Circovirus Disease in Kansas

What a Difference a Year Can Make!

Your K-State PCV₂ Team

KSU Swine Day

November 15, 2007
History

Nov 2005

Disease appears in multiple Kansas farms with many stunted and wasting pigs, mortality 8-30%, we don’t know much!
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K-State PCV$_2$ Team formed; diagnostic methods, virus isolation and identification, impact of disease
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**Feb 2006**
Funding from NPB, KSA producers and affected farms, virus identified as PCV$_{2b}$ strain
History

July 2006
K-State VDL develops genotype-specific diagnostic assays for tracking PCV$_{2a&b}$ virus
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Began first vaccine trial with Suther Farms, 2 dose conditionally licensed vaccine
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Nov 2006 - Swine Day!
Almost all farms are affected at some level. Early vaccine trial results = reduced mortality
History

Feb 2007
Vaccines becoming available and producing excellent field results in reduced mortality
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Most farms are vaccinated, new cases are rare, performance fantastic!
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Most farms are vaccinated, new cases are rare, performance fantastic!

Case closed?
Not by a long ways! Many trials are completed, others are ongoing, many questions and puzzles that need answers.

Your K-State Team is busy at work!
Where we were a year ago
Swine Day 2006?

• It was still a pretty grim story last year.

• Mortality rates were rising in herds across Kansas.

• We left you with the following slide at last year’s Swine Day……
Even if vaccine stops the bleeding
What about the future?

- Field experience is limited and a great deal is to be learned yet (need field research, Dr. Dritz!)
  - How does this virus move around?
  - Impact on morbidity, will growth benefit?
  - 4-2-2 vaccine and 3-2-1 virus?
  - Timing of vaccination, does it vary with immune status of pigs?
  - Does pre-existing viremia compromise vaccination?
  - How is breeding herd vaccination best managed and what is the benefit/lack of benefit?
  - Need tools to measure immunity!
  - These other viruses – Why? What? How serious?
What has been learned?

• Nearly all herds are affected at some level by circovirus infections, not just those infected with PRRSv and other agents.

• Immunization results in dramatic reduction in mortality

• Immunization results in an amazing and surprising improvement in growth in all trials
Vaccines to the forefront

• Three companies have vaccines licensed in the US
  – **Intervet** – 2 dose baculovirus-vectored, killed vaccine
  – **Fort Dodge** – 1 dose chimera, killed vaccine
  – **Boehringer-Ingelheim** – 1 dose baculovirus-vectored, killed vaccine

• All cost about the same, all result in reduced mortality and improved performance

• Unlike last year, vaccines are now readily available

• Trials comparing vaccine performance – some are completed, others still underway
Topics to review today

- **Vaccines** – how do they work, differences?
- **Growth** – what is the impact in immunized animals?
- **Immunity** – how can we use antibody to guide best vaccine use?
- **Genetics** – is there a difference between genetic lines in response to vaccine?
- **Diagnostic methods** – next generation methods from the K-State VDL
- **PCV₂ itself** – is it changing and what does that mean?
- **New tools** – tests needed to differentiate strains in infections, vaccinated successfully vs. failed to immunize
- **Virus elimination** – is it possible?
The key to solving any complex problem is the right team plus teamwork.
Coach Prince has his version...
Now we bring you our own K-State PCV$_2$ Team version of the **CATS 2007**!
Bring on the Cats

• At Center, taking in cases as they come

~ Dr. Jerome Nietfeld
Bring on the Cats

• Wide receiver, taking the ball and running it in new directions – ‘get that man the ball!’

~ Dr. Bob Rowland
Bring on the Cats

- Veteran at quarterback, calling the next play

~Dr. Dick Hesse
Bring on the Cats

• At safety, preventing disaster, “not in OUR house!”

~Dr. Steve Dritz

“In God we trust; all others must bring data!”
Bring on the Cats

• Punt returner, sending it right back at you

~Dr. Dick Oberst
Bring on the Cats ~ Offensive line

Getting the job done.

