Mastitis in non-bovine dairy species, companion animals and breastfeeding mothers

Chris Knight

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Objectives

• To stimulate thought/discussion regarding the relevance and importance of mastitis and mastitis research in non-bovine farmed species

• To highlight issues related to diagnosis of mastitis in non-dairy farmed species

• To highlight the knowledge gap when comparing bovine and human mastitis

• To do this in a Nordic context
Follow-up on the NordForsk CoLact Human Mastitis Action Point

• **Stage 1:**
  - Chris Knight and Linda Kvist to review the human mastitis literature with a view to proposing a unifying definition suitable for general use

• **Stage 2:**
  - Input from veterinary mastitis specialist(s)

• **Stage 3:**
  - Draft proposal for primary prevention research project
World milk production

Total Milk Production

- 112,114,290
- 62,941,367
- 27,817,850
- 6,743,740
- 25

in tonnes
Year: Latest Available
Source: FAO Statistics Division
Goat milk production

Goat Milk Production

- 4,114,290
- 2,309,786
- 1,020,854
- 247,495
- 20

in tonnes
Year: Latest Available Source: FAO Statistics Division
Perspectives Differ!

**Lactation in Perspective**
- Cow
- Buffalo
- Goat
- Sheep
- Camel
- Human

100%

**Births in Denmark**
- cows
- 16%
- Human
- 84%
Meat production

Meat Production in tonnes

- 80,970,62
- 45,457,19
- 20,090,46
- 4,870,419
- 6

in tonnes
Year: 2011
Source: FAO
## Sheep mortality

<table>
<thead>
<tr>
<th>Cause of death diagnosed at autopsy</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mastitis</strong></td>
<td>11</td>
</tr>
<tr>
<td>Acute fluke</td>
<td>7</td>
</tr>
<tr>
<td>Johnes disease</td>
<td>6</td>
</tr>
<tr>
<td>Ovine pulmonary adenocarcinoma</td>
<td>6</td>
</tr>
<tr>
<td>Bacterial bronchopneumonia</td>
<td>6</td>
</tr>
<tr>
<td>Chronic suppurative pneumonia</td>
<td>6</td>
</tr>
<tr>
<td>Pulmonary neoplasia</td>
<td>6</td>
</tr>
<tr>
<td><strong>Other cause of death (individually minor events)</strong></td>
<td>26</td>
</tr>
<tr>
<td>Autolysis</td>
<td>9</td>
</tr>
<tr>
<td>No diagnosis</td>
<td>17</td>
</tr>
<tr>
<td>No cause of death diagnosis</td>
<td>6</td>
</tr>
</tbody>
</table>

Strugnell and Lovatt (2013)  
*Proc. BSAS* 4(1) 14
Recent reviews:
- Conington et al 2008 (objective: increased genetic resistance)
- Mavrogianni et al 2011 (therapy)

Estimates of prevalence in both dairy and meat sheep vary, but values in excess of 33% are reported.

In addition to S. aureus, Mannheimia haemolytica is a common isolate.

Modelling suggests that a 10% reduction in incidence would save £2.7M pa in the UK Texel industry.
Recent review focused on diagnostic tools: Koop et al 2012

Typically lower incidence of clinical mastitis than in cattle, but higher subclinical

Why?

Interpretation of SCC data is different to that in cattle
Changes in SCC during lactation
Buffalo mastitis


- Compared improved and periurban production
- Actually focused on bovine mastitis
- Cited evidence of lower subclinical mastitis incidence in buffalo compared to cattle (5-20% vs 10-50%)
- Clinical mastitis claimed to be between 1 and 10%
- Significant effect of season claimed but not supported by data (15.05 vs 13.97% and 8.89 vs 7.04%, rainy vs summer, cows vs buffalo)

- Very few truly comparative data, most rather old
“At Dubai dairy, camels are the new cows”

International Herald Tribune, Wed 25th August 2010

Problem: salty taste

Solution: feed carrots and dates to the 700 camels

Benefit: 3X more Vit C, low lactose

“Camelicious”
• Several recent reports
• Typically 30-40% subclinical mastitis
• Typically 5-10% clinical mastitis
• SCC appears to be useful
• High incidence of blind quarters
• Traditional management probably predisposes to mastitis
• Pathogen profiles probably similar to cattle
Equine mastitis

