New surveillance methods to detect PRRS at low prevalence

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Iowa Swine Day
June 28th, 2018. Ames, IA
“Evaluation of strategies to prevent, detect, or manage swine infectious diseases under field conditions”

**Prevention**
- Identifying biosecurity aspects associated with outbreaks: minimum # questions that when combined give great correlation w/ frequency of outbreaks

**Detection**
- Swine disease reporting system (4 major VDLs data): reporting, and detecting changes in patterns over time, age groups, region, specimens...
- Field epidemiology on non-conventional VDL cases: understanding the meaning of detecting PAv3, PSV, PTV, APPV
- Ecology of type I PRRSv in Europe
- Oral fluids-based slaughter surveillance
- Processing fluids: series of studies from lab to the field: PRRS / PED / PCV2
- Family oral fluids for improved PRRS detection in due-to-ewean pigs
- Automated, ongoing monitoring of production data (breeding sow, growing pigs)

**Control**
- Economic benefit of eliminating Mycoplasma hyopneumoniae
- Field studies on best PRRS management practices [breeding herds]
- Comparison of PRRS vaccination of growing pigs under field conditions
- Dynamics of wild type PRRS infection in vaccinated growing pig flows
- Effect of whole-herd health & production data on growing pig performance
- Field studies with MJ technology (PRRS typing and immunization)
- Impact of MLV on breeding herd productivity, and on downstream flow.

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Agenda

• Population-based monitoring and surveillance systems
• Breeding herd
  • Processing fluids
  • Family oral fluids
  • Production data
• Veterinary Diagnostic Laboratory data
• Summary
Swine industry increasingly using population-based samples for disease monitoring

**Individual pig sampling**
Serum, blood swab, tonsil scraping

**Population-based sampling**
Oral fluids, processing fluids

More practical, cheaper, ↑ herd sensitivity
Monitoring and Surveillance Systems (MOSS): take home messages

- MOSS 2.0 is based on population-based samples:
  - More practical, easier, cheaper, better performance compared to “conventional” (individual pig-based sampling)
- Toolbox:
  - Methods depend on The Question:
    - Processing fluids: 3-5 days old piglets
    - Family oral fluids: due-to-wean litters
    - Automated SPC: early signs of disease
    - Oral fluids-based slaughter surveillance
    - Aggregated VDL (megatrends) data

Mix n’ match to answer your question
Lopez et al., 2017

Real-time automated production records to detect outbreaks

https://fieldepi.cvm.iastate.edu/

Baseline
Production

Signal

Exponential
Weighted Moving
Average

Abattoir surveillance
Processing fluids

The good
- ↑ Sensitivity @ whole room level
- Easy, practical, people picking up...
- Great ORF-5 Seq success rate
- Antibody testing

The caution
- 3-5 days may not reflect due to wean piglet status
- Expect longer time to test negative
- “Poor” sensitivity at litter level, great sensitivity at the room level

Time to 3 consecutive negative weekly PCRs on PF testing (= 25 herds):

- 25\textsuperscript{th} percentile: 26 weeks
- 50\textsuperscript{th} percentile: 28 weeks
- 75\textsuperscript{th} percentile: 31 weeks

Trevisan et al, work in progress
Preweaning piglet PCR tests for PRRS: Which farm is PRRS stable? PRRS Negative vs. PRRS Positive Result

Farm A and Farm B = same farm!

Farm A (10 months)

<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
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<td>PED 3/31/18</td>
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Dr. Grant Allison, Walcott Veterinary Clinic

Farm B (10 months)

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Weekly PF (2 per room)
Pooled week CT values vs. individual day CT values for processing fluids

<table>
<thead>
<tr>
<th>CT value Pooled samples</th>
<th>→</th>
<th>Individual day CT value (from the pool)</th>
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<tr>
<td>27.1</td>
<td>→</td>
<td>&gt;=37 28 27.6 27.3 26.5</td>
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<td>24.0</td>
<td>→</td>
<td>23.7 &gt;=37 &gt;=37 23.1 24.7</td>
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<tr>
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<td>→</td>
<td>28.6 27.3 26.1</td>
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<td>26.4</td>
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<td>26.6 &gt;=37 29.7 25 &gt;=37 &gt;=37</td>
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<td>&gt;=37</td>
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<td>33.4</td>
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<td>&gt;=37 31.0 33.4 &gt;=37 &gt;=37</td>
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<td>&gt;=37</td>
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<td>27.4</td>
<td>→</td>
<td>&gt;=37 25.2 26.5 35.6</td>
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<tr>
<td>29.4</td>
<td>→</td>
<td>&gt;=37 &gt;=37 27.0 &gt;=37</td>
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<td>→</td>
<td>&gt;=37 &gt;=37 &gt;=37</td>
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</tbody>
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Yeske et al., AASV 2018
Acknowledgements for processing fluids studies

