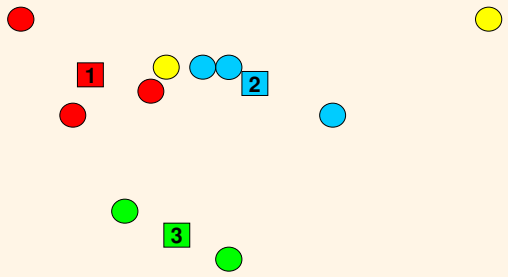

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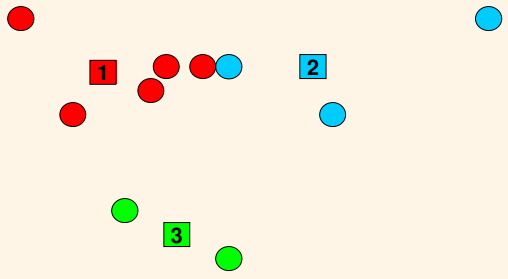

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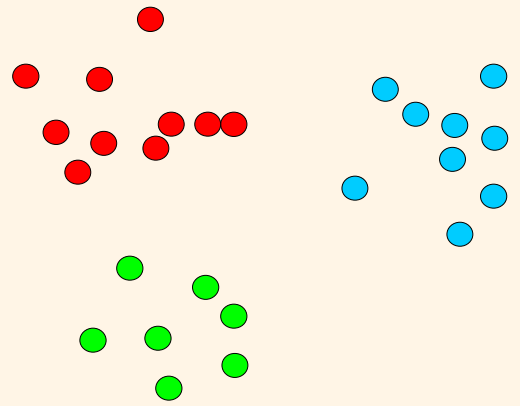

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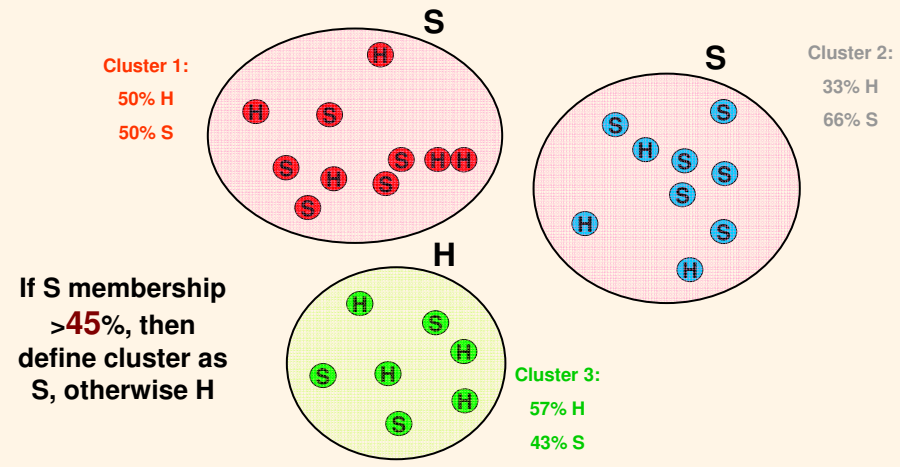