Dr. Jay Jacela
(outstanding walk-on)

Dr. Megan Potter
(new top recruit
out of Purdue)

Dr. Kyle Horlen
(lost to aggressive recruiter from Texas)
Bring on the Cats ~ Defensive Line

Mike Hays

Su-Ann Murdock

Joe Anderson and Jessica Jewell

Amanda McGarry

Heather Wisdom
Bring on the Cats ~ Special Teams

Maureen Kerrigan
Ben Trible
Brandi Struve
Scott Hahn
Sean Smith
Bring on the Cats

• Recruiter, Athletic Director and Funding Pitch-man

~ Dr. Steve Henry

“In God we trust; all others must bring money!”
Bring on the Cats

- Punter, for those 4th and long situations (and several game-saving tackles!)

~ Dr. Lisa Tokach
It Takes Teamwork!

Suther Farms

K-State

B&K Livestock Farms Inc.
Clay Center, KS

PIC

Keevecker Agri Business, Inc.
Washington, Kansas

AAH

Iowa State University
College of Science and Technology

SDSU

Kansas Swine Alliance

K-State

New Horizon Farms LLP

HENRYS LIMITED
Critical Support and Key Efforts

- K-State administrative support – Drs. Wefald, Richardson, Chengappa and Anderson
- K-State VDL team – Drs. Rowland, Nietfeld, Hesse and Oberst developed methods in efficient diagnosis
- K-State developed the PCR test to differentiate PCV$_{2b}$ from PCV$_{2a}$ (Rowland)
- Whole genome sequences for specific, unique identification (Rowland)
- Identified other (unexpected) viruses in affected animals (Hesse)
- Linked vaccinology/immunology between the lab and the field (Hesse)
- Adaptation of the long-respected K-State Swine Team methodology in nutrition investigations to disease interventions (Dritz)
Critical Funding

- K-State (Horlen, Dritz) and Suther Farms – vaccine research trial funded by National Pork Board
- KSA farms provided 50¢ per weaned pig for a year to support KSU investigations ($32,000) and still contributing!
- Dr. Rowland’s lab and research budget
- K-State VDL services
- Pork producers and production systems both in and outside of Kansas
- More grants have been awarded, more funding is being sought
Critical Funding

• Your contributions matter!
Publications

- Kansas herds are affected by PCV$_{2b}$ (321) strain of PCV2
- Immunized animals respond with decreased mortality, increased growth rate - even in herds with mild clinical signs
  - Suther study – accepted *JAVMA*
- A specific, differential PCR test was developed (Rowland) to sort out PCV$_{2a}$ (422) and PCV$_{2b}$ (321) infections and co-infections
  - 24 of 97 cases were co-infected with PCV$_{2a}$ and PCV$_{2b}$
  - Recent discovery of a 321/422 recombinant virus at K-State, first to document recombination in North America
    Manuscript submitted - *Virus Research*
- And more coming…
Key points we’ve learned since we last met

• Circovirus disease is a population-base immunological dysfunction
• PCV$_{2b}$ is a primary pathogen in swine
• Immunization dramatically improves growth performance and lowers mortality
• “Vaccination” and “Immunization” are not equivalent definitions with current vaccines
• Animal genetic lines differ greatly in response to immunization
• Reassortments and new variants are being discovered
Key points we’ve learned since we last met

• Immunization effectively lowers mortality, consistently improves growth rate with evidence of improved feed efficiency

• Immunized animals have low concentrations of virus
  – Identified by differential QPCR methods developed at K-State and the only differential available in the US

• “Vaccination” is not always “Immunization”
  – Antibody titer profiling
Knowing more about this virus

- PCV\textsubscript{2} is a non-enveloped, single stranded, circular DNA virus

- Inactivation, lack thereof:
  - Stable at pH 3 (eats concrete)
  - Resistant to dry heat of 120°C (248°F)
    - 30 minutes only led to 1 log reduction in titer
  - Resistant to pasteurization (wet heat)
    - 65°C (150°F) for 30 minutes had no reduction of titer
    - 75°C (who cares) for 30 minutes only reduced 1.59 logs


Courtesy of Dr. Darin Madson, ISU, AASV Jul ’07
Table 2: Reduction in infectivity of porcine circovirus type 2 (PCV2) after a 10-minute exposure of the virus to commercial and laboratory disinfectants.