• Zoetis
• IDEXX
• National Pork Board
• ISU Veterinary Diagnostic Laboratory
  • Drs. Rodger Main, Karen Harmon, Phil Gauger, Nubia Macedo, Laura Bradner, Sarah Bade, Luis Gimenez-Lirola, Jeff Zimmerman
• Collaborators:
  • Drs. Clayton Johnson, Paul Yeske, Emily Byers, Rebecca Robins, Matt Turner
**Litter** oral fluids = poor reproducibility

**Family** oral fluids = success rate ~ 90%

Dr. Marcelo Almeida
Study design:

- 72 matching sets of FOF, & sera from all piglets in the litter
- PRRSV RNA by rRT-PCR

Almeida et al., work in progress
Results

Room A

Piglet prevalence: 6.3%
Litter prevalence: 19.0%
FOF-positive litters = 9.5%

Room B

Piglet Prev: 19.0%
Litter Prev: 29.4%
FOF Pos = 17.6%

Room C

Piglet Prev: 57.3%
Litter Prev: 82.4%
FOF Pos = 82.4%

NOT randomly distributed

Almeida et al., work in progress. Iowa State University.
FOF: high herd sensitivity to detect PRRSv in DTW

![Bar chart showing the probability to detect PRRSV in FOF based on the number of viremic pigs in the litter.]

- Number of viremic pigs in the litter:
  - 0: 0%
  - 1 or 2: 50%
  - 3 or more: 100%

Almeida et al., work in progress
How many FOF samples to detect PRRSv in a farrowing room?

<table>
<thead>
<tr>
<th># Viremic piglets</th>
<th>Prevalence</th>
<th>Individual samples</th>
<th>FOF samples</th>
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<tbody>
<tr>
<td>4</td>
<td>1.0%</td>
<td>211</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2.0%</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>5.0%</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>10.0%</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

Work in progress...
Latent Class Model: assumptions

Beta Buster: 95% confident that Sp > 95%, and mode at 99.5%
Latent Class Model: assumptions

Prior information on Prevalence:
• 95% sure that Prev. < 0.05, with mode at 0.01.
  • Based on recent individual-based monitoring of 60 piglets

Monitoring scheme:
• Aggregate sample, each representing ~ 12 pigs
• Scenario 1: collect 10 FOF samples from a room
Results:
All 10 FOF testing neg. by PRRS RT-PCR:
Results:

What if 1 out of 10 FOF tests positive?
Family oral fluids

The good
- ↑ Specificity
- Sensitivity ~80% @ litter level
  - Room level depends on sample size
- Easier, more practical, and cheaper than individual pig blood/serum
- Antibody testing

The caution
- More data needed on near zero prevalence
- Not as simple as PF... but still needed to assess DTW piglet status
Acknowledgements for family fluids studies

• Boehringer Ingelheim Vetmedica, Inc.
• Iowa Pork Producers Association
• ISU Veterinary Diagnostic Laboratory
  • Luis Gimenez-Lirola, Jeff Zimmerman
• Collaborators
  • Hans Rotto, Pete Schneider, Clayton Johnson, Paul Yeske, Kate Dion, Tara Donovan
Ongoing automated production data screening for PRRS detection

Cesar Moura, Swaminathan Jarayaman, Cory Farver, Gustavo Silva, Mark Schwartz, Daniel Linhares
Applied SPC to detect *herd level signs of PRRS*

Silva, Schwartz, Morrison, Linhares, Preventive Veterinary Medicine 2017
Ongoing SPC with automated notifications:

Web-application for secure data collection:

- Farm-specific login/password
- Data encryption
- Uploaded directly to ISU server
  - User does not access the database
- Automated SPC, automated *notification*
Add Data

Date: 11/03/2017
Aborts: 4
Preweaning Mortality: 13
Prenatal Mortality: 12
Sows Off-Feed: 3

Submit Edit
Dear User,

There has been a significant deviation in PreweaningMortality status, as it has crossed the specified control limits. Information regarding the deviation is attached with this email for your reference.