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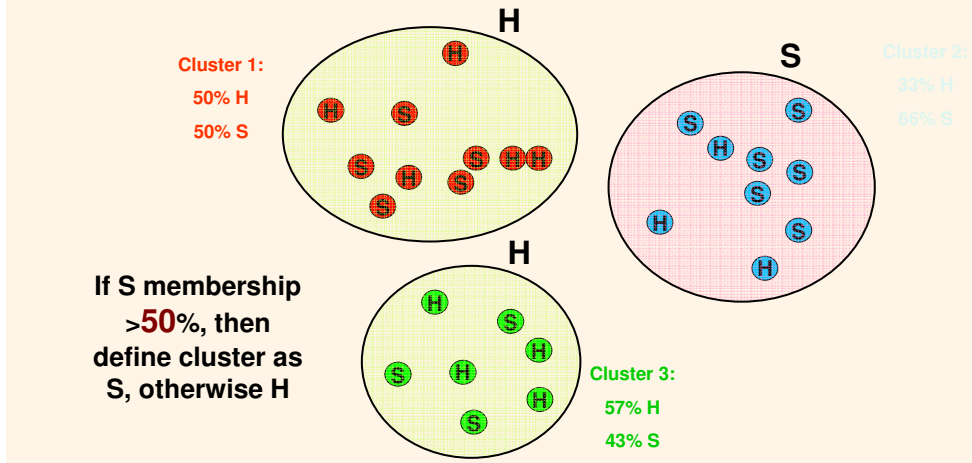
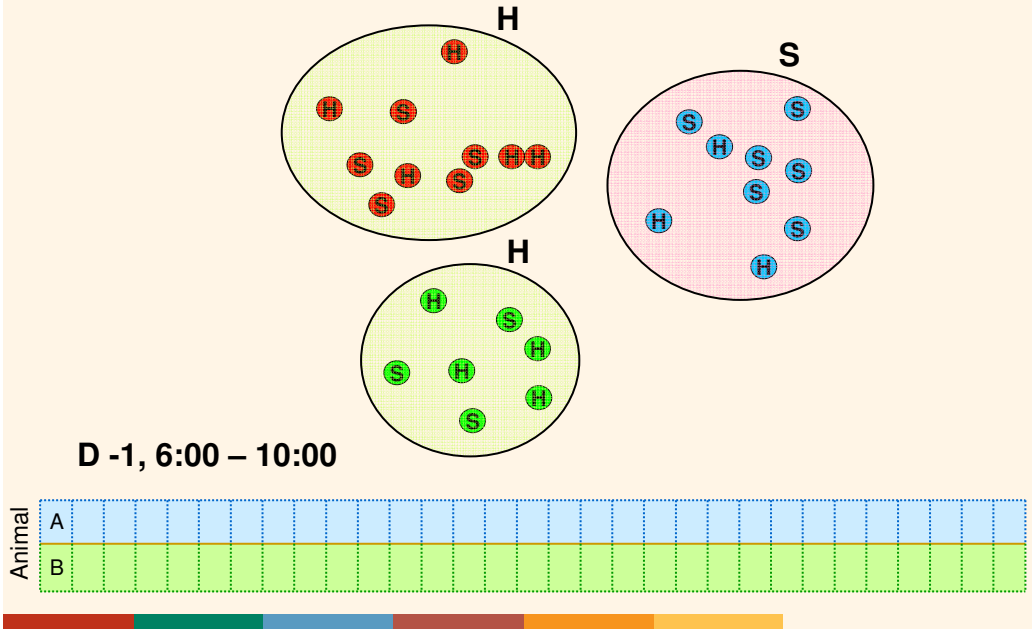