- Very few reports since a number of short reviews in the 1980s

- A recent review of milking horse herds in Netherlands/Flandres identified 13 such farms
Canine mastitis

• Few scientific reports, mainly case studies

• Issues:
  - “Dairy farm reservoir” (eg *Streptococcus canis*)
  - Pseudopregnancy
  - Perinatal mortality
  - Chronic subclinical mastitis and carcinomas

• One experimental challenge study used *Staphylococcus intermedius* (Ververidis et al 2007)

• Therapy has been reviewed (Wiebe and Howard 2009)

• Feline mastitis is less well documented
Porcine mastitis

- Gerjets et al 2009, 2011

- Mastitis-metritis-agalactia syndrome, postpartum dysgalactia syndrome, puerperal mastitis, coliform mastitis

- Typically around 13% of sows affected, range up to 60% in some herds

- Associated with E coli but cause and effect not established, and recent research shows no difference in infection rate or virulence factors between healthy and diseased sows

- Risk factors include increased fecundity, being a gilt, bith intervention. Birth induction and season are not risk factors
## Risk analysis overview

<table>
<thead>
<tr>
<th>Category of animal</th>
<th>Incidence</th>
<th>Diagnosis</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family herds</td>
<td>Known, amenable to management improvement</td>
<td>Well developed</td>
<td>Well developed</td>
</tr>
<tr>
<td>AMS herds</td>
<td></td>
<td>Developed</td>
<td>In development</td>
</tr>
<tr>
<td>Large herds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other milked ruminants</td>
<td>Some information, management intervention possible</td>
<td>Less well developed</td>
<td>Less well developed</td>
</tr>
<tr>
<td>Non-milked ruminants</td>
<td>Very scarce information. Often wrongly(?) assumed to be low incidence</td>
<td>Poorly developed</td>
<td>Little opportunity</td>
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<tr>
<td>Companion animals</td>
<td>Scarce information. Most do not lactate, so incidence probably low</td>
<td>Reliance on lay knowledge</td>
<td>Little opportunity</td>
</tr>
<tr>
<td>Breastfeeding mothers</td>
<td>Some information, quite variable. Probably similar incidence to well managed dairy cow herd</td>
<td>Variable, self diagnosis and healthcare worker rates differ</td>
<td>Variable, major debate regarding effectiveness of antibiotics but little data</td>
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Potential for use of high-dose oxytocin to improve diagnosis of mastitis in dairy cows and beef suckler cows

Lina Jonsson, Christopher Knight and Kerstin Svennersten-Sjaunja

Swedish University of Agricultural Sciences and University of Copenhagen

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Our objective was to investigate a possible physiological basis for the development of a single-visit milk-based mastitis diagnostic test suitable for use in beef suckler cows.

We hypothesised that high-dose oxytocin would create leaky mammary tight junctions, increased SCC and shedding of pathogen into milk, and thereby provide a milk sample with enhanced diagnostic potential.
Introduction

The problem

Subclinical Mastitis
- Diagnosed as SCC > 200K cells/ml in milk from several milk samples

Beef suckler cows
- Assumed to have a low frequency of subclinical mastitis
  - Recent studies shows that this is not the case.

Material and methods

• 14 Dairy cows.
• 10 cows with a previous history of high SCC (HIGH).
• 4 cows SCC < 50 000 cells/ml milk (LOW).
• Milked twice a day over an 11 day study period.
• Milk samples were collected as shown in the next slide.
• At the AM milking on day 3, 100iu of oxytocin was given.
• The sample taken that afternoon, approx. 8 h after the oxytocin was given, was designated the test sample.
• Samples were analysed for mastitis pathogens, SCC and gross composition using standard methodologies.
Experimental design

Experimental Milking

Fore

Bulk

Hind

SCC, Bacteriology

SCC, Composition

Bacteriology

Day number

1 2 3 4 5 6 7 8 9 10 11 12

Sample number

Oxytocin

“Test” sample

Experimental Day
Results

• No evidence of increased pathogens in sample 5 or 6.