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Mean titer after disinfection (log_{10})</th>
<th>SD</th>
<th>Reduction of mean titer^1 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no disinfectant)^2</td>
<td>6.00</td>
<td>0.00</td>
<td>NA^3</td>
</tr>
<tr>
<td>Nolvasan</td>
<td>5.17</td>
<td>0.72</td>
<td>13.9</td>
</tr>
<tr>
<td>DC&amp;R</td>
<td>4.42</td>
<td>0.14</td>
<td>26.4</td>
</tr>
<tr>
<td>Weladol</td>
<td>4.33</td>
<td>0.52</td>
<td>27.8</td>
</tr>
<tr>
<td>Ethanol</td>
<td>4.25</td>
<td>0.25</td>
<td>29.2</td>
</tr>
<tr>
<td>Tek-Trol</td>
<td>4.17*</td>
<td>0.29</td>
<td>30.6</td>
</tr>
<tr>
<td>Fulsan</td>
<td>3.92*</td>
<td>1.13</td>
<td>34.7</td>
</tr>
<tr>
<td>1-Stroke Environ</td>
<td>3.58*</td>
<td>0.63</td>
<td>40.3</td>
</tr>
<tr>
<td>Clorox Bleach</td>
<td>3.25*</td>
<td>1.15</td>
<td>45.8</td>
</tr>
<tr>
<td>Roccal D Plus</td>
<td>3.00*</td>
<td>0.43</td>
<td>50.0</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>2.33*</td>
<td>1.04</td>
<td>61.1</td>
</tr>
<tr>
<td>Virkon S</td>
<td>1.58*</td>
<td>0.80</td>
<td>73.6</td>
</tr>
</tbody>
</table>

1 For each disinfectant, titers were means of an indirect immunofluorescence assay performed on porcine kidney cells (PK-15) 48 hours after inoculation with PCV2 virus stock that had been treated with disinfectant (three replicates). Titers were compared to the negative control.
2 Untreated PCV2 stock used as negative control.
3 NA=not applicable.
* Statistically different (P<.05) from negative control (Dunnett’s test).


Courtesy of Dr. Darin Madson, ISU, AASV Jul ‘07
The Suther Trial

“This trial was the breakthrough in how to do trial work applied to vaccine, the growth impact, and the first trial to link laboratory virology to field performance.”
Suther Trial

• Fantastic support from Micki, Grace, Dan and Ron!

• 300 sow Farrow to Finish Farm

• Nursery groups: One week weaning and AIAO

• Finisher Groups: Two nursery groups combined into a group for hoop barn finishing ~200 head per hoop barn

• PRRS negative

• Historical, recent W->F mortality of >12.5%

• History of PCVD - PCV$_{2b}$ (321) infection
Study Design

• 485 pigs
  – 250 controls & 235 vaccinates
  – Within litter allotment

• Randomized blind clinical trial – 6 weaning groups and 4 finisher groups

• Vaccination - 2 doses (3 & 6 wks age) Intervet

• Pigs weighed at weaning, end of nursery and just prior to market

• Controls and vaccinated pigs housed in the same pen
The Suther Trial

Mortality and Growth Responses
Effect of PCV₂ Vaccination on Mortality Rate

WF & Fin Vaccine Effect P < 0.01

<table>
<thead>
<tr>
<th></th>
<th>Mortality, %</th>
</tr>
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<tbody>
<tr>
<td>Control</td>
<td>18.1</td>
</tr>
<tr>
<td>Vaccinate</td>
<td>7.7</td>
</tr>
<tr>
<td>WF</td>
<td>16.7</td>
</tr>
<tr>
<td>Nur</td>
<td>1.3</td>
</tr>
<tr>
<td>Fin</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Horlen et al. KSU 2007
Effect of PCV₂ Vaccination on ADG

WF & Fin Vaccine Effect P < 0.01

WF & Fin Vaccinate

WF: 1.55 1.66
Nur: 1.05 1.04
Fin: 1.74 1.91

Control
Vaccinate

WF Nur Fin

Horlen et al. KSU 2007

K-State / Suther Farms
Cumulative Mortality During the Finishing Phase

- Control
- Vaccinate

Week of Finishing Phase: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

Horlen et al. KSU 2007
Market Weight Histogram

- Control: Avg = 278
- Vaccinate: Avg = 297

Minimum Market Weight Goal

Frequency

Weight Category, lb

150 175 200 225 250 275 300 325 350 375 >375

Horlen et al. KSU 2007
The Suther Trial

Immune responses
PCV2 Serology

Time After Vaccination

- 0 weeks Before Vaccination
- 3 weeks Booster
- 6 weeks 3wk After Booster
- 14 weeks Mid Finisher

Titer (Log2)