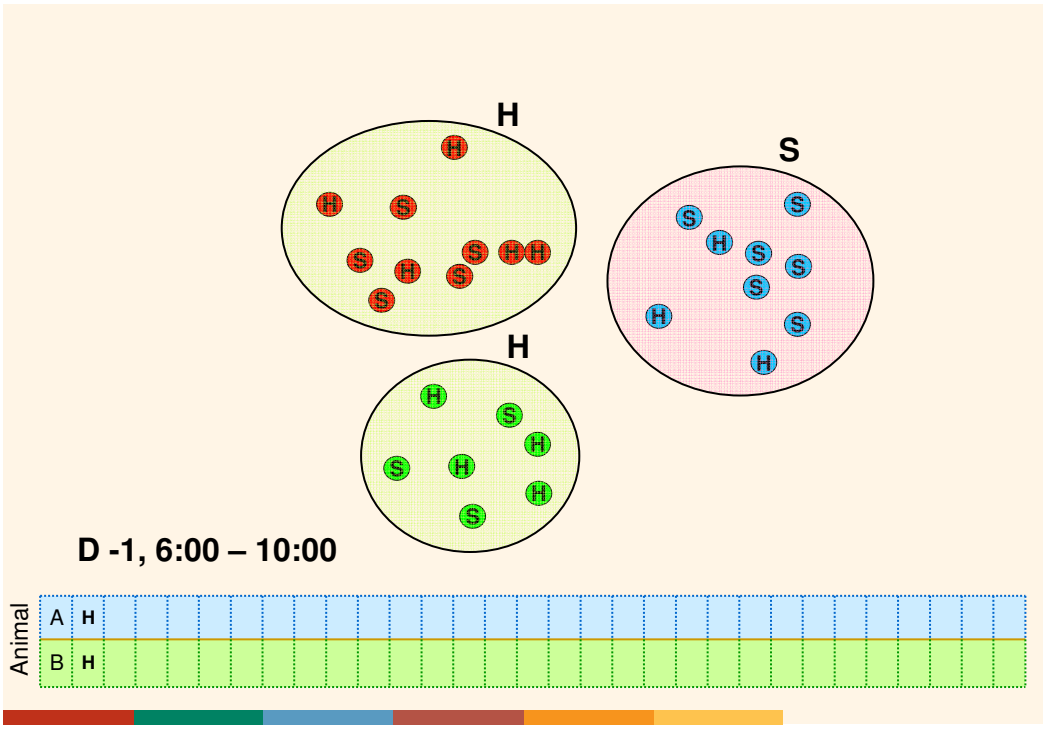
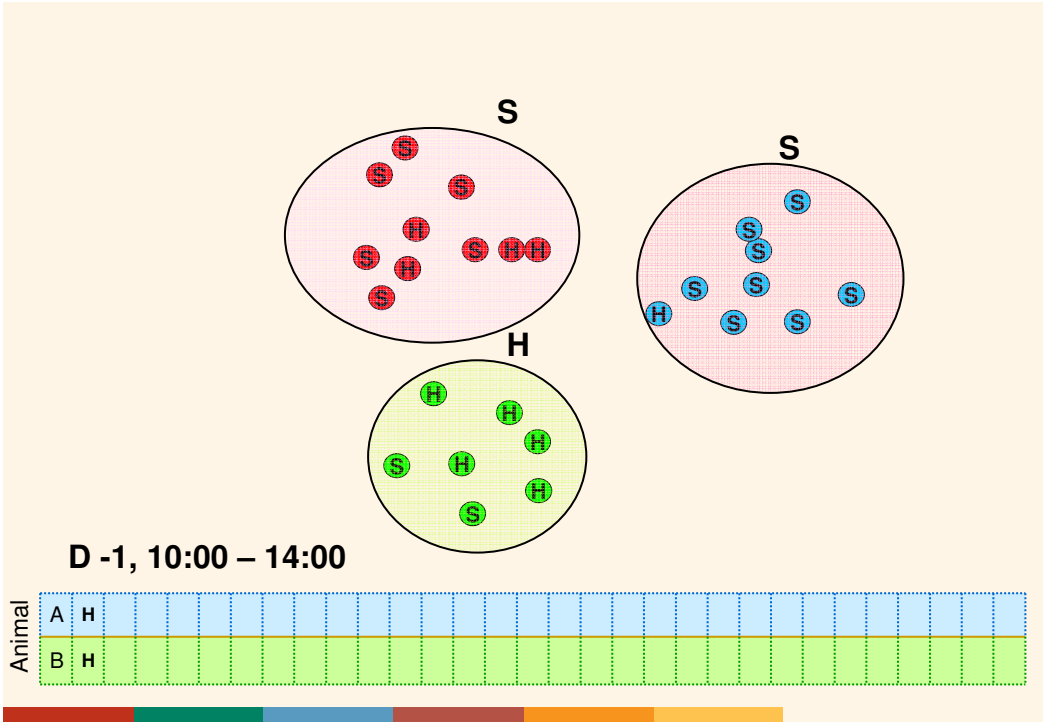
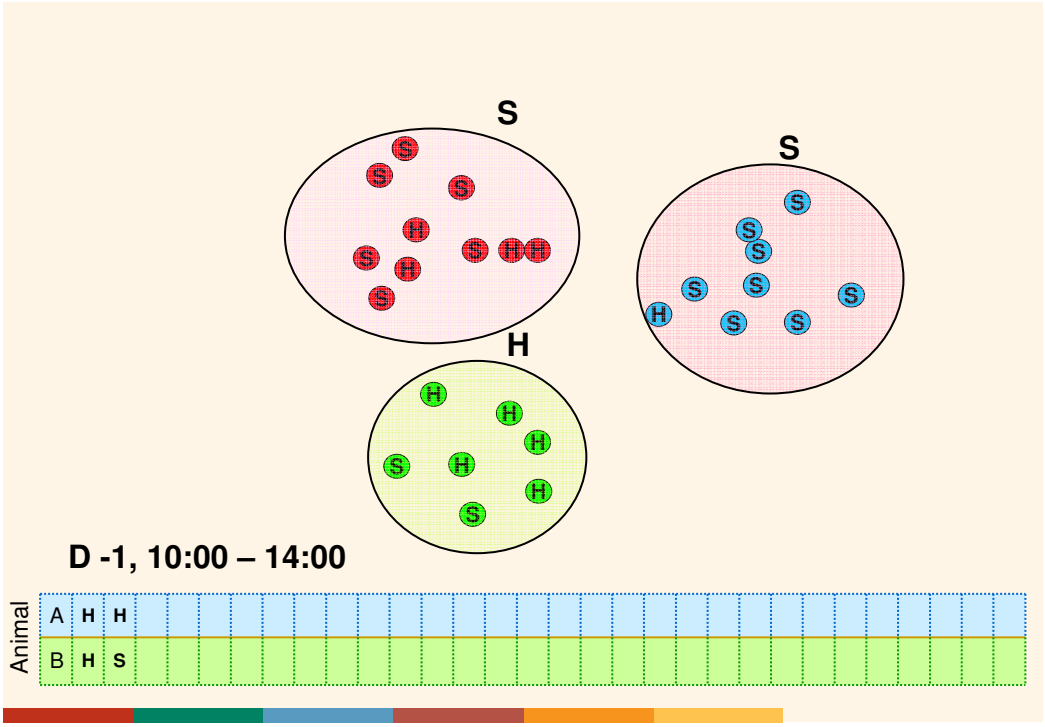





