# Managing and Eliminating Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) During Farm Outbreaks

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Banff Pork Seminar

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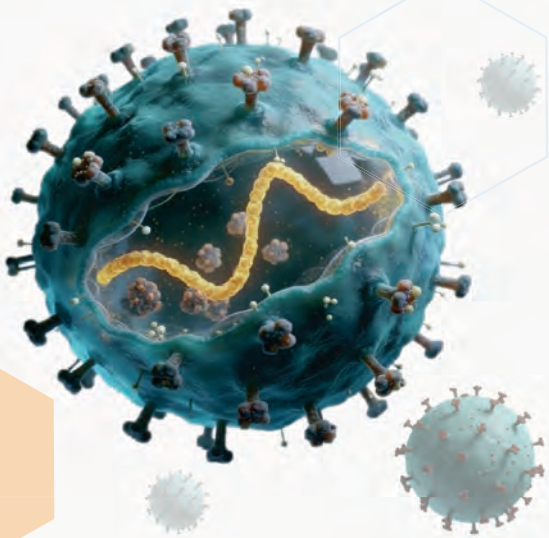
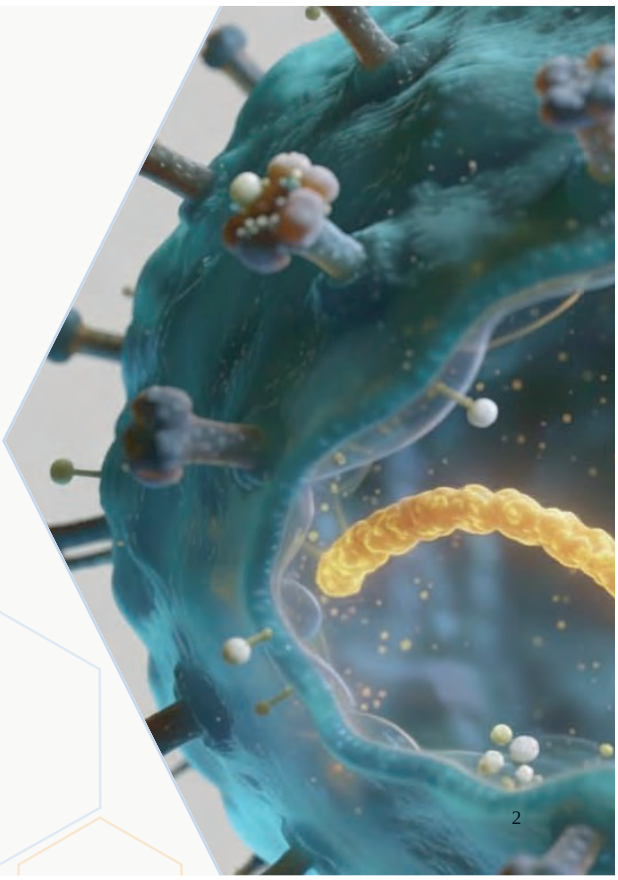
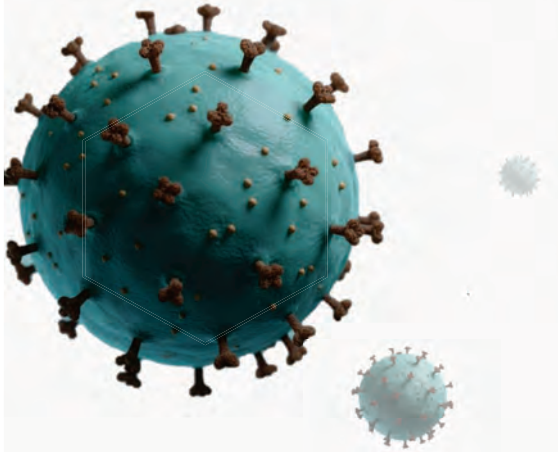




# PRRSV: An Overview

- Highly contagious viral disease
- Significant impact on global pork production
- Severe respiratory issues – young and growing pigs
- Reproductive failure: Breeding herds
- Management and elimination -comprehensive understanding of etiology, epidemiology, and economic impact