• SCC increased markedly in sample 6 and recovered to pre-oxytocin levels thereafter.
Results

SCC (Individual HIGH cow)
Results

SCC (Individual LOW cow)
Results

("Hard to categorize" cow)
### Results

<table>
<thead>
<tr>
<th></th>
<th>Samples 1-5 (Milk)</th>
<th>Test sample (Modified milk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosed subclinical mastitis (quarters)</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Missclassified at least once (quarters)</td>
<td>6 (40%)</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Clinical signs (samples)</td>
<td>72</td>
<td>14</td>
</tr>
<tr>
<td>Missed by SCC (samples)</td>
<td>25 (35%)</td>
<td>1 (7%)</td>
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Conclusions

• Measurement of SCC in the single sample collected approximately 8h after oxytocin administration was shown to have much better diagnostic potential than other single samples.

• High-dose oxytocin could be a useful mastitis diagnostic tool in beef suckler cows, and in dairy cows where frequent sampling is not possible.
Evolving dairy farms

From The Sunday Times
February 28, 2010

‘Battery’ dairy of 8,000 cows sparks protests

1. Rotary platform – internal or external milking
2. Milk cooling and storage tank
3. System cleaning unit
4. Vacuum supply system
5. Milking station
6. GCC – buffer pond/drainage cooling unit
7. Milk storage tank
8. Milk divert unit
9. Vacuum supply system
Think out of the box?
No, think things into the box!

Frequent, regular, reproducible, manipulatable, controllable, time on its hands
Stress related biomarkers

- Cortisol
- Inflammatory cytokines
- Blood
- Saliva
- Milk (and modified milk)
- Sweat
- Hair

Systemic
- Minutes
- Weeks

Local?
DairyCare

- Proposed COST Action in dairy animal health and welfare
- Involving 20 EU countries, 5 non-EU
- "Economic dimension" of 22M euro
- WG1: Biomarker-based welfare technologies
- WG2: Activity-based welfare technologies
- WG3: System-level welfare technologies
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Human Mastitis

- Mastitis
- Mammitis
- Mastadenitis
- Milk fever
Definition required

Mastitis

Causes
- Pathogens
- Blocked ducts
- Cracked nipples
- Physiological mastitis

Management
- Antibiotic: (Systemic) (Local) (Prophylactic)
- Oxytocin
- Liniment
- Analgesia

Diagnosis
- Incidence
- Self-diagnosis
- Health worker
- Researcher
- Clinical vs Subclinical
- Acute phase response
- Analysis of milk

Consequences
- Mother: Pain, Anxiety, Breast cancer?
- Baby: Nutrition, Protection, Disease vector

Order of magnitude variation
3% to 30%

3rd NBC Meeting Copenhagen 2009

Suckling Breast pump

Order of magnitude variation
3% to 30%
Mastitis is inflammation of the breast

Mastitis can be assumed to be present if the subject reports or has a red, tender, hot or swollen area of the breast, together with one or more of the following:

- a high temperature
- symptoms of fever (body aches, headaches, chills)
- a diagnosis of mastitis from a medical practitioner

Terminology to avoid or restrict to specific use

- **Lactational mastitis**
  - avoid, use non-lactational when needed
- **Puerperal mastitis**
  - strict definition needed if it is to be useful (<5d?)
- **Contagious mastitis, environmental mastitis**
  - not useful outside bovine mastitis
- **Suppurative mastitis**
  - should be rendered redundant
- **Infective mastitis, infectious mastitis**
  - avoid (infective is generalized risk, infectious is specific risk)
- **Pathogenic mastitis**
  - suggested use for when a known mastitis pathogen has been identified
  - alternative would be to adopt the diagnostic term “intramammary infection”
- **Physiological inflammation (of the mammary gland)**
  - use to describe the local inflammatory response to prolonged milk accumulation
Mastitis is inflammation of the breast

You have mastitis if you have a red, tender, hot or swollen area of the breast, together with either a high temperature or symptoms of fever (body aches, headaches, chills)

If you have mastitis your milk is still safe for your baby. You should continue to breastfeed from both breasts and seek immediate medical advice and treatment?
Consequences

Diagnosis

Causes

Pathogens
- Blocked ducts
- Cracked nipples
- Physiological mastitis

Incidence

Treatment: Antibiotic or not?

Prevention: How?

Definition required

Management

Mastitis

Mother:
- Pain
- Anxiety
- Breast cancer?

