Monitoring endemic diseases in pig herds

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Outline presentation

- Introduction
- Respiratory disease
- Enteric diseases
- Other diseases
- Discussion and conclusions
Animal health

• Different from realizing genetic potential of animals
• We do not measure health, but:
  - (absence of) disease
  - level of management and biosecurity
• Different levels: animal, group, herd, region, country, ...
• Distinction: « infection » ↔ « disease »
Why so many infectious diseases? → numerous transmission routes!!

• **Direct pig contact**, incl. sow-piglet
• **Indirect**: personnel and visitors, contaminated objects, rodents, insects, feral pigs, ..
• Other: feed, water, via needles, etc.
• Semen (AI)
• Airborne!
Transmission routes infectious diseases

**Pig-to-pig transmission**

- Most important for most diseases
- Within and between herds
- Subclinical infections, carrier animals, long viremia

\[ N : \text{number of pigs} \rightarrow \text{risk increase on transmission of pathogens} = N^2 - N \]

15 pigs \(\rightarrow\) 210; 50 pigs \(\rightarrow\) 2450
Transmission routes infectious diseases

Pig-to-pig transmission

- from sow to piglet ("vertical transmission")
- "Early" vs. "late" colonizing pathogens
Transmission routes infectious diseases

- **Contaminated people:**
  Examples: CSF, FMD, *E. coli*, TGE, PRRSV  
  Mainly by persons having direct contact with pigs

- **Rodents:**
  Examples: swine dysentery, leptospiroisis, *Salmonella*
## Transmission pig diseases by insects

### Examples

<table>
<thead>
<tr>
<th>Diseases and Organisms</th>
</tr>
</thead>
</table>

- Biological or mechanical vectors
- *Musca domestica* → 1.5 km
- Mostly based on experimental data
Transmission pig diseases

- Birds
- Iatrogenic transmission → injections
- Vehicles → CSF, PRRSV
- Feed, water
- Other: *e.g.* feral pigs
### Important viruses in pig semen
(Maes et al., Theriogenology, 2008)

<table>
<thead>
<tr>
<th>Organism</th>
<th>Timing of detection (test used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical swine fever virus</td>
<td>7-63 DPI (RT-PCR); 11-53 DPI (virus isolation)</td>
</tr>
<tr>
<td>FMD virus</td>
<td>Up to 9 days post exposure (virus isolation)</td>
</tr>
<tr>
<td>Japanese encephalitis virus</td>
<td>35 DPI</td>
</tr>
<tr>
<td>Porcine circovirus</td>
<td>Intermittently between 5-47 days DPI (nPCR)</td>
</tr>
<tr>
<td>Porcine enterovirus</td>
<td>45 DPI (virus isolation)</td>
</tr>
<tr>
<td>Porcine parvovirus</td>
<td>Detected (virus isolation)</td>
</tr>
<tr>
<td>PRRS virus</td>
<td>Up to 92 DPI (nested RT-PCR)</td>
</tr>
<tr>
<td></td>
<td>Up to 43 DPI (swine bioassay)</td>
</tr>
<tr>
<td>Pseudorabies virus</td>
<td>10 DPI (virus isolation)</td>
</tr>
<tr>
<td>Rubula virus</td>
<td>2 to 49 DPI (virus isolation)</td>
</tr>
<tr>
<td>Swine vesicular disease virus</td>
<td>Up to 4 DPI (virus isolation)</td>
</tr>
</tbody>
</table>
Airborne transmission

PRRS virus and Mycoplasma: > 9 km (Otake et al., 2010)
Other pathogens *e.g.* swine flu → neighborhood infections (Madec et al. 1982)
Pig production in the EU

High density populated areas (e.g. >3000 pigs / km²)
Outline presentation

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# Respiratory pathogens in pigs