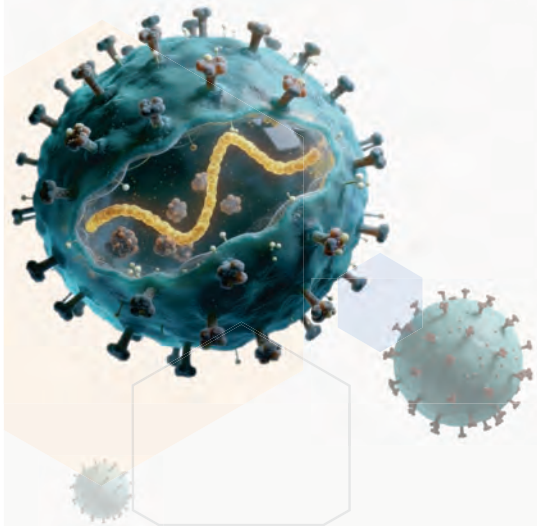




# Topics




# Etiology and Economic Significance



**Betaarterivirus europensis (PRRSV-1)**

**Betaarterivirus americense (PRRSV-2)**

- demonstrates extensive genetic and antigenic diversity due to high mutation and recombination rates, leading to the continual emergence of novel isolates
- genetic variability complicates diagnostics and limits vaccine and control program effectiveness.

**Economic Impact**

- most recent assessments indicate the cost now exceeds $1.2 billion annually
- Losses from direct and indirect costs



International Committee on Taxonomy of Viruses (ICTV)

# Epidemiological Characteristics

## PRRSV Stability

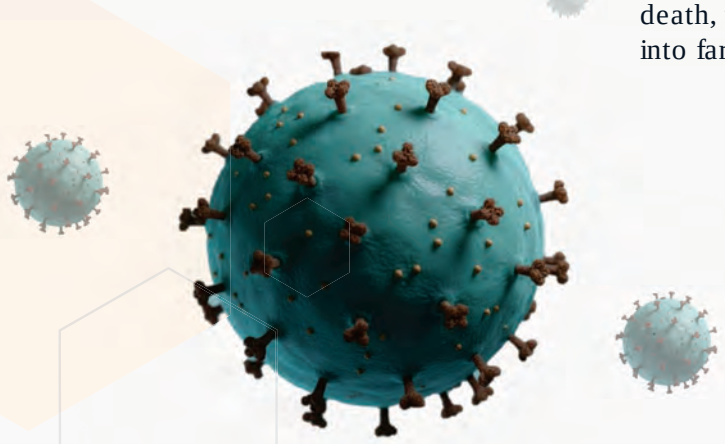
- Survival influenced by: moisture, temperature, pH, matrix, UV light
- Temperature stability:
  - Stable for months to years at −70°C and −20°C
  - Rapidly inactivated by heat and drying
- pH stability:
  - Optimal at pH 6.25 (4°C) and pH 6.0 (37°C)
- Water survival: Up to 11 days – contaminated drinking water and lagoons are potential sources
- Manure/feces:
  - Half-life: 112.6 h at 4°C, 14.6 h at 22°C
  - Feces protects virus from heat by insulating inner layers
- Inactivation:
  - Lipid solvents, common disinfectants (chlorine, iodine, quaternary ammonium compounds)
  - Low-concentration detergents disrupt the viral envelope
- Surface decontamination:
  - Drying or thermal-assisted drying
  - Glutaraldehyde or quaternary ammonium chloride disinfectants
  - UV-C treatment