Thank you.

[Attached Report Graph.pdf]
Herds undergoing PRRSv elimination:
1) negative @ birth; 2) *remain* negative @ weaning

**BIG OPPORTUNITY WINDOW**
“you can only manage what you measure”

*We* spread PRRSV to pigs/litters born negative (through management practices)

| PF, 3-5 days old: | + + + | - - - - - - - - - - |
| FOF, DTW litters: | + + + | + + + + + + + + + - - - - - - |

Time
Take homes, sampling thoughts

• Use PF as screening method (easiest, most practical and affordable)
  • Weekly test from daily samples (start pooling daily results / week)
  • Until testing negative

• Use FOF to confirm due-to-wean pig status
  • Weekly PF + 10 FOF until testing negative on both (PF and FOF)

• Productivity data:
  • Great to early identify outbreaks
  • Poor predictor of time to stability (TTBP < TTS)
Development and implementation of a domestic swine bio-surveillance monitoring and surveillance system. Part 1: Establishing a swine disease reporting system in the USA
Detection of PRRSV by RT-PCR over time

Year and Season

PRRSV Result: 1-Negative, 2-Positive, 3-Suspect, 4-Inconclusive, Percent of total porcine cases

Total number of cases:
- 2007: Summer, 1.9K; Fall, 2.0K
- 2008: Winter, 1.7K; Spring, 1.3K
- 2009: Summer, 1.7K; Fall, 1.3K
- 2010: Winter, 1.7K; Spring, 1.3K
- 2011: Summer, 2.4K; Fall, 1.9K
- 2012: Winter, 2.9K; Spring, 1.3K
- 2013: Summer, 4.0K; Fall, 1.5K
- 2014: Winter, 4.5K; Spring, 1.5K
- 2015: Summer, 4.6K; Fall, 1.6K
- 2016: Winter, 4.6K; Spring, 1.5K
- 2017: Summer, 4.5K; Fall, 1.5K
- 2018: Winter, 4.3K; Spring, 1.5K
- 2019: Summer, 4.2K; Fall, 1.5K
- 2020: Winter, 4.1K; Spring, 1.5K

% of PRRS/Total porcine cases received at the ISU Lab:
- 2007: 50.24%
- 2008: 48.94%
- 2009: 48.12%
- 2010: 51.26%
- 2011: 53.67%
- 2012: 55.28%
- 2013: 53.67%
- 2014: 51.26%
- 2015: 48.94%
- 2016: 48.12%
- 2017: 46.22%
- 2018: 44.29%
- 2019: 43.40%
- 2020: 42.19%
Detection of PRRSV by RT-PCR over time

- 2017 3-Summer: 0.0K cases
- 2017 4-Fall: 0.4K cases
- 2018 1-Winter: 0.55K cases
- 2018 2-Spring: 0.75K cases

Total number of accession ID cases:
Swine Disease Reporting System
Trevisan et al., 2018

PRRS detection in Iowa: within expected
Swine Disease Reporting System
Trevisan et al., 2018

PRRS detection in the US:
Above the expected
Swine Disease Reporting System
Trevisan et al., 2018

PED detection rate in the US:
As expected
Delta Coronavirus detection rate in the US: above the expected, gradually returning to baseline levels.
There was an 15.38% increase in the number of cases in 2018 compared to 2017 (from 195 to 225 cases) during spring months.

*Streptococcus suis* continues to be the main pathogen associated with CNS disease.

**Figure 4.** Pathogen detection on CNS tissue over time. Each green bar indicates a different agent or syndrome. The red bar accounts for the sum of the green bars. Bottom: spring months of 2016, middle spring months of 2017, top spring months of 2018. Spring months contains results of March, April, May. ‘Multiple agents’ represent cases with more than one pathogen detected on CNS tissues.
Agent Detection on Respiratory Tissues Over Time

Pathogens detection on Respiratory tissue Over Time
Monitoring and Surveillance Systems (MOSS): take home messages

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  - More practical, easier, cheaper, better performance compared to “conventional” (individual pig-based sampling)

- Toolbox:
  - Methods depend on The Question:
    - **Processing fluids**: 3-5 days old piglets
    - **Family oral fluids**: due-to-wean litters
    - **Automated SPC**: early signs of disease
    - **Oral fluids-based slaughter surveillance**
    - Aggregated VDL (megatrends) data

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