H
S
H
D -1, 6:00 – 10:00
Animal
A H
B H


S
S
H
D -1, 10:00 – 14:00
Animal
A H
B H



Finding ‘sick’ pattern

→ Healthy

Animal

A	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1
B	0	1	0	1	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1

→ Sick

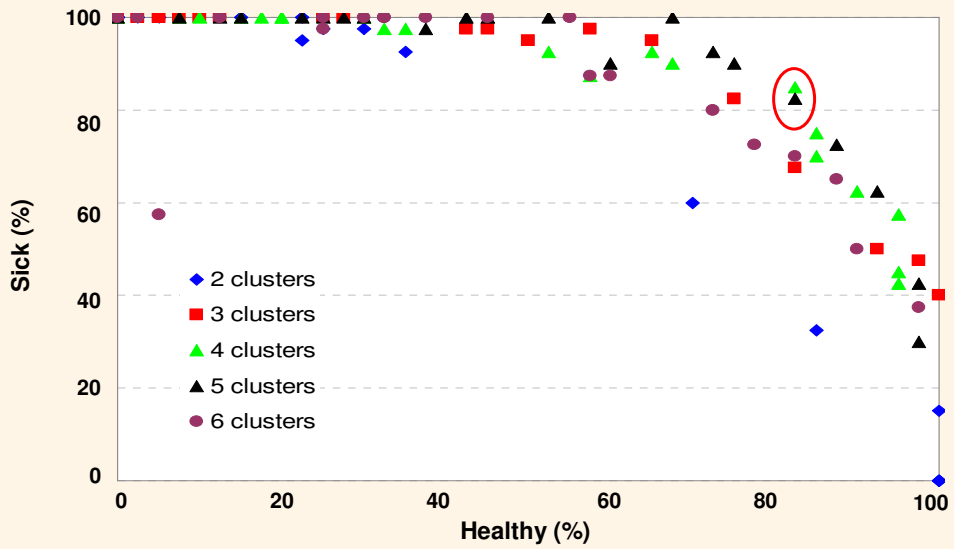
0 - Healthy

1 - Sick

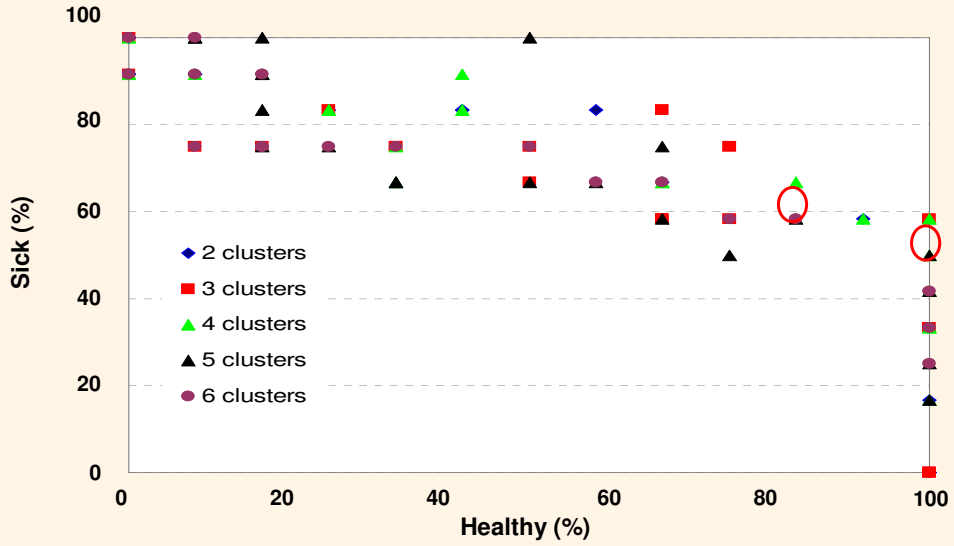
Model Summary

Cluster Membership	Cluster Size	Window Size
45%	2 to 6	3 to 15
50%	2 to 6	3 to 15
55%	2 to 6	3 to 15

Model Dataset (n=40)



Test Dataset (n=12)



Conclusion

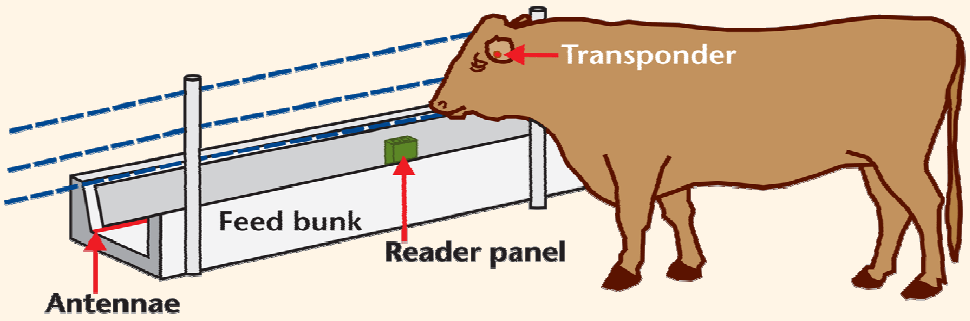
- Morbid and healthy cattle behave differently at the feedbunk
- Model predicts healthy and morbid animals with ~ 70 to 75% accuracy in test data set, 1 to 9 days prior to traditional methods

Neural Network Modeling of Feeding Behavior to Predict Morbidity in a Commercial Feedlot

B. Hill, Karen Schwartzkopf-Genswein*, *et al*.

Agriculture and Agri-Food Canada,
Research Centre, Lethbridge, AB

Feed Bunk Monitoring



1998 and 2002 Experiments

- Feeding data modeled using Neural Networks to predict (classify) each animal as healthy or sick, **in advance of sick being pulled** by pen checker
