Strategies to control & eliminate PRRSv from breeding herds

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Outline

1. Background – applied PRRS transmission dynamics
2. Managing PRRS, breeding herd level
   - Solutions and metrics
3. Summary
• Costs over $1.0 B / year to the US swine industry (Holtkamp et al., 2013)

• North America: efforts towards PRRSv regional elimination

• Regional elimination depends on ability to
  – decrease infection frequency in breeding herds and growing pig sites
  – increase success rate of PRRSv control & elimination projects
PRRS incidence, US swine industry

Chart 1 - PRRS cumulative Incidence / weekly and cumulative
Beginning July 1 for years 2009-2016

% of herds reporting new infections


Betlach & Morrison, Feb 5th
PRRSv infection dynamics: key points

**How?**
- via aerosols, direct contact (pigs, semen), indirect contact: contaminated boots, coveralls, vehicles, supplies...

**PRRSv infection dynamics:** key points

- **Virus in blood (PCR):** 1 to ~35 dpi
- **Peak:** ~1 week
- **Antibodies (ELISA):** Beginning ~1 wk, ~90% @ 2wks

- **Virus in lung, tonsils, lymph nodes (PCR):** 1st day to ~5-6 months

**Shedding (transmission):** from day 1 to ~3 months
- ~3-6 weeks: Protective immunity
  - This is at individual (pig) level.
  - At pop'n level, all pigs don't get infected at the same time. Thus, depending on pig flow, infection can persist in the population forever.

**This is why we want to manage (control / stabilize) PRRSv infection in farms and whenever feasible, we want to eliminate it from herds, systems, regions.**
Science of herd closure

Susceptible → Infected (shedding) → Resistant (no shedding, no disease) → No PRRS transmission
Each susceptible gilt introduction into non-stable PRRSv herd:
= re-start PRRS clock (i.e. wood in fire)
Introduction of susceptible gilt into stable PRRSv herd:
= keeps gilt “susceptible” (not infected, not sick, not PRRSv source)
Evaluation of immune management strategies to control PRRSv

Comparison of time to PRRSv-stability and production losses between two exposure programs to control PRRSv in sow herds

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Study design & methods

Prospective study:

Breeding herds acutely infected with PRRSv

Herd closure + LVI (n=41)

Herd closure + MLV (n=20)

Time to negative pig (TTNP)

TTNP definition based on PRRSv monitoring:
- Herds were monitored for PRRSv by serum RT-PCR
- Monthly testing 30 piglets, starting at 12 weeks post intervention
- Herds achieved TTNP when 4 consecutive negative tests were obtained
  - Based on Am. Assoc. Swine Vet.’s PRRS herd classification 2b (Holtkamp et al., 2011)
The effect of treatment (LVI, MLV) on TTS was adjusted by the following covariates*:

- Number exposures (doses)
- LVI vs MLV
- Veterinary clinic
- Prior PRRSv infection
- RFLP pattern 1-4-4
- Days from detection to LCE

Statistical analysis:
- Descriptive statistic
- Kaplan-Meier & Cox proportional hazards regression

* Information on covariates collected using a survey at the moment of farm enrollment
“200 days” was not enough to achieve TTNP for ~half of the herds:

% herds that achieved TTNP

Weeks post whole-herd inoculation

Cumulative TTNP - all farms

84 days 200 days 300 days

~40% herds: ≥ 1 PCR-neg followed by PCR-positive
Treatment: LVI vs MLV

Median TTNP and 95% CI:
LVI: 26.3 (22.57, 29.57)
MLV: 33.0 (32.00, 41.00)

(Log rank p-value 0.0171)
Prior PRRSV-infection: yes vs no

Median TTNP and 95% CI:
Prior_infect.: 26.00 (20.71, 30.57) 
No prior inf.: 32.57 (26.28, 38.00) 

(Log rank p-value 0.0066)
Effect of LCE treatment on productivity

Part 2 of the study...
MLV herds had less total losses

Difference of 1,443 pigs / 1,000 sows

Wilcoxon p-value 0.0171
MLV achieved TTBP sooner than LVI

Log rank p-value <0.0001
TTBP was shorter for herds w/ “prior PRRS-infection” and herds of a specific veterinary clinic:

**Log rank p-value <0.0014**

**Log rank p-value <0.0031**
Production level was not a good predictor of time-to-negative. Biosecurity and management practices should remain strict until Negative.
Economic analysis of immunization strategies for PRRS control

Linhares D; Johnson C; Morrison R. PLOS One 10(12).

☑ LVI or MLV?
☑ Preventive vaccination?
The MLV program was economically advantageous compared to the LVI program.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cost to expose</th>
<th>Opportunity Cost for pigs not weaned</th>
<th>Opportunity cost for W-F performance</th>
<th>Total OC*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exposure</td>
<td>TTBP</td>
<td>Total loss</td>
<td>OC*</td>
</tr>
<tr>
<td>MLV</td>
<td>$3,000</td>
<td>12</td>
<td>1,222</td>
<td>$81,532</td>
</tr>
<tr>
<td>LVI</td>
<td>$100</td>
<td>20</td>
<td>2,665</td>
<td>$177,809</td>
</tr>
<tr>
<td>Difference (MLV-LVI)</td>
<td>$96,277</td>
<td>(66,829)</td>
<td>$26,548</td>
<td></td>
</tr>
</tbody>
</table>

* OC = Opportunity cost
Economically worth it to preventively vaccinate herds to “build” PRRSv herd immunity?