- > 15
- 15
- 14
- 13
- 12
- 11
- 10
- 9
- 8
- 7
- 6
- 5
- < 5

p = 0.6
p < 0.05
p < 0.05
p < 0.05

n = 30
n = 21
n = 30
n = 20
n = 30
n = 21
n = 31
n = 21

Open = Controls  Black=Vaccinates
PCV$_2$ Serology

Time After Vaccination

- 0 weeks Before Vaccination
- 3 weeks Booster
- 6 weeks 3wk After Booster
- 14 weeks Mid Finisher

Open = Controls Black = Vaccinates
PCV₂ Serology

- Before Vaccination
- Booster
- 3 wk After Booster
- Mid Finisher

Time After Vaccination

- 0 weeks
- 3 weeks
- 6 weeks
- 14 weeks

Open = Controls
Black = Vaccinates
PCV₂ Serology

Time After Vaccination

0 weeks Before Vaccination
3 weeks Booster
6 weeks 3wk After Booster
14 weeks Mid Finisher

Open = Controls Black=Vaccinates
Summary of The Suther Trial

- Significant reductions in mortality, increased finisher pig growth rate, and fewer lightweight pigs at market
- Suggests an effective level of cross-protection (vaccine is 422, field virus is 321)

Bottom Line

- Vaccine is an *effective tool* to aid in the control of PCVD
- Significant economic benefit in vaccinated pigs
- First field study to link virology and growth performance
Virology

Things we’ve learned about this nasty little virus…
Genome sequences of four separate farm isolates from clinical cases cluster closely together, most like the RFLP 3-2-1 and AF055393 (French isolate) Are substantially different than the RFLP 4-2-2 variants found also in affected herds and in all unaffected tested thus far.
Differential PCV$_2$ PCR

PCV$_2$ signature motif

PCV2a (422) 1463-TATGAGATTTTGTTG
PCV2b (321) 1462-C.C...CGGGGG..A

A

PCV2 Template b a b a
Reverse Primer b b a a

B

Virus Isolate

1 2 3 4 5 6 7 8

PCV2a

PCV2b

C

Serum Sample

1 2 3 4 5 6 7 8 9 10

PCV2a

PCV2b

24 of 97 samples Dx lab submissions showed the presence of both PCV2a and PCV2b in the same pig

K-State
Differential PCR
SYBR Green and TaqMan

High
Con

Low
Con

Fluorescence vs. Cycles graph:
- High and low conditions are indicated.
- The graph shows the amplification curve with Ct values.

Standard Curve graph:
- Represents the amplification efficiency.
- The efficiency is 94%.

K-State University logo
Differential qPCR
SYBR Green and TaqMan
Melting Curve Results
PCR Results

Mean Vaccine = 1.3

Mean Control = 2.6

PCV2 DNA Concentration (log_{10} templates/rxn)
The Pipestone/KSU Research Trial #1

“This trial investigated field performance results of PCV$_2$ vaccinated pigs in a controlled commercial production setting.”
Evaluation of PCV₂ Vaccination in a Commercial Research Finishing Barn (Trial 1)

- PRRS POS - Historical Finisher Mortality ≈ 6%
- Histopath lesions of PCVD had been previously characterized
- Genetic Background: PIC 337/280 x 1050

- Commercial PCV2 Vaccine became available

- Pigs were vaccinated at 9 and 11 weeks of age (Late!)
- Pigs housed within pens by vaccination or controls in a single finisher
- 24 pens (650 pigs) controls and 24 pens (650 pigs) vaccinates
Effect of PCV$_2$ Vaccination on Mortality - Trial 1

Clinical signs and histopath lesions consistent with PCVD were noted in pigs from this barn.

Mortality, %

Control: 5.6
Vaccine: 3.0

P <0.02
Effect of PCV2 Vaccination on ADG and Feed Efficiency - Trial 1

ADG, lb

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2.03</td>
<td>2.10</td>
<td></td>
</tr>
</tbody>
</table>

FG

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>2.57</td>
<td>2.52</td>
<td></td>
</tr>
</tbody>
</table>
Economics: Mortality, growth rate, and feed efficiency improvements were calculated to result in a benefit of $3.94 per pig
The Pipestone/KSU Research Trial #2

“Repeated Trial #1 with a younger vaccination age closer to label recommendations with the next group in the barn.”
Evaluation of PCV$_2$ Vaccination in a Commercial Research Finishing Barn (Trial 2)