- Cattle defined as **sick** based on hospital diagnosis and drug treatment
- Cattle defined as **healthy** based on never having been pulled or treated

13 Daily Input Variables

1. Initial BW (564-866 lb; 388-688 lb)
2. Days on test (1-107 d)
3. No. visits to bunk/day
4 - 8. Feeding duration - min, max, avg, SD, total (sec)
9 - 12. Inter-meal interval - min, max, avg, SD, total (sec)
13. Max daily temp (℃)

used to predict whether an animal healthy or sick **at different days** before sick were actually pulled

Data Sets

- Healthy and Sick animals were **matched in a 1:1 ratio** by Days on Test (DOT) and Pen
- Animals with 0 visits on a day were excluded from the data sets for that day
- No. of animals for modeling decreased with DOT

1998	60% of morbid pulled by 6 DOT
2002	35% of morbid pulled by 6 DOT

Data Sets

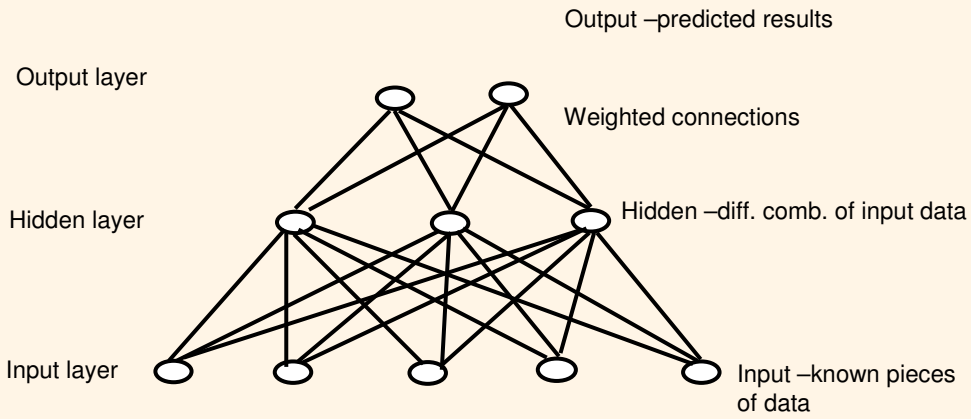
1998	• 108 animals, 1 d before pull • 88 animals, 5 d before pull
2002	• 232 animals, 1 d before pull • 152 animals, 5 d before pull • 108 animals, 10 d before pull