Lower production impact if wild type PRRSv is introduced*

Considering attenuated PRRSv impact: 1.5 PSY, $1.00 growth performance

Break even = 1 year & 9 months (Linhares, Johnson, Morrison, 2015 PLOS One)

Continuous impact on PSY, growth performance**

* Linhares et al., 2013
**Johnson, 2013 (field data); Bøtner et al., 1997; Dewey et al., 1999 and 2004; Nielsen et al., 2002
Part 4 of the study…

Couple slides on success rate...
Herds that adopted LCE and completed PRRSv monitoring: 70% LVI and 75% MLV reached AASV category III

<table>
<thead>
<tr>
<th></th>
<th>Failure (reinfected)</th>
<th>Success (negative)</th>
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</thead>
<tbody>
<tr>
<td>LVI</td>
<td>12 (30%)</td>
<td>28 (70%)</td>
</tr>
<tr>
<td>MLV</td>
<td>4 (25%)</td>
<td>12 (75%)</td>
</tr>
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</table>

P = 0.2441

<table>
<thead>
<tr>
<th></th>
<th>Failure (reinfected)</th>
<th>Success (negative)</th>
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</thead>
<tbody>
<tr>
<td>LVI</td>
<td>9 (24%)</td>
<td>28 (76%)</td>
</tr>
<tr>
<td>MLV</td>
<td>1 (8%)</td>
<td>12 (92%)</td>
</tr>
</tbody>
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P = 0.1574

Failures:
LVI: 3 new, 9 old; MLV: 3 new, 1 old
For herds that achieved TTNP:
80% LVIs and 86% MLVs reached AASV Category III

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<tr>
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<th>OLD and NEW</th>
<th>OLD only</th>
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<tr>
<td></td>
<td>Failure (reinfected)</td>
<td>Success (negative)</td>
</tr>
<tr>
<td>LVI</td>
<td>7 (20%)</td>
<td>28 (80%)</td>
</tr>
<tr>
<td>MLV</td>
<td>2 (14%)</td>
<td>12 (86%)</td>
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</table>

P = 0.2979

P = 0.1943

Failures:
LVI: 2 new, 5 old; MLV: 2 new
Summary
General conclusions

Success rate
MLV ≈ LVI

LCE with serum or vaccine?

TTNP
↓ LVI

Total loss
↓ MLV

TTBP
↓ MLV

productivity
↓ MLV

Cost/benefit:
MLV

Total loss
↓ MLV

Total production
↓ MLV

Impact on productivity
↓ MLV

Success rate
MLV ≈ LVI

Cost / benefit:
MLV
General conclusions (continued)

• Herds achieved TTS sooner and had a less severe PRRSv break when:
  – There was prior PRRSv infection in the 3 years prior to study
  – Herds were part of a particular production system

• PRRSv monitoring:
  – Needs to be repeated over time
  – Monitoring scheme suggested by AASV (2011), which is based on n=30 samples/month over 4 months assumes that PRRSv infection dies out within 90 days once prevalence is below 10%. We showed that this was not always the case
  – Don’t rely on sow farm productivity as sign that PRRSv is out
Best strategy?

<table>
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<tr>
<th>Herd characteristics and PRRSv infection history</th>
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<tbody>
<tr>
<td>prior immunity</td>
</tr>
<tr>
<td>nearby swine density</td>
</tr>
<tr>
<td>frequency of virus introduction</td>
</tr>
<tr>
<td>building layout</td>
</tr>
<tr>
<td>overall biosecurity level</td>
</tr>
<tr>
<td>parity segregation, batch farrowing</td>
</tr>
<tr>
<td>PRRSv status and PRRSv genetic line</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Practices to control PRRSv infection</th>
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<tbody>
<tr>
<td>Gilt exposure</td>
</tr>
<tr>
<td>Time gilt exposed to sow farm introduction</td>
</tr>
<tr>
<td>Sow exposure program</td>
</tr>
<tr>
<td>bio-management practices</td>
</tr>
<tr>
<td>Frequency of whole herd exposure</td>
</tr>
<tr>
<td>Herd closure-associated practices</td>
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<table>
<thead>
<tr>
<th>Success</th>
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</thead>
<tbody>
<tr>
<td>Time to produce negative pig</td>
</tr>
<tr>
<td>Time to baseline production</td>
</tr>
<tr>
<td>Total loss attributed to PRRS</td>
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Proposed model: Linhares & Holtkamp
# General recommendations for PRRSv control / elimination – sow herds

<table>
<thead>
<tr>
<th>What</th>
<th>Target, Elimination path</th>
<th>Target, Control path</th>
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<tbody>
<tr>
<td>Virus circulation (prevalence)</td>
<td>Zero</td>
<td>Low</td>
</tr>
<tr>
<td>Type of PRRS virus</td>
<td>From wild type to none</td>
<td>From wild type to MLV</td>
</tr>
<tr>
<td>Incoming gilts</td>
<td>Naïve when prevalence reaches zero</td>
<td>Previously immunized (2-3 months)</td>
</tr>
<tr>
<td>semen</td>
<td>Naïve</td>
<td>Naïve</td>
</tr>
<tr>
<td>Weaned pig vaccination strategy</td>
<td>Depends on probability of infection and type/severity of PRRSv in the neighborhood</td>
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</tr>
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Thank you very much!

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