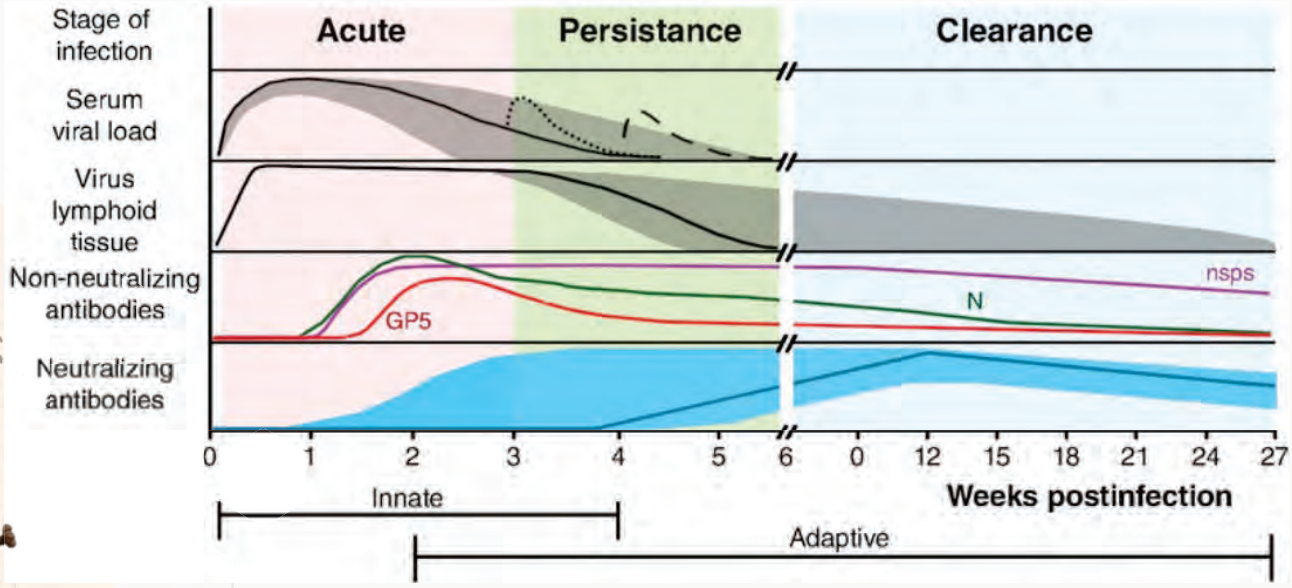
# Epidemiological Characteristics

## Transmission

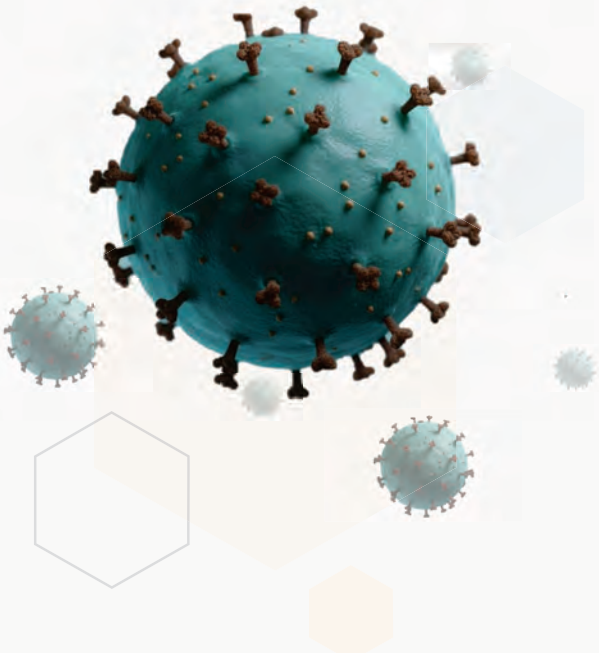
- virus is shed in multiple bodily fluids
- **Horizontal transmission** occurs through direct contact and parenteral routes
- IM infectious dose as low as ≤ 20 viral particles
- **Vertical transmission** during late gestation can cause fetal death, weak born or stillborn piglets, and introduce infection into farrowing rooms



# PRRSV Infection





## The Challenge

### Prolonged Infection and Viral Persistence

- ability to establish prolonged infections in individual animals
- persist in lymphoid tissues, particularly the tonsils and lymph nodes
- infectious virus detected up to 157 days post-infection and viral RNA up to 251 dpi
- Clinically healthy carriers can intermittently shed virus acting as reservoirs

# Managing and Eliminating PRRS Strategies

Whole-herd depop-repop

Herd Closure and Rollover

(Test-and-removal)



# Whole-herd depopulation and repopulation strategy

- most effective for PRRSV elimination, minimizing reinfection risk and ensuring complete virus removal
- extremely high cost makes it impractical for most commercial operations
- justifiable in herds infected with highly virulent isolates that are challenging to stabilize
- feasible alternative for farrow-to-finish herds where on-going replication of PRRSV in the growing population does not allow for the elimination of the virus

# Herd closure and rollover strategy

- the most widely used, balancing cost and efficiency.