Baby:
- Nutrition
- Protection
- Disease vector

Self-diagnosis
- Health worker
- Researcher
- Clinical vs Subclinical
- Acute phase response
- Analysis of milk

Suckling
- Breast pump

Antibiotic:
- (Systemic)
- (Local)
- (Prophylactic)

Oxytocin Liniment Analgesia
Antibiotic treatment

A/B use for human mastitis:
- Finland: 38%
- Australia: 75%
- USA: 86%
- Sweden: 15% (mostly following bacteriology)

Cochrane review: 2009, updated in 2013
Antibiotic use: Cochrane review

References to studies included in this review

**Hager 1996  [published data only]**

**Thomsen 1984  [published data only]**

**Abstract**

**Background**

Mastitis can be caused by ineffective positioning of the baby at the breast or restricted feeding. Infective mastitis is commonly caused by *Staphylococcus aureus*. Incidence of mastitis in breastfeeding women may reach 33%. Effective milk removal, pain medication and antibiotic therapy have been the mainstays of treatment.

**Authors’ conclusions**

There is insufficient evidence to confirm or refute the effectiveness of antibiotic therapy for the treatment of lactational mastitis. There is an urgent need to conduct high-quality, double-blinded RCTs to determine whether antibiotics should be used in this common postpartum condition.
Table 2 The most important predisposing factor for the development of mastitis as reported by the respondents (n = 86)

<table>
<thead>
<tr>
<th>Factor</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete emptying of the breast/irregular emptying/inefficient breastfeeding</td>
<td>47 (55)</td>
</tr>
<tr>
<td>Attachment problems/wrong position/wrong technique</td>
<td>12 (14)</td>
</tr>
<tr>
<td>Cracked nipples</td>
<td>10 (12)</td>
</tr>
<tr>
<td>Plugged ducts/blocked milk</td>
<td>5 (6)</td>
</tr>
<tr>
<td>Over-production of milk</td>
<td>4 (5)</td>
</tr>
<tr>
<td>Being cold</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Lack of help/maternal stress</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Bacteria</td>
<td>2 (2)</td>
</tr>
</tbody>
</table>

Four respondents did not suggest a predisposing factor.
Antibiotic therapy

Adequate antibiotic therapy is essential. Where possible this should be guided by microbiological culture and sensitivity (such as when fluid is aspirated from an abscess). As *S. aureus* is the common causative organism, antibiotic therapy of choice at least 5 days of flucloxacillin or dicloxacillin in a dose of 500 mg four times per day. Due to antibiotic packaging in Australia this may require two consecutive 6 day courses of antibiotics. For patients allergic to penicillin,
Management of mastitis: Cochrane review

- Crepinsek et al 2012

- Five trials in total, 960 women
- A/B vs none: no significant difference (NSD)
- Specialist advice vs usual care: NSD
- Specialist diet vs normal diet: NSD
- Other therapies vs none: NSD
Scott et al 2008

- Prospective longitudinal study of 420 breastfeeding mothers in Glasgow
- Cases self-diagnosed or detected at subsequent telephone interview
- 74 women (18%) experienced at least one episode of mastitis, repeated incidence occurring in almost one-third
- More than half of new cases occurred in first four weeks of lactation
- Lactation duration was not decreased
- Of 57 mothers who received advice, 6 were inappropriately advised
- Of 30 mothers who received antibiotic, 10 were inappropriately prescribed
- Retrospective bacteriological analysis did not yield useful research conclusions
Mastitis

**Causes**
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- Self-diagnosis
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**Management**
- Suckling
- Breast pump
- Antibiotic: (Systemic) (Local) (Prophylactic)
- Oxytocin
- Liniment
- Analgesia

**Incidence**
- Breast cancer?
Chicken and egg?

Do blocked ducts cause mastitis?

Why treat with antibiotic?

Or does mastitis cause blocked ducts?

Why NOT treat with antibiotic?
Potential animal models

- Similar mammary anatomy
- Allows for intra-lobular pathogen challenge
- Allows for sealing individual ducts
- Discrete suckling episodes of very different frequencies
- Supplementary questions:
  - Is infection transmitted from lobule to lobule?
  - In this regard, is nipple hygiene particularly important when blocked ducts need to be cleared?
  - When does physiological inflammation start (cross-species)?
Follow-up on the CoLact Human Mastitis Action Point

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- **Stage 2:**
  - Input from veterinary mastitis specialist(s)

- **Stage 3:**
  - Draft proposal for primary prevention research project
Where to start?

- Post-feed routine
- Weaning strategy
- Early lactation strategy
- Hit recurrent mastitis hard