Mastitis in sows – current knowledge and opinions

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OUTLINE

⇒ introduction
  ⇒ synonyms *et cetera*
  ⇒ clinical and economic importance

⇒ „geMMA“-project
  ⇒ material and methods
  ⇒ results and discussion

⇒ summary
INTRODUCTION

⇒ physiological conditions in lactation

- tubulo-alveolar gland with secretory lobules

- 2 teat channels
- 2 glandular systems

- 24-26 milk ejections/day
- 10-20 seconds of milk ejection
- < 10 minutes/day milk available
INTRODUCTION

⇒ milk yield

⇒ today: larger litter sizes
⇒ increase in milk yield per day


1990ies ~ 10 kg (Sauber et al. 1996, King&Eason 1998)
relatively higher increase in piglets ~9 ⇔ ~12-14

⇒ milk amount per piglet decreases

healthy sows with sufficient milk production
Introduction

- Mastitis in sows
- Major problem in postparturient sows
- 12-48 h post partum
- Since 1960 described worldwide
SYNONYMS

- Agalactia toxemica, A. complex, A. post partum
  (Ringarp 1960, Penny 1970, Hermansson et al. 1978)
- Coliform Mastitis (CM)
  (Bertschinger & Pohlenz 1980)
- Farrowing Fever
  (Halgaard et al. 1983)
- Lactation Failure (LF)
  (Elmore & Martin 1986)
- Mastitis-Metritis-Agalactia (MMA)
  (Tharp & Amstutz 1958, Smith 1965)
- Periparturient Hypogalactia Syndrome (PHS)
  (Smith 1992)
- Postpartum Dysgalactia Syndrome (PDS)
  (Klopfenstein 1999)
- Puerperal Septicaemia and Toxaemia
  (Bostedt et al. 1998, Heinritzi & Hagn 1999)
**SYNONYMS**

<table>
<thead>
<tr>
<th>Synonyms under discussion for mastitis in sows:</th>
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</thead>
<tbody>
<tr>
<td><strong>Coliform Mastitis (CM)</strong></td>
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<td>Farrowing Fever</td>
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**Lactation failure (Dysgalactia, Hypogalactia, Agalactia) >> Mastitis >> Metritis**
Obstipation
Endometritis
Cystitis
Mastitis

- fever (T > 39.5°C)
- loss of appetite

Endotoxins

Obstipation
Endometritis
Cystitis
Mastitis

Prolactin

- milk yield ↓
- dysgalactia
Obstipation
Endometritis
Cystitis

Endotoxins

→ fever (T > 39.5°C)
→ loss of appetite

Prolactin ↓

Mastitis
(Bertschinger et al.)

„coliform mastitis“
clinical changes

sow
- reduced milk production (dysgalactia, hypogalactia, agalactia)
- modified milk composition
- disturbed general condition
- fever
- ventral position

piglets
- intake of colostrum ↓
- lower weight gain
- starving, restlessness, lethargy
- intake of other fluids
- secondary infections
**D I A G N O S I S**

<table>
<thead>
<tr>
<th>Mastitis</th>
<th>Clinical Signs</th>
<th>Bacteriological Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Clinical mastitis</td>
<td>Yes</td>
<td>Subclinical mastitis</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>or latent infection</td>
</tr>
<tr>
<td>Unspecific mastitis</td>
<td>-</td>
<td>Healthy</td>
</tr>
</tbody>
</table>

**Differences between clinical and subclinical mastitis**

Simple classification concerning clinical signs and bacteriological results:
**When is a sow positive for mastitis?**