**Load-Close-Expose (LCE) protocol**

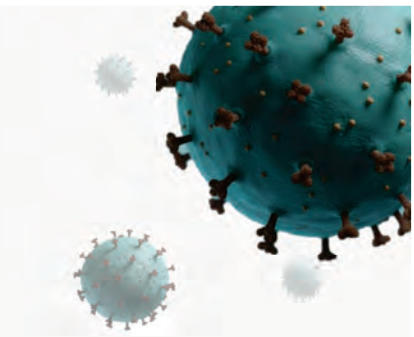
- LOAD involves introducing a single batch of PRRSV-negative gilts to meet replacement needs
- CLOSE the herd to new introductions for 210–250 days, or more depending on the PRRSV isolate, and management practices employed
- EXPOSE to PRRS to homogenize the herd using Modified Live Vaccine (MLV) and/or Live Virus Inoculation (LVI), used under veterinary supervision

**Rollover**

- naive gilts are introduced at the end of the herd closure to assure that PRRSV is no longer shed in the breeding herd.
- The herd "rolls over" as the old, once infected sows replaces by ne, PRRS-negative female.



# Test and removal strategy



- identifies and culls PRRSV-positive animals via repeated qPCR testing
- effective but rarely applied in large herds due to expense and time constraints
- can be applied late in the closure period to identify and cull remaining positive animals

# Defining the Goal

## The AASV Herd Classification System

The updated AASV classification system categorizes herds as:

- Positive Unstable (I-A/I-B)
- Positive Stable (II or II-vx if vaccinated),
- Provisional Negative (III)
- Negative (IV)



**Herd classification system for PRRSV.**

| Herd category | Shedding status | Exposure status | Evidence to promote a herd to category |
|---|---|---|---|
| Positive Unstable High Prevalence (IA) | Positive, high prevalence | Positive | None required |
| Positive Unstable Low Prevalence (IB) | Positive, low prevalence | Positive | Serum or FOF from weaning-age pigs or PF tested by PCR |
| Positive Stable Without Vaccine (II) and With Vaccine (II-vx) | Uncertain | Positive | Serum from weaning-age pigs (may be used w/ PF and FOF concurrently) tested by PCR |
| Provisional negative (III) | Negative | Positive | Serum from PRRSV naive replacement breeding animals tested by ELISA |
| Negative (IV) | Negative | Negative | Serum from adult breeding animals tested by ELISA |

# Defining the Goal

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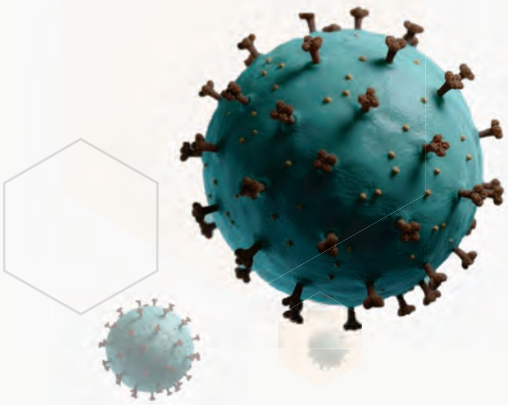
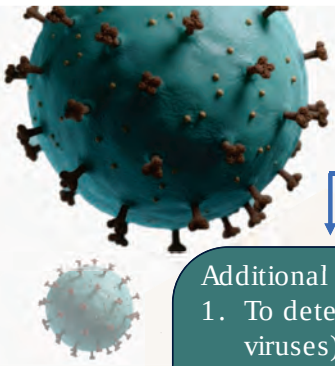


# Comparing Exposure Methods

## Selecting the "immunogen"

- critical decision that influences both virological control and economic outcomes
- identify the PRRSV isolate





**Sample (serum, tissue)**

PRRSV screening PCR

**Positive**

**Negative**

STOP: if screening PCR is reliable

Additional molecular testing dependent on needs:

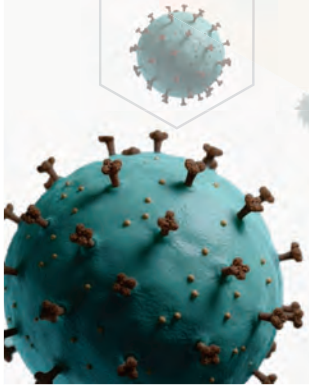
1. To determine the genetic relatedness of the detected virus with other strains (e.g. vaccine viruses) – use **ORF5 Sanger sequencing**
2. To thoroughly genetically characterize (e.g. recombination analysis) – **Whole-genome sequencing via NGS**
3. To determine if co-infection with ≥ PRRSV strains (same species) – NGS metagenomics approach
4. To help determine if PRRSV vaccine like virus is present – vaccine-like PCR can be conducted