- Same production system and commercial PCV$_2$ Vaccine as Trial 1
- Pigs were vaccinated at 5 and 7 weeks of age
- Pigs were housed in the same barn as Trial 1

- Pigs housed within pens by vaccination or controls in a single finisher
- 21 pens (592 pigs) controls and 24 pens (661 pigs) vaccinates
Effect of PCV₂ Vaccination on Removal Rate, Trial 2 d 0 to 105

Clinical signs and histopath lesions consistent with PCVD have been noted in pigs from this barn.
Effect of PCV$_2$ Vaccination on Cumulative Removal Rate - Trial 2 d 0 to 105

Week of Finishing Phase

Frequency

Control
Vaccinate
Effect of PCV$_2$ Vaccination on ADG and FE
Trial 2 d 0 to 105

- ADG, lb
  - Control: 1.96
  - Vaccine: 2.03
  - P < 0.01

- FG
  - Control: 2.54
  - Vaccine: 2.48
  - P < 0.14
Effect of PCV₂ Vaccination on ADG over Time
Trial 2 d 0 to 105

<table>
<thead>
<tr>
<th>Period, Days</th>
<th>Control</th>
<th>Vaccinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 14</td>
<td>1.52</td>
<td>1.49</td>
</tr>
<tr>
<td>14 to 28</td>
<td>1.95</td>
<td>1.92</td>
</tr>
<tr>
<td>28 to 42</td>
<td>2.24</td>
<td>2.14</td>
</tr>
<tr>
<td>42 to 56</td>
<td>2.13</td>
<td>2.20</td>
</tr>
<tr>
<td>56 to 70</td>
<td>2.26</td>
<td>2.29</td>
</tr>
<tr>
<td>70 to 84</td>
<td>1.88</td>
<td>1.98</td>
</tr>
<tr>
<td>84 to 98</td>
<td>2.26</td>
<td>2.20</td>
</tr>
<tr>
<td>98 to 105</td>
<td>2.06</td>
<td>1.94</td>
</tr>
</tbody>
</table>

K-State
Effect of PCV₂ Vaccination on Cumulative Removal Rate - Trial 2 d 0 to 105

Week of Finishing Phase

0% 2% 4% 6% 8% 10% 12% 14% 16% 18%

Frequency

0.0% 0.7% 0.6% 1.7% 0.9% 1.5% 1.5% 2.1% 2.3% 2.8% 3.0%

Control

Vaccinate

K-State
Effect of PCV2 Vaccination on Average Initial and Final Pig Weight - Trial 2

<table>
<thead>
<tr>
<th></th>
<th>Initial, lb</th>
<th>D 105 Weight, lb</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>57.7</td>
<td>263.1</td>
</tr>
<tr>
<td>Vaccine</td>
<td>56.5</td>
<td>269.4</td>
</tr>
</tbody>
</table>

P < .01

Control Vaccine
Economics: Mortality, growth rate, and feed efficiency improvements were calculated to result in a benefit of **$8.68 per pig** ($3.94 in Trial 1)
The J-Six Antibody Trial

“Can we vaccinate pigs in the farrowing house at younger ages and will ½ dose of vaccine be equivalent to full dose?”
J-Six Antibody Trial

- Genetic Background: Triumph TR4 x PIC C22
- PRRS positive
- Multi-site KS production system
J-Six Antibody Trial

Experimental Design:
• 25 pigs per treatment 1 pig per litter for each treatment,
• Bled at weaning, end of nursery and mid finishing

Treatments:
Control – No vaccination
Young Full – 1 and 3 weeks of age and 2 x 2 ml dose
Old Full - 3 and 5 weeks and 2 x 2 ml
Young Half – 1 and 3 weeks and 2 x 1 ml
Old Half – 3 and 5 weeks and 2 x 1 ml
Geometric Mean Titer

Pigs with ≤ 320 at 3 weeks
Geometric Mean Titer

Pigs with > 320 at 3 weeks

- 3 Week
- 9 Week
- 18 Week

Young Old Young Old

Full Half Control
Prevalence of Natural Infection
Defined as a rise in titer from the 9 to 18 week sample

\[ a, b \ P < 0.05 \]

- Young Full: 35%
- Old: 6%
- Young Half: 30%
- Old: 26%
- Control: 37%

\[ a \]

\[ a, b \]
Passive maternal antibody interference with immunization?

