Ecology of Disease

Theme: ANIMAL PRODUCTION
- Gradients of infection

Distribution of the Herd

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Gradients of infection

- Each member of a herd is affected by one or more of the epidemiological triad factors differently

- Disease in a group is often manifest as a **spectrum** ranging from in-apparent (subclinical) to clinical to fatal

- Each individual will react differently to infection therefore disease severity will also change over time

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Gradients of infection

Status/spectrum of exposure/infection/disease

Exposure Status	Unexposed	Exposed			
Infection Status		Uninfected	Infected		Recovered
Disease Status			Subclinical (Inapparent)	Clinical Disease (Apparent)	Convalescent
				Morbidity (Sickness)	Morbidity
				Mortality	Cured
				Mild / Severe / Fatal	

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Gradients of infection

Lower in severity spectrum	Higher in severity spectrum
Low infective dose	High infective dose
Middle age	Neonate or Elderly
Low stress	High stress
No other diseases	Other infections, metabolic disorder
High specific immunity (immunocompetent)	Low specific immunity

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Iceberg concept

Clinical Perception   Actual Problem

Clinically Affected   Clinically Affected

Subclinically Affected

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Iceberg concept

- Host-Pathogen-Environment (triad) interaction is not "black and white" nor "all-or-none"
  - Continuum of different degrees of disease severity
  - Outbreak-specific variation in proportion of
    - Affected animals
    - Affected animals that become clinically infected
    - Animals that die
  - Time-specific variation in the same factors
  - Variation in immune status of herd
  - Environment varies - change of season
  - Farmers change management practices

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Cost of subclinical disease

Distribution of the Herd
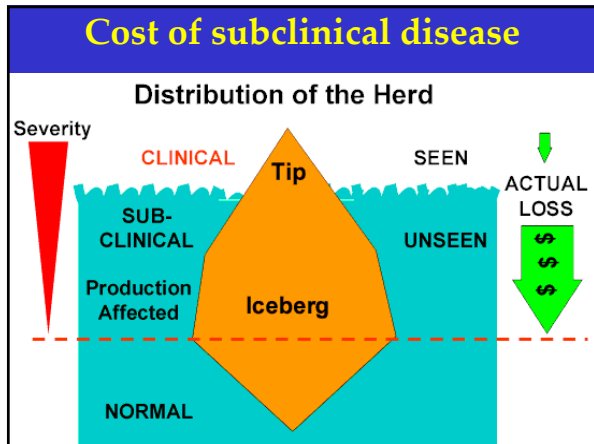
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Exemplars of subclinical infections

- Johne's disease
- bacterium related to tuberculosis and leprosy pathogens
- wasting disease of ruminants

- Bovine respiratory disease
- bacterial disease
- 'shipping fever'
- Endemic Stability (pathogen abundant, but disease rare)

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Johne's disease

- Heinrich Albert Johne (pronounced "YO-nees")
- Johne & Frothingham (1895) first to describe disease
- now known as bovine paratuberculosis.

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Johne's disease

Aetiological agent
- *Mycobacterium avium* subsp. *paratuberculosis* (MAP)
  - related to tuberculosis and leprosy pathogen

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Johne's disease

Infected gut

Uninfected gut

- thickened intestinal mucosa
- malabsorption
- progressive wasting
- contagious
- untreatable!

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Johne's Disease - "Iceberg"

3-6 years of age

Young Calves

All four stages present in infected herd (for each Stage IV, 5-15 in Stages I-III)

Stage IV Final Phase
Stage III 1st Clinical Signs
Stage II "Silent" Carrier
Stage I Initial Infection