<table>
<thead>
<tr>
<th>PRIMARY</th>
<th>SECONDARY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viruses</strong></td>
<td><strong>Bacteria</strong></td>
</tr>
<tr>
<td>Influenzavirus (H1N1, H3N2, H1N2) PRRSV, PRCV, PCV2, ...</td>
<td><em>M. hyopneumoniae</em> <em>A. pleuropneumoniae</em> <em>H. parasuis</em> <em>B. bronchiseptica</em></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Importance of each pathogen very variable ~ continent, country, herd, time within herd, health status (conventional vs. high health)
% of slaughter pigs with lung lesions
(Meyns et al 2011; Fraile et al 2010; Merialdi et al. 2012)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Belgium</th>
<th>Spain</th>
<th>Italy</th>
<th>Major pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>% pleuritis</td>
<td>21</td>
<td>14</td>
<td>26</td>
<td>A. pleuropneumoniae, H. parasuis, P. multocida, M. hyorhinis, S. suis, ..</td>
</tr>
<tr>
<td>% pneumonia</td>
<td>25</td>
<td>56</td>
<td>46</td>
<td>M. hyopneumoniae, viral pathogens,..</td>
</tr>
</tbody>
</table>

→ similar prevalences as 20-30 years ago!
- 1978: Backström and Bremer 27%
- 1990: Christensen and Culinane 45%
- 1991: Charrier 30%
- 1993: Paisley et al 63%
% of herds with **seropositive** slaughter pigs

(European study, 2008; Meyns et al., Vet J 2011)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Belgium (50 herds)</th>
<th>Spain (107 herds)</th>
<th>Italy (46 herds)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. pleuropneumoniae</em></td>
<td>96</td>
<td>89</td>
<td>100</td>
</tr>
<tr>
<td><em>M. hyopneumoniae</em></td>
<td>98</td>
<td>82</td>
<td>91*</td>
</tr>
<tr>
<td>PRRSV</td>
<td>94</td>
<td>89</td>
<td>100*</td>
</tr>
<tr>
<td>Influenza (H1N1)</td>
<td>100</td>
<td>90</td>
<td>78</td>
</tr>
<tr>
<td>Influenza (H3N2)</td>
<td>98</td>
<td>100</td>
<td>63</td>
</tr>
<tr>
<td>Influenza (H1N2)</td>
<td>98</td>
<td>97</td>
<td>14</td>
</tr>
</tbody>
</table>

* Blood sampling at 80 kg
Monitoring respiratory pathogens

• Historic information

• Clinical symptoms, ev. coughing index (Nathues et al. 2012)

• Routine necropsies affected pigs → further diagnostic work-up

• Slaughter checks:

  Advantages: cheap, easy, lesions are economically important

  Limitations: no etiologic diagnosis (!), regression of lesions, subjective, min. 30 animals, different scoring methods, severe pleurisy may mask other lesions, fast speed of slaughter line, ...
Monitoring respiratory pathogens

- Serial or cross-sectional sampling at herd
  Samples:
  - blood, oral fluids, ... → antibodies
  - blood, oral fluids, BAL fluid, tracheal, tonsil / nasal swabs, ... → pathogen or parts of pathogen

- Blood sampling at slaughter

- Herd veterinarian should integrate information from herd, laboratory, necropsy, etc.
- Challenge is mostly not “is pathogen present on herd” but mostly “which pathogens are important in specific age group”
Paired or serial sampling

= same animals sampled over time

**Advantage:**
• provides the most informative results

**Disadvantages:**
• requires time before results are known
• different herd visits necessary
• needs individual identification of animals
Cross-sectional sampling

= sampling different age groups at same day
e.g. nursery, growing and fattening pigs

Advantage:
• results quickly known (one herd visit)
• no individual identification of animals

Disadvantage:
• results more difficult to interpret

→ Possible to combine serial and cross-sectional sampling
Serology

- **Different tests:**
  - mostly ELISA
  - other (HI-test swine flu, virus neutralization, etc.)