Morbidity modeled using 1 d of data at a time

Neural Network (NN) Modeling

- NN are a **non-linear modeling technique** that find patterns in example data sets. Can handle many co-related inputs
- **Inputs together with known outputs** presented on a case-by-case basis to the NN software
- NN software adjusts weighting factors applied to each input by trial and error until predictions agree with the known outputs
- Result is a 'mapping' (matrix) of weight values that **can be used to predict future unknown cases**

Neural Net



Neural Network (NN) Modeling

- Used commercial software, **Predict®** v3.13, from NeuralWare (Carnegie, PA)
- Used **10X Cross Validation** procedure - divided data into 10 'equal' parts; used 9 parts to train NN and 1 part to validate NN
- Rotated the 1 part in-and-out of training sets so that after 10 training runs, every record appeared in validation set once
- Results presented as average classification accuracies over 10 validation sets

Results of NN Modeling on 1998 Experiment

Overall Classification Accuracies (SD)

Days before pull	
D1	0.81 (0.09)
D2	0.74 (0.14)
D3	0.74 (0.13)
D4	0.74 (0.09)
D5	0.72 (0.14)

* NS diff (P>0.05) among D1-D5

Results of NN Modeling on 1998 Experiment

- NN used 8-9 of the 13 inputs

Input variables	
Most important	**Least important**
min inter-meal interval (sick, longer min interval)	no. of visits
days on test	total feeding duration
min feeding duration (sick, longer min feeding)	

Results of NN Modeling on 2002 Experiment

Overall Classification Accuracies (SD)

Days before pull		
D1	0.75	(0.05)
D2	0.70	(0.10)
D3	0.75	(0.04)
D4	0.75	(0.08)
D5	0.78	(0.10)

* NS diff (P>0.05) among D1-D5

Results of NN Modeling on 2002 Experiment

- NN used 8-10 of the 13 inputs

Input variables	
Most important	**Least important**
min feeding duration (sick, longer min feeding)	max temp
min inter-meal interval (sick, longer min interval)	max interval
days on test	

NN Modeling Extended to 10 d Before Pull

Overall Classification Accuracies (SD)

Days before pull	
D1	0.75 (0.05)
D2	0.70 (0.10)
D3	0.75 (0.04)
D4	0.75 (0.08)
D5	0.78 (0.10)
D6	0.76 (0.05)
D7	0.74 (0.11)
D8	0.73 (0.10)
D9	0.76 (0.09)
D10	0.75 (0.11)

Conclusions from NN Modeling to Predict Morbidity

- Classification accuracies (70-81%) were essentially the 'same' over the ranges of 1-5 d and 1-10 d before pull
- Accuracies over 1-10 d were similar for healthy (0.73) and sick animals (0.77)

'Testing' NN Modeling to Predict Morbidity

- **How can NN looking at feeding patterns pick-out a sick animal 10 d before the pen checker?**
- Modeling 'tested' by making healthy and sick assignments **to each case at random**; result was a classification accuracy of 0.5, as expected

'Testing' NN Modeling to Predict Morbidity

- Modeling 'tested' by running data from the 1998 experiment …..through the best five 2002 NN models
- Despite differences between 1998 and 2002 experiments (heavier animals; different years, weather, feed, pen checker?), the average accuracy was 0.66 (0.02)

Conclusions from NN Modeling to Predict Morbidity

- **How can NN looking at feeding patterns pick-out a sick animal 10 d before the pen checker?**
- It appears NN identify the '**different-eaters**' and these different-eaters get sick most often
- Different-eaters 'consistent' in feeding patterns no matter how many days before pull
- Once a different-eater always a different-eater? Could identify and manage the different-eaters?