**ORF5 Sequencing (Ct < 34)**
(Sanger Method with/without CLAMP)
Analysis:
Phylogenetic analysis
Genetic Lineage

If further genetic characterization is needed

**Whole-Genome Sequence (Ct < 30)**
(NGS Method)
Analysis:
Phylogenetic analysis
Genetic Lineage
Recombination Analysis
Co-infection with ≥ 2 PRRSV strains

**PRRSV vaccine-like PCRs if available in a laboratory**
Analysis:
Presence of vaccine-like virus, recombinant virus



## Comparing Exposure Methods

**Selecting the "immunogen"**

- critical decision that influences both virological control and economic outcomes

Main options:

- Live Virus Inoculation (LVI), which uses the farm's resident field virus, and
- commercial Modified-Live Virus (MLV) vaccines
- *PRRS Killed Vaccine? – less immunogenic*
- *Autogenous Killed Vaccine?*
- To date, exposure to live virus remains the most effective approach for inducing protective immunity.



# Key Recovery Metrics:

- **Time to Stability (TTS)**
  - virological endpoint
  - From Day 0 → PCR-negative pigs at weaning
- **Time to Baseline Production (TTBP)**
  - economic endpoint
  - number of weeks required for the farm to recover pre-outbreak productivity
- **Total losses per 1000 sows:**
  - cumulative pigs not weaned per 1000 sows attributable to the outbreak and its control program

# Time to Stability (TTS) and Time to Baseline Production (TTBP)

*61 breeding herds (2009-2012)*

| | LVI | MLV |
|---|---|---|
| Median TTS | **25.1 weeks** (IQR: 20.7-31.0) | **32 weeks** (IQR: 26.6-41.0) |
| Median TTBP | **21 weeks** (IQR:13-24) | **10 weeks** (IQR:0-15) |
| Cumulative losses (pigs not weaned/1000 sows) | 2665.0 pigs | 1222.2 pigs |

*Linhares et al., 2014*

IQR (interquartile range) = the spread of the middle 50% of the data.



# Time to Stability (TTS)

*161 PRRS Outbreak, 82 breeding herds;* Midwestern USA (MN, IA, NE, SD, CO)

Dr. Bob Morrison Swine Health Monitoring Project (MSHMP)

| | |
|---|---|
| Median TTS | **41 weeks** |
| Max TTS: | 163 weeks |
| Summer:29 | Median 53 weeks |
| **Fall:58** | **Median 38 weeks** |
| **Winter:44** | **Median 35.5 weeks** |
| Spring:30 | Median 54 weeks |

*Sanhueza et al., 2018*

Q1 = 25% stabilized in **31 weeks**

Q3 = 75% stabilized in **55 weeks**

- **Spring and summer outbreaks have longer TTS mainly because the "last phase" of elimination runs through the cold season.**
- **18/161 =** farms that had a previous PRRS outbreak within a year achieved stability twice as fast

# Study on PRRSV-2 Variant L1C1–2–4

- **Field Surveillance 2018–2023**
- **Study Overview:** Evaluated time to stability and genomic classification of a new PRRSV-2 variant (monophyletic clade L1C.2) detected in U.S. swine herds
  **Data Source:** 41,038 ORF5 sequences from MSHMP database (2018–2023).
- **Key Finding:** Monophyletic clade L1C.2 had superior diagnostic accuracy (PPV 90.95%) compared to traditional RFLP and lineage classifications for identifying the emergent variant.

| 33 herds | L1C1–2–4 variant |
|---|---|
| Median TTS | **87 weeks** (IQR=44-91 weeks) |