Infectious dose ~10^3, young animals more susceptible
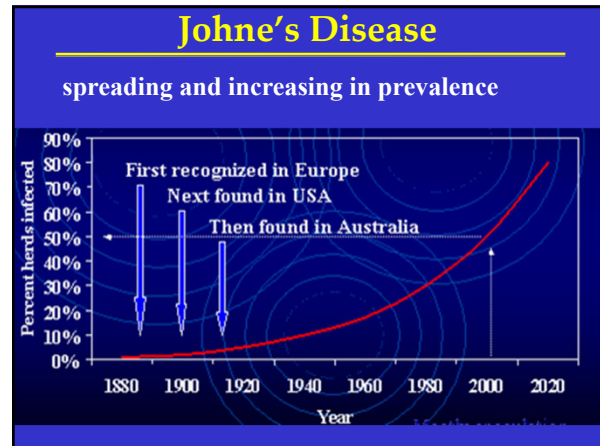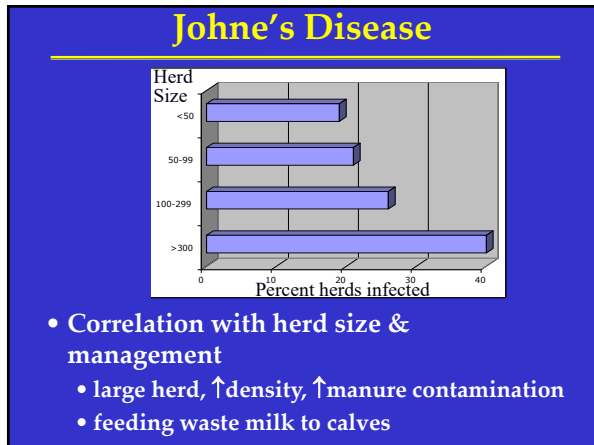
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Johne's Disease

- <u>Stage I</u>: initial infection
  - ingestion of MAP, penetrate mucosa
  - survive phagocytosis
  - animal appears healthy
  - no shedding of MAP

- <u>Stage II</u>: silent carriage
  - MAP reproduce inside macrophages
  - localise in Peyer's patches
  - no clinical signs
  - MAP excreted (10^6-10^8 per gram)

- <u>Stage III</u>: clinical disease
  - immunopathology, extensive lesions
  - weight loss ± diarrhoea

- <u>Stage IV</u>: terminal infection
  - MAP disseminate to internal
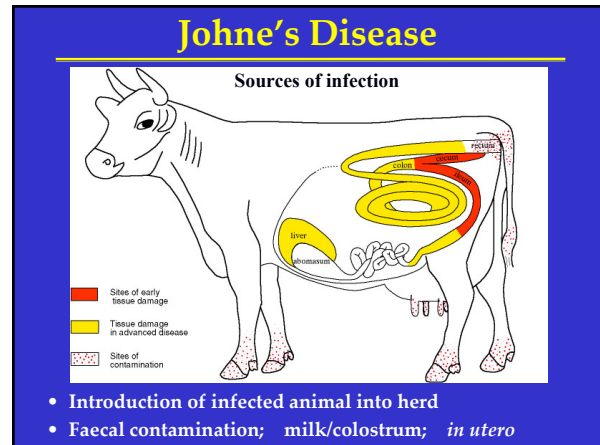
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Johne's Disease

spreading and increasing in prevalence

First recognized in Europe
Next found in USA
Then found in Australia

Percent herds infected — Year

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Johne's Disease

Herd Size — Percent herds infected

(<50, 50-99, 100-299, >300)

- **Correlation with herd size & management**
  - large herd, ↑density, ↑manure contamination
  - feeding waste milk to calves

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Johne's Disease

Sources of infection

- Sites of early tissue damage
- Tissue damage in advanced disease
- Sites of contamination

- **Introduction of infected animal into herd**
- **Faecal contamination;   milk/colostrum;   *in utero***
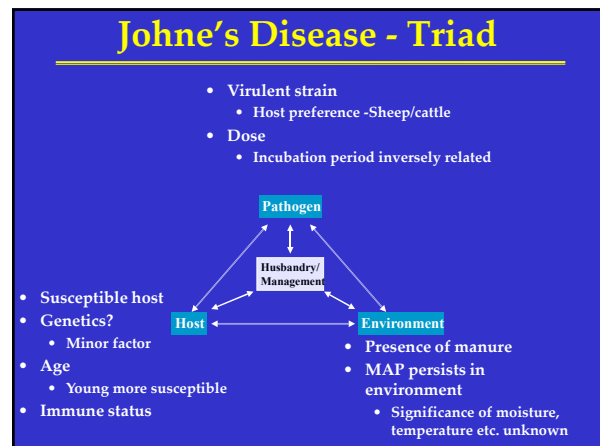
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Johne's Disease