### Diagnostic pattern for sows mammary glands

(Wendt, Bostedt et al. 1994)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Clinical Signs</th>
<th>pH-Value</th>
<th>Cells (Mio/ml)</th>
<th>Bacteriological Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy Lactating</td>
<td>No</td>
<td>&lt; 6,8</td>
<td>&lt; 2,5</td>
<td>Negative</td>
</tr>
<tr>
<td>Healthy Atrophic</td>
<td>No</td>
<td>&gt; 7,0</td>
<td>&gt; 6,5</td>
<td>Negative</td>
</tr>
<tr>
<td>Bacterial Colonisation</td>
<td>No</td>
<td>&lt; 6,8</td>
<td>&lt; 2,5</td>
<td>Positive</td>
</tr>
<tr>
<td>Latent Infection</td>
<td>No</td>
<td>&gt; 7,0</td>
<td>&gt; 6,5</td>
<td>Positive</td>
</tr>
<tr>
<td>Subclinical Mastitis</td>
<td>No</td>
<td>&gt; 7,0</td>
<td>&gt; 10,0</td>
<td>Neg/Pos</td>
</tr>
<tr>
<td>Clinical Mastitis</td>
<td>Yes</td>
<td>&gt; 7,0</td>
<td>&gt; 10,0</td>
<td>Pos/Neg</td>
</tr>
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Wegmann, 1985: >5 Mio cells/ml and >70% neutrophils
alternative subclinical changes

somatic cell count
>5x10^6 cells/ml (Bertschinger & Bühlmann 1990)
>10x10^6 cells/ml (Persson et al. 1996)

pH-value milk
>6.7 (Waldmann & Wendt 2001)

milk compositions
Lactose, Protein, Na^+

acute phase proteins
Haptoglobin, α1-acid-glycoprotein

cytokines
IL-1β, IL-6, IL-8, TNFα

in praxi difficult to establish!

(Gooneratne et al. 1982; Zhu et al. 2007; Mirko & Bilkei 2004)
milking a sow

- only directly post partum without Oxytocin injection
- 2 - 3 days p.p. 20 I.U. i.m.
- later on 40-60 I.U. i.m.
- milk ejection 5 - 10 minutes after injection for 10 minutes
- 3 - 4 ml

in praxi difficult to establish!
**DIAGNOSIS**

طيع التدفق على مستوى الجرثوم:

- التحكم اليومي في درجة الحرارة في الثلاثة أيام الأولى بعد البلع.

  + التغييرات السريرية على الأنف والأنف (الالتباس، الهضبة، تверد).

  + تغيرات في السلوك العلوي في السوينات والأنبياء.
## Diagnosis

<table>
<thead>
<tr>
<th>Sow</th>
<th>Piglets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased performance</td>
<td>Increased death rate</td>
</tr>
<tr>
<td>Conception failure</td>
<td>Runt piglets</td>
</tr>
<tr>
<td>Reduced litter size</td>
<td>Crushed piglets</td>
</tr>
<tr>
<td>Abortions</td>
<td>Intake of colostrum ↓</td>
</tr>
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<td>Reduced milk yield and milk quality ↓</td>
<td>Lower weight gain</td>
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### Prevalence

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<th>Prevalence Range</th>
<th>Location/Reference</th>
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<td>3.7%</td>
<td>Sweden (Ringarp 1960)</td>
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<td>5.5-10.3%</td>
<td>Sweden (Bäckström 1973)</td>
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<tr>
<td>13.1% (-19.8%)</td>
<td>Missouri, USA (Threlfall &amp; Martin 1973)</td>
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<td>6.9% (1.1-37.2%)</td>
<td>Illinois, USA (Bäckström et al. 1984)</td>
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<td>16.5-18.5%</td>
<td>Norway (Lingaas &amp; Ronningen 1991)</td>
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<td>25%</td>
<td>Denmark (Berg et al. 2001)</td>
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<tr>
<td>38.4%</td>
<td>Germany (Krieter &amp; Presuhn 2009)</td>
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<tr>
<td>6.5% (1-15%)</td>
<td>Belgium (Papadopoulos et al. 2010)</td>
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▷ 'problem herds' with prevalences up to 80-100%

(Glock 1983, Martin et al. 1974, Waldmann & Wendt 2004)
### Prevalence in Literature (1960-2010)

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Prevalence ↓ due to improvement of husbandry, feeding … and prophylactic treatment
Influenoing Factors

- Husbandry
- Pen climate
- Pathogens
- Immune defense
- Mycotoxins
- Genetics
- Milk withdrawal
- Birth assistance
- Partus induction
- Hormone level
- Water intake
- Food intake

mastitis $\uparrow$:

- Immune defense $\downarrow$
- Infection pressure $\uparrow$
- Birth duration $\uparrow$
INFLUENCING FACTORS

Pathogens

- *Escherichia coli*
- *Strep. dysgalactiae*
- *Staph. aureus*

Environmental factors

- Husbandry
- Hygiene
- Feeding

Sow factors

- Parity number
- Partus condition
- Genetic variation
TREATMENT

pathogens
⇒ prebiotics
⇒ antibiotics

environmental factors
⇒ husbandry
⇒ hygiene
⇒ feeding

sow factors
⇒ NSAIDs
⇒ oxytocin
Future aspects

- medicamental treatment is not a long-term solution

Methods of choice

- 1st approach: improve farm management (hygiene, feeding, husbandry)
- 2nd approach: breeding and genetic improvement
- 3rd approach: medicamental treatment
FUGATOplus: “geMMA – structural and functional analysis of the genetic variation of the MMA-syndrome”

2007-2011

Nicole Kemper, Jens Wolfmüller
Imke Gerjets, Regine Preißler

2011-...

Danilo Bardehle, Regine Preißler,
Nicole Kemper, Jörg Lehmann

CAU Kiel

MLU Halle-Wittenberg
• structural and functional analysis of the genetic variation of the MMA-syndrome geMMA

phenotype
- bacteriological analysis
- *Escherichia coli*

genotype
- genome-wide association
- candidate genes

phenotypic variation

genetic variation
geMMA

- pathogens
- environment

- host
  - parity number
  - partus induction (y/n)
  - birth assistance (y/n)
  - genetic variation
MATERIAL AND METHODS

- family based Case-Control-Design

12-48 h post partum
fever: Temp > 39.5°C

+ clinical investigation
mammary glands
piglets

affected sow

unaffected half- or fullsibs

n = 1.028
n = 973
Material and Methods

- bacteriological analysis of milk samples (Gerjets et al., 2011)
- genotyping using the PorcineSNP60 BeadChip from Illumina
- statistical analysis (R, GenABEL, Plink, Haplovie, …)
**RESULTS**

Absolute frequency of PDS-affected and PDS-unaffected sows in relation to rectal temperature

- **16.6%** of affected sows had rectal temperatures (T) < 39.5°C
- **28.8%** of affected sows had T > 40.0°C
RESULTS

Gerjets et al., 2011

no significant differences in bacteria spectrum
## RESULTS

Gerjets et al., 2011

<table>
<thead>
<tr>
<th></th>
<th>PDS=1 (n=1024)</th>
<th>PDS=0 (n=970)</th>
<th>Total 1994 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>no „pathogen“*</td>
<td>188</td>
<td>147</td>
<td>335 (16.8%)</td>
</tr>
<tr>
<td>all „pathogenes“*</td>
<td>6</td>
<td>5</td>
<td>11 (0.5%)</td>
</tr>
<tr>
<td>only STREP¹</td>
<td>25</td>
<td>16</td>
<td>41 (2.1%)</td>
</tr>
<tr>
<td>STREP + SA²</td>
<td>6</td>
<td>1</td>
<td>7 (0.3%)</td>
</tr>
<tr>
<td>only COLIFORM³</td>
<td>619</td>
<td>597</td>
<td>1.216 (61.0%)</td>
</tr>
<tr>
<td>only SA</td>
<td>25</td>
<td>16</td>
<td>41 (2.1%)</td>
</tr>
<tr>
<td>STREP + COLIFORM</td>
<td>134</td>
<td>174</td>
<td>308 (15.4%)</td>
</tr>
<tr>
<td>COLIFORM + SA</td>
<td>21</td>
<td>14</td>
<td>35 (1.8%)</td>
</tr>
<tr>
<td></td>
<td><strong>1024</strong></td>
<td><strong>970</strong></td>
<td><strong>1994 (100%)</strong></td>
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* „pathogen“ .. STREP+COLIFORM+SA
1 STREP: *Streptococcus dysgalactiae* and/or *Streptococcus agalactiae*,
2 SA: *Staphylococcus aureus*,
3 COLIFORM: all Coliforms (especially *Escherichia coli*)
RESULTS