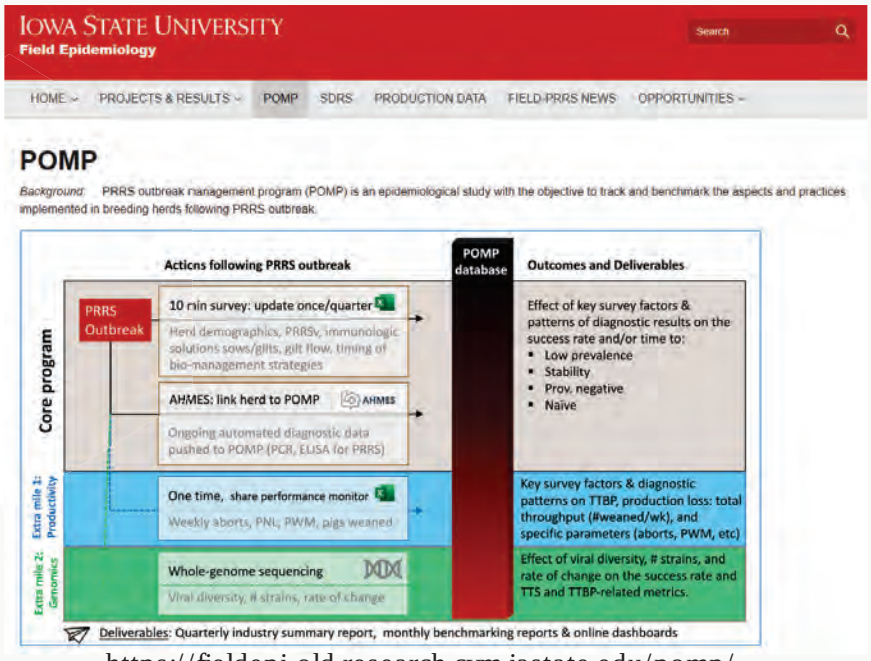
IQR = the spread of the middle 50% of the data.

| Classification Method | PPV (%) | Interpretation |
|---|---|---|
| RFLP 1–2–4 alone | 39.95 (TP=292, FP =439, FN=90) | Most 1–2–4 sequences not L1C1–2–4 |
| Lineage 1C alone | 4.74 | Broad label, many non-variant viruses |
| Lineage 1C + RFLP 1–2–4 | 65.32 | Better but still many false positives |
| Monophyletic clade L1C.2 | 90.95 | Best performance; true variant identification |

*Kikuti et al., 2024*



# The Impact of Farm Management on Recovery




https://fieldepi-old.research.cvm.iastate.edu/pomp/

# The Impact of Farm Management on Recovery

**Management System**

- Determinant of recovery than the specific biological tools used according from the PRRS Outbreak Management Program (POMP), a database tracking hundreds of herd outbreaks.
- clear contrast between farms utilizing batch farrowing versus weekly farrowing systems:
  - **TTS was 25 weeks faster in farms using batch farrowing** compared to those operating continuous flow systems

**McRebel**

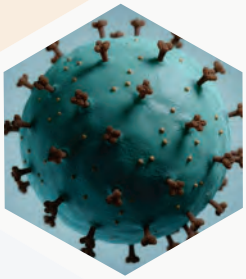
focus on minimizing piglet exposure to pathogens through strategic management changes



# The Impact of Farm Management on Recovery

**MCREBEL[25,26] (Management Changes to Reduce Exposure to Bacteria to Eliminate Losses)**

- Purpose: A systematic approach to reduce the spread of secondary bacteria and PRRSV among farrowing house pigs and to nursery pigs.
- Protocol:
  - —cross foster only during the first 24 hours of life;
  - —do not move sows or piglets between rooms;
  - —eliminate the use of nurse sows;
  - —humanely destroy piglets that become sick and are unlikely to recover;
  - —minimize handling of piglets, especially administration of routine antibiotics or extra iron injections;
  - —do not transfer undersized pigs back to rooms containing younger litters;
  - —immediately stop all feedback of porcine tissue;
  - —move nursery pigs according to strict AIAO principles, allowing for 2–3 days between groups for cleaning and disinfecting.