CONTROL
- **"Manure management"**
  - Clean maternity area
  - Remove calves from dams
  - Clean feed/water

- **"Milk management"**
  - "Low risk" colostrum/milk
    - Test for MAP

- **"Infected animals management"**
  - Remove "late stage" animals ASAP
  - Cull test-positives
  - Do not feed their colostrum/milk
  - Cull/segregate offspring

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Johne's Disease - Triad

- **Virulent strain**
  - Host preference -Sheep/cattle
- **Dose**
  - Incubation period inversely related

Pathogen
Husbandry/Management
Host ↔ Environment

- **Susceptible host**
- **Genetics?**
  - Minor factor
- **Age**
  - Young more susceptible
- **Immune status**

- **Presence of manure**
- **MAP persists in environment**
 - Significance of moisture, temperature etc. unknown

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Endemic/Enzootic Stability

- **Revisited!**
- **Dynamic ecological state where disease is rare despite high incidence of pathogen**
- **Situation where all factors influencing disease occurrence are relatively stable**
  - **little fluctuation in disease incidence over time**
  - **BUT, changes in one or more of these factors can lead to an unstable situation in which major disease outbreaks occur**

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Bovine Respiratory Disease (BRD)

- **Aetiological agents**
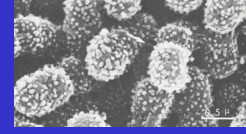
  - **Main pathogen**
    - **Bacterium *Mannheimia haemolytica***
      - **Serotype A1**

  - **Occasionally, other organisms involved**
    - **Viruses**
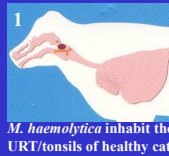   - **Other "less-pathogenic" bacteria**

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Bovine respiratory disease

- **also known as "shipping fever"**
  - **disease of cattle trucked to feedlot**

- **Primary cause of sickness and death in feedlots**
  - **~50% of all deaths**
  - **~70-80% of all morbidity**
  - **subclinical disease a major limitation to production**

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Bovine respiratory disease

1 *M. haemolytica* inhabit the URT/tonsils of healthy cattle

2 *M. haemolytica* move to the LRT when animal is stressed

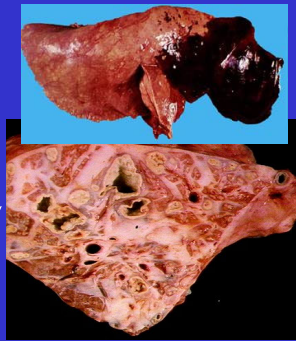**3** Macrophages and neutrophils move to the site of infection

4 *M. haemolytica* releases a toxin that lyses the neutrophils leading to extensive pulmonary necrosis

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Bovine respiratory disease

- **Damage is due to a toxin (leucotoxin) produced by *M. haemolytica* which kills neutrophils leading to neutrophil-mediated tissue injury**

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Bovine respiratory disease

- **Clinical**
  - **sudden onset of fever**
  - **profuse salivation**
  - **severe depression**
  - **hot painful swellings in throat etc.**
  - **dyspnoea - tracheal obstruction**
  - **recumbency**
  - **shock, hypotension**
  - **death in 24 hr**
  - **mortality up to 100%**

- **Subclinical**
  - **decreased weight gain**
    - **60-80g per day**
  - **decreased market value**