- **Sensitivity and specificity may vary**

- **Antibodies may develop fast or slow after infection, or may not be detectable**

- **Correlation** \(\text{e.g. HI-antibodies swine flu}\) **or no correlation** \(\text{e.g. Mycoplasma}\) **with degree of protection**
Serology

• Interpretation difficult in:
  - vaccinated populations
  - nursery pigs because of maternal antibodies
• Retrospective data
• Interpretation at group level
Oral fluids

- Quick, easy, and inexpensive to collect
- Prospective → to forecast health and productivity
- Mixture of saliva and "oral mucosal transudate"
- *e.g.* PRRSV, PCV2, SIV and *M. hyopneumoniae*

  Antibodies against these pathogens → test validation needed

- No individual samples → no prevalence data
Samples of respiratory tract

- Nose → tonsil → trachea → BAL fluid
- Depends on pathogen *e.g.* BAL fluid and trachea more sensitive for M. hyo; nasal swabs ok for swine influenza in acute outbreaks
- Upper respiratory tract (nose) easier for routine sampling
- Detection of bacterial pathogens ~ antimicrobial medication
For optimal laboratory testing, veterinarians should...

- Define **goal** of submission
- Select appropriate **sample(s)**
- Use correct method of **submission**
- Select animals with **typical** disease
- Submit adequate **number** of samples
- Include samples from **control** animals
- Consider strengths and weaknesses of lab **tests**
- Interpret in relation with **farm data***

* Herd **veterinarian** should **integrate information** from herd, laboratory & necropsy
**Clostridium perfringens**
*(Songer 2012)*

<table>
<thead>
<tr>
<th><strong>Type A</strong></th>
<th><strong>Type C</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Neonatal necrotizing enteritis, gas gangrene</td>
<td>• Neonatal hemorrhagic and necrotic enteritis</td>
</tr>
<tr>
<td>• Usually from 1w after birth until weaning; low mortality</td>
<td>• Mostly in 3-day-old piglets; rare &gt;1w</td>
</tr>
<tr>
<td></td>
<td>- directly after birth: severe bloody diarrhea + high mortality</td>
</tr>
<tr>
<td></td>
<td>- later: lower morbidity and mortality</td>
</tr>
<tr>
<td>• α-toxin</td>
<td>• α- and β-toxin</td>
</tr>
<tr>
<td>• Normal inhabitant of intestinal tract → quantification (pure cultures of &gt;10^6/g feces)</td>
<td>• Primary pathogen, can also colonize lesions of other diseases</td>
</tr>
</tbody>
</table>

Other Clostridia in pigs: *C. difficile, C. novyi*
Neonatal *E. coli* enterotoxicosis

- Enterotoxigenic *E. coli* (ETEC) important cause of diarrhea
- Adhesion factors (mainly F4*, F5, F6, F41)
- Enterotoxins (LT, Sta, Stb)
- Intestinal epithelium intact

* F4+ ETEC highly prevalent in pig breeding farms – 65% of young sows seropositive (Van den Broeck et al., 1999)
Post-weaning diarrhea/edema disease

• Both caused by *E. coli* that colonize the small intestine and produce exotoxins

  • **Diarrhea:** mostly F4+ and F18+ ETEC Enterotoxins
  
    **Edema disease:** mainly F18ab+ EDEC Shiga-toxin

• From 2d after weaning onwards
Prevalence of pathogens in recently weaned pigs (Animal Health Service, Flandres, 2012)

- 100 recently weaned pigs at necropsy during one year
- Control pigs n=25; pigs with weaning diarrhea n=75
- 57% hemolytic E. coli
Virotypes of *E. coli* with virulence factors in weaned pigs (Animal Health Service, Flandres, 2012)

- 114 isolated *E. coli* strains
- Approx. 60% of *E. coli* strains contained virulence factors
- Most common virotype: F4/LT/STb
Prevalence rotavirus A infections in pigs with and without diarrhea (Theuns et al. 2015)