# The Critical Role of Diagnostics and Monitoring

**Sampling Schemes to Confirm Stability**

**The Test and Removal Strategy**

**From Serum to Novel Tonsil-Based Methods**



| | Category | I-B **(Positive Unstable, Low Prevalence)** | II and II-vx **(Positive Stable and Positive Stable With Vaccination)** |
|---|---|---|---|
| | Testing Purpose | To promote into | To promote into |
| Option 1 | Sample Tested | 30 Serum from weaning-age pigs | 60 Serum from weaning-age pigs |
| | Test (PCR) | 5 pigs/pool | 10 pigs/pool |
| | Testing Frequency | Monthly for 90 days or at least 4 batches | Monthly for 90 days or at least 4 batches |
| | Requirement to promote | 75% (3 of 4) of monthly or batch herd tests are negative | 100% (4 of 4) of monthly or batch herd tests are negative |
| Option 2 | Sample Tested | Processing fluid (Majority of litters from 1 week farrowing) | Concurrently:<br>1) 30 serum from weaning-age pigs;<br>2) Processing fluids (Majority of litters from 1 week farrowing) |
| | Test (RT-PCR) | 1 or more pools | 1) 5 pigs/pool<br>2) 1 or more pools |
| | Testing Frequency | Monthly for 90 days or at least 4 batches | 1) Monthly for 90 days or at least 4 batches<br>2) Weekly for 90 days or at least 4 batches |
| | Requirement to promote | 75% (10 of 13) of weekly or batch herd tests are negative | 1) 100% (4 of 4) of monthly or batch herd tests are negative<br>2) 100% (13 of 13) of weekly or batch herd tests are |



**The AASV Herd Classification System (*Holtkamp et. al, 2021*)**

| | Category | III (Provisionally Negative) | IV (Negative) |
|---|---|---|---|
| | Testing Purpose | To promote into | To promote into |
| Option 1 | Sample Tested | 60 serum from PRRSV naive replacement breeding animals that have been in herd for at least 60 days | Serum from adult breeding animals |
| | Test (ELISA) | Individual | Individual |
| | Testing Frequency | Once | Once |
| | Requirement to promote | One-time herd test is negative | One-time herd test is negative |

**The AASV Herd Classification System (*Holtkamp et. al, 2021*)**



## Prolonged Infection: A Key Challenge

**PRRSV Persistence:**

- PRRSV persistence in sow herds prolongs time to stability (TTS).
- Even with effective load–close–expose (LCE) programs, some animals become prolonged shedders.
- Detection occurred at very low prevalence
- Majority of positives identified during the farrowing phase
- Key risk factors for prolonged carriage include younger age (<33 weeks old) and breed - Meishan *(Mainquist-Whigham et al.).*

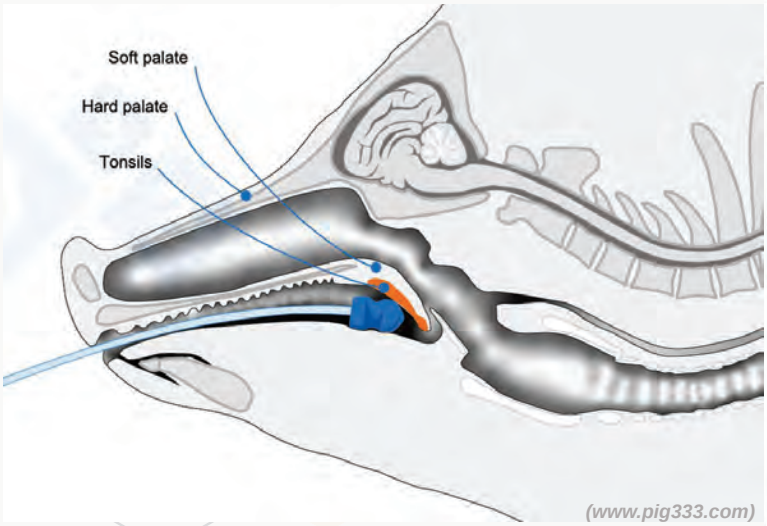
## Overcoming Prolonged Infection: The Test and Removal Strategy

### Test-and-Removal Strategy

- Applied late in herd closure (approximately 140–150 days post-infection)
- Objective: identify and segregation or removal of remaining PRRSV-positive animals
- Proposed to accelerate achievement of herd stability
- Applications of TOSc Sampling as an alternative to Tonsil Scraping



| Feature | Tonsil scraping | TOSc (tonsil-oral-scrubbing) |
|---|---|---|
| Sampling tool | Rigid instrument (e.g., long-handled spoon) scraping tonsil surface. | Sponge/swab rubbed briefly over tonsil and oral cavity. |
| Invasiveness / welfare | **Most invasive;** more abrasion and discomfort. | Least invasive; scrubbing, less discomfort |
| Restraint needed | Usually **full restraint**/snarer. | Brief handling; sometimes **no snare needed**. |
| Sensitivity | **Highest detection** and lowest Ct vs serum, oral fluids, TOSc. | **Better detection** than serum/oral fluids but lower than scraping. |
| Labor | **Time-consuming**, hard to scale. | **Fast** and practical for routine herd monitoring. |
| Typical use case | Maximal sensitivity for persistent carriers, small high-value groups. | Routine PRRSV monitoring in sow herds where welfare and labor are major constraints. |