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BRD development

Healthy (asymptomatic) calf carrying *M. haemolytica* serotype A1 in nasopharynx

Stress lowers immunity. Nasopharynx and lung susceptible to colonisation

Viral Infection further compromises defences

Healthy calves

Nasopharynx and lung susceptible to colonisation leading to rapid bacterial growth in the nasopharynx

Eliminate infection

Bacteria move into lung in aerosol droplets

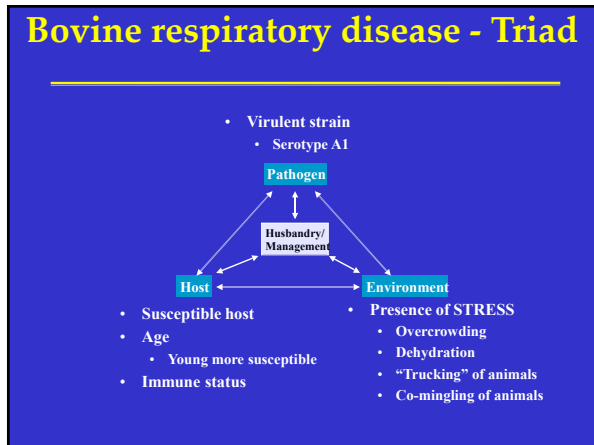Rapid growth of bacteria in lung resulting in pneumonia

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BRD - Gradients of infection

Lower in severity spectrum	Higher in severity spectrum
Direct from Ranch	From sale yards/barn/buyer
Well watered	Dehydrated
Vaccinated before weaning	Not vaccinated
Weaned before shipping	Not weaned before shipping
Low co-mingling	High co-mingling
Short Haul	Long Haul
Good weather	Bad weather
Yearlings	Calves

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Bovine respiratory disease - Triad

- **Virulent strain**
  - **Serotype A1**

Pathogen

Husbandry/ Management

Host — **Environment**

- **Susceptible host**
- **Age**
  - **Young more susceptible**
- **Immune status**

- **Presence of STRESS**
  - **Overcrowding**
  - **Dehydration**
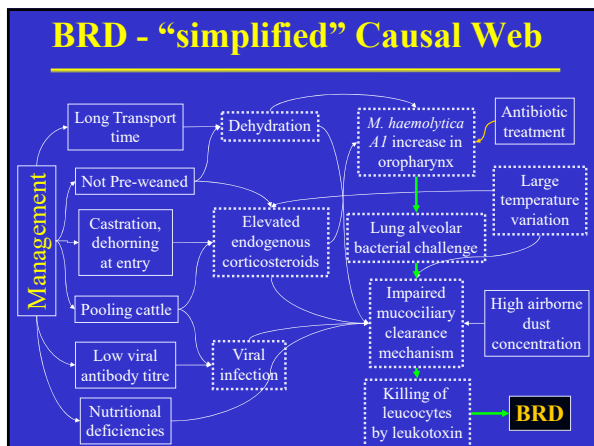 - **"Trucking" of animals**
  - **Co-mingling of animals**

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Causal Webs

- **To induce disease, concurrence of different factors required, none of which is absolutely necessary for disease development**

- **Multivariate inter-relationships (= ecology)**

- **Specific sets of Pathogen + Host + Environment factors associated with disease**

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BRD - "simplified" Causal Web

Management

Long Transport time

Dehydration

M. haemolytica A1 increase in oropharynx

Antibiotic treatment

Not Pre-weaned

Large temperature variation

Castration, dehorning at entry

Elevated endogenous corticosteroids

Lung alveolar bacterial challenge

Pooling cattle

Impaired mucociliary clearance mechanism

High airborne dust concentration

Low viral antibody titre

Viral infection

Nutritional deficiencies

Killing of leucocytes by leukotoxin

BRD

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What's examinable?

- **Gradients of infection**
  - **subclinical – clinical – fatal**

- **Iceberg concept**
  - **many asymptomatic – few clinical**

- **Endemic/Enzootic stability**
  - **pathogen prevalent but disease rare**

- **Causal webs**
  - **concurrence of triad factors**

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