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Diagnostic test</th>
<th>Age (days)</th>
<th>Symptoms</th>
<th>n=</th>
<th>% RVA positive</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA, Canada, Mexico</td>
<td>2009-2011</td>
<td>RT-qPCR</td>
<td>1-3</td>
<td>D</td>
<td>954</td>
<td>30%</td>
<td>[62]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4-21</td>
<td>D</td>
<td>2144</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22-55</td>
<td>D</td>
<td>2538</td>
<td>84%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;55</td>
<td>D</td>
<td>1207</td>
<td>61%</td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td>1999</td>
<td>PAGE + antigen EIA</td>
<td>&lt;45</td>
<td>ND</td>
<td>901</td>
<td>3.3%</td>
<td>[63]</td>
</tr>
<tr>
<td>Canada</td>
<td>2005-2007</td>
<td>RT-PCR</td>
<td>Slaughter</td>
<td>ND</td>
<td>96</td>
<td>8.3%</td>
<td>[64]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;24</td>
<td>ND</td>
<td>50*</td>
<td>16.0%</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>2006-2007</td>
<td>EIA</td>
<td>1-28</td>
<td>D</td>
<td>308</td>
<td>10%</td>
<td>[65]</td>
</tr>
<tr>
<td>Germany</td>
<td>nd</td>
<td>EM</td>
<td>1-21</td>
<td>D</td>
<td>102</td>
<td>2.0%</td>
<td>[66]</td>
</tr>
<tr>
<td>Italy</td>
<td>2004-2006</td>
<td>RT-PCR</td>
<td>28-84</td>
<td>D</td>
<td>102</td>
<td>71.5</td>
<td>[67]</td>
</tr>
<tr>
<td>Ireland</td>
<td>2005-2007</td>
<td>RT-PCR</td>
<td>28-63</td>
<td>ND</td>
<td>292</td>
<td>6.5%</td>
<td>[68]</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2004-2005</td>
<td>RT-PCR</td>
<td>1-21</td>
<td>D</td>
<td>6</td>
<td>50%</td>
<td>[69]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22-70</td>
<td>D</td>
<td>14</td>
<td>35.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;70</td>
<td>ND</td>
<td>133</td>
<td>25.6%</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>2000-2002</td>
<td>PAGE</td>
<td>suckling weaning</td>
<td>D</td>
<td>36</td>
<td>18 outbreaks</td>
<td>[70]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3-70</td>
<td></td>
<td>475</td>
<td>38.3%</td>
<td>[71]</td>
</tr>
<tr>
<td>South Korea</td>
<td>2006-2007</td>
<td>nested RT-PCR</td>
<td>3-70</td>
<td>D</td>
<td>475</td>
<td>38.3%</td>
<td>[71]</td>
</tr>
<tr>
<td>Thailand</td>
<td>2000-2001</td>
<td>antigen EIA</td>
<td>7-49</td>
<td>D</td>
<td>175</td>
<td>22.3%</td>
<td>[72]</td>
</tr>
<tr>
<td>Vietnam</td>
<td>2012</td>
<td>RT-qPCR</td>
<td>all ages</td>
<td>D</td>
<td>76</td>
<td>19.7%</td>
<td>[73]</td>
</tr>
</tbody>
</table>

Legend: D diarrheic; ND non-diarrheic; EIA enzyme immunoassay; EM electron microscopy; PAGE polyacrylamide gel electrophoresis; * mixed samples from multiple animals
Rotavirus A infections in pigs with and without diarrhea (Theuns et al. 2015)

• Molecular diagnostic techniques such as RT-qPCR and RT-PCR → better surveillance techniques than fast antigen detection tests and virus isolation

• Pigs may become successively infected with different rotavirus A types after weaning → second replication peak less pronounced → some cross-protective immunity
Porcine epidemic diarrhea infections

- Sporadic PEDV cases on Belgian pig farms (2015): diarrhea without mortality
- Strains genetically almost identical to German and US INDEL strains → milder symptoms
- INDEL strains: genetically different from highly virulent US (spring 2013) and Asian PEDV strains, and the European PEDV strain CV777 (1970s-1990s)
- **Diagnosis:** most efficiently = RTqPCR analysis of RNA extracted from diarrheic feces; Detection of virus by ELISA or EM in feces
Swine dysentery