Gerjets et al., 2011

prevalence of *Escherichia coli* virulence factors
RESULTS

Prevalence of virulence-associated genes in *E. coli*-isolates of healthy and diseased sows

Gerjets *et al.*, 2011

no specific 'CM-strain', if conditions are unfavorable, any strain could cause CM

(Gerjets, Traulsen, Reiners & Kemper 2011, Veterinary Microbiology)
RESULTS

„The characteristic microbe of a disease might be a symptom instead of a cause.“

(G.B. Shaw in „The Doctor’s Dilemma“, cited by Ringarp 1960)


⇒ heritability estimates:

- $h^2 = 0.1-0.2$ (Lingaas et al. 1991)
- $h^2 = 0.02-0.06$ (Berg et al. 2001)
- $h^2 = 0.13$ (Krieter & Presuhn 2009)
- $h^2 = 0.09$ (geMMA)
RESULTS

Landrace (L)
Large White (LW)
L_Duroc (L_D)
LW_Duroc (LW_D)
RESULTS

17 principal components + birth assistance
RESULTS

SSC17:

MAF=0.39, OR=0.62 (1.61)

OXT, GNRH2

haptoglobin QTL,

IFN-γ/IL-10 ratio QTL
RESULTS

SSC15:
MAF=0.08, OR=0.35 (2.86)
unsure annotation!
NRP2
body temperature QTL, ...

-log_{10}(p)

chromosomes
RESULTS

SSC13:
- MAF=0.23, OR=0.55 (1.82)
- PRICKLE2
  - age at puberty QTL,
  - ovulation rate QTL,
  - nonfunctional nipples QTL
association with several QTLs (body temperature QTL, age at puberty QTL, ovulation rate QTL, nonfunctional nipples QTL, haptoglobin QTL, IFN-γ/IL-10 ratio QTL)

multiple genes involved (e.g. SSC13, SSC15, SSC17)

different pathomechanisms:

- neurohormonal processes and networks

- immune system interactions (Haptoglobin, IFN-γ/IL-10 ratio)

replication and confirmation study in process
possible reasons for positive bacteriological results in clinical unaffected sows

- only bacterial colonisation
- emerging subclinical mastitis in sows
- contamination via teat canal (two to three milk cisterns)
- resistance due to genetic variation
- resistance due to unknown factors

requires further clinical and experimental studies...
sow
- dysgalactia
- mastitis
- fever (>39.5°C)

piglets
- intake colostrum ↓
  ↓ apathia, diarrhea, death

antibiotics and antiphlogistics

milk substitute

prevalence ↓

subclinical cases ↑
SUMMARY

- husbandry
- food intake
- pen climate
- pathogens
- immune defense
- mycotoxins
- genetics
- milk withdrawal
- birth assistance
- partus induction
- hormone level
- water intake

multifactorial disease
SUMMARY

→ main results from geMMA up to now

→ no significant differences in pathogen spectrum

→ >60% only coliform mastitis, >18% mastitis without pathogen described in literature,
  >13% Strep-coliform mastitis, 2,5% Staph. aureus mastitis, 2,1% Staph. aureus-coliform

→ significant correlation between birth assistance and CM

→ genomewide moderate significant genetic variations

→ moderate genetic risks (OR) ranging from 0,3 to 2,2

→ heritability 9%

replication and confirmation study is under planning
SUMMARY

- New insights - special recommendations

- diagnosis: 12-48 h p.p. >39.5°C + clinical examination
- careful recording and documentation on herd level
- immediate, adequate and specific treatment
- hygiene - hygiene - hygiene
- special emphasis on healthy piglets (‘restaurant-hypothesis‘)

- holistic approach with long-term measures → plan ahead (feeding, housing, breeding…)


Mastitis in sows – current knowledge and opinions

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Thanks for your attention!

Special thanks to all colleagues and collaborating affiliations.