(www.pig333.com)

(Li et al., 2025)

(Li et al., 2025)



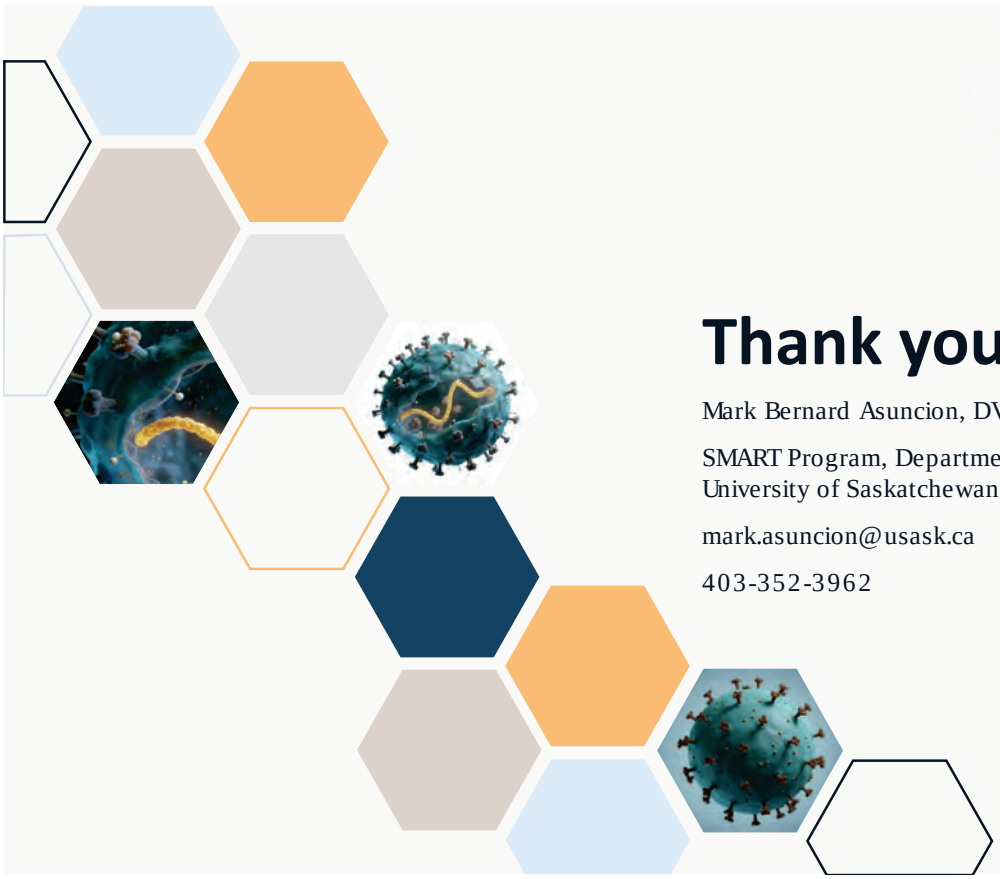
# Summary

**PRRSV Outbreak Management: Three Pillars**

- **Rapid Containment:** Strict external & internal biosecurity.
- **Herd Stabilization:** Herd closure & rollover; deliberate exposure with LVI/MLV to homogenize immunity.
- **Stepwise Elimination:** Structured, preplanned frameworks guided by diagnostics and AASV PRRS classification.

**Key Success Factors:**

- Management as critical as immunogen choice: batch farrowing, all-in/all-out, McREBEL piglet care → shorter time-to-stability, lower losses.
- Monitoring: serum, processing fluids, tonsil-oral scrapes in low-prevalence herds.
- Advanced options: depop–repop or targeted removal of prolonged shedders in select scenarios for accelerated elimination



# Thank you

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