- Increased prevalences in many countries
- Major losses to farms
- New Brachyspira species: *B. hampsonii, B. suanatina*
- Treatment: expensive, few effective antimicrobials, antimicrobial resistance problem *(Herbst et al., 2014)*
### MIC$_{50}$ and MIC$_{90}$ for pleuromutilins

(Vangroenweghe et al., 2010, ESPHM)

<table>
<thead>
<tr>
<th>Year</th>
<th>Tiamulin</th>
<th></th>
<th></th>
<th>Valnemulin</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIC$_{50}$</td>
<td>MIC$_{90}$</td>
<td></td>
<td>MIC$_{50}$</td>
<td>MIC$_{90}$</td>
</tr>
<tr>
<td>2006</td>
<td>0.25</td>
<td>2</td>
<td></td>
<td>0.03</td>
<td>0.50</td>
</tr>
<tr>
<td>2008</td>
<td>0.50</td>
<td>8</td>
<td></td>
<td>0.12</td>
<td>8</td>
</tr>
<tr>
<td>2009</td>
<td>&gt;8</td>
<td>&gt;8</td>
<td></td>
<td>8</td>
<td>&gt;8</td>
</tr>
</tbody>
</table>

→ Significant increase in MIC values!
→ No vaccine available against *B. hyodysenteriae*
Swine dysentery: monitoring

- Demonstration of *B. hyodysenteriae* (and/or other types) in feces or colon:
  - PCR-test: specific or more general
  - bacteriology: anaerobic culture – 6-9 d
    MIC testing

- Serology → not in practice
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**Streptococcus suis**

- **Early colonizer:** upper respiratory tract (tonsils, nasal cavity), genital and alimentary tract
- **Septicaemia:** meningitis, arthritis, pericarditis, polyserositis, inflamm. heart valve, pneumonia (?)
- **Zoonotic**
- **Isolation of pathogen in lesions – no serology**
- **Important for preventive use of antibiotics in piglets**
Porcine Reproductive and Respiratory Disease Syndrome (PRRS)

- Major economic losses
- Many pig herds infected
- Large heterogeneity of strains
Porcine Reproductive and Respiratory Disease Syndrome (PRRS)

• Monitoring: breeding – nursery – fattening

• Blood samples:
  - antibodies (IF, SN, ELISA → European vs. US strains)
  - detection of pathogen: VI, PCR
  - molecular characterisation of strains

• Oral fluids

• Control:
  - management and biosecurity, vaccination
  - filtration of incoming air → 80% reduction of PRRS introduction
    (Alonso et al., 2013)
Other diseases → slaughterhouse information

- **Stomach lesions:**
  - finishing pigs: >65%
  - sows: 10-15%

- **A. suum infections** → liver white spots (serology)

- **Skin lesions** → mange

- **Urogenital tract infections in culled sows**
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Primary disease prevention

- = pathogen (or virulent strains) not present
- Disease-free animals: quarantine, vaccination
- SPF or « high health » herds
- Depop-repop, partial depopulation, medication
- **Balance**: cost to become free vs. benefits of remaining free
- Difficult for diseases with airborne spread in pig dense areas → filtration of incoming air
Secondary disease prevention

- Infection is present
- Prevention of clinical disease, maintaining optimal production targets
- Control programs: good balance between host and infection pressure
Monitoring

Essential for primary and secondary prevention:

• To confirm freedom of infection
• To assess infection level, affected age group, optimal age for vaccination, prevalence and severity of lesions, etc.
Conclusions

- Most herds infected with major pathogens, some are SPF

- Monitoring essential in both situations:
  - Health → blood, oral fluids, feces, clinical scores, slaughter data, …
  - Antimicrobial resistance
  - Performance
  - Feed & water intake, climatic parameters

- More & better diagnostics: fast testing for multiple pathogens (characterisation, virulent strains, …)