- Appears that pigs with ≤320 develop a post-vaccination response
- Suggests antibody response is inhibited by antibody titer >320
- Many new questions….
The Keesecker Agri Business Trial

“Are all PCV₂ vaccines created equally?”
KAB: comparative vaccine trial

- Treatments:
  - Unvaccinated Controls
  - One Dose PCV Chimera vaccine (Fort Dodge)
  - Two Dose Baculovirus vectored vaccine (Intervet)
Background Information

- Genetic Background: Triumph TR4 x PIC C22
- 1,470 Pigs randomly allotted to control or the two vaccine treatments
- Three different weaning groups
- Treatment pigs commingled within the same pens
- PCVD histopath lesions confirmed in each of the three weaning groups
Effect of PCV$_2$ Vaccination on Mortality Weaning to Market

No significant differences

Mortality, %

Control: 11.0
FortDodge: 7.8
Intervet: 7.7
Effect of PCV$_2$ Vaccination on ADG
Weaning to Day 143 after weaning (just prior to first pigs marketed)

<table>
<thead>
<tr>
<th></th>
<th>ADG, lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.53</td>
</tr>
<tr>
<td>FortDodge</td>
<td>1.58</td>
</tr>
<tr>
<td>Intervet</td>
<td>1.60</td>
</tr>
</tbody>
</table>

a, b P < .05
Day 143 after Weaning Difference in Average Weight

- Control: 0.0 lb
- FortDodge: 7.6 lb
- Intervet: 10.2 lb
Market Weight Histogram
Day 143 after weaning (just prior to first pigs marketed)

- Control Avg=237.3
- 1 Dose Avg=244.8
- 2 Dose Avg=247.4
The Genetic Trial

“Do all genetic lines respond to PCV<sub>2</sub> virus and vaccination equally?”
Clinical Signs and Background

- Diagnosis of PCV\textsubscript{2b} infection in early ’06 based on histopathologic lesions and the presence of virus (IHC and PCR)
- Mortality was not the primary clinical sign
- Clinical manifestation was an increasing incidence of ill-thrift and stunted pigs
- Morbidity rather than mortality.
Genetic by Vaccine Response Interaction Trial

Genetic background of the two lines:
- A: Duroc-based line
- B: Synthetic sire line
  (Duroc, Pietran & Large White)

PRRS and Myco Negative Herd
Experimental Plan

- Randomly allot to control and vaccinate balanced within genetic combination (AxA, AxB, BxA, BxB)
- Initially 454 pigs placed on-test
- Vaccine was administered at weaning and three weeks later – Intervet Vaccine
- Controls intermingled with vaccinates
Allotment to Treatment

- Pigs were ranked by birth weight within litter and gender
- Randomly assigned to control or vaccinate based on birth weight balanced across treatment
- Treatments:
  - Vaccine: Control or PCV2 Vaccine
  - Genetic: AxA AxB BxA BxB
  - Gender: Boar or Gilt
- Birth weight was balanced across vaccine treatment within each genetic combination
Effect of PCV₂ Vaccination and Genetic Line on Off Test Weight

Trt x Genetic $P = .05$

- **Control**
- **Vaccinate**

<table>
<thead>
<tr>
<th>Genetic Line</th>
<th>A x A</th>
<th>AXB/BXA</th>
<th>B x B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccinate</td>
<td>221</td>
<td>235</td>
<td>221</td>
</tr>
<tr>
<td>Control</td>
<td>201</td>
<td>227</td>
<td>226</td>
</tr>
</tbody>
</table>

Weight, lb
Effect of PCV$_2$ Vaccination and Genetic Line on Fat Depth at Off Test

Trt $P = .13$ Genetic $P = .02$ Trt x Genetic $P = .46$

![Bar chart showing the effect of PCV$_2$ vaccination and genetic line on fat depth at off test.](chart.png)

- Control = 11.3
- Vaccinate = 11.6

<table>
<thead>
<tr>
<th>Treatment Combination</th>
<th>Depth, mm</th>
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<tbody>
<tr>
<td>AxA</td>
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<tr>
<td>AxB</td>
<td>12.0</td>
</tr>
<tr>
<td>BxA</td>
<td>11.2</td>
</tr>
<tr>
<td>BxB</td>
<td>10.6</td>
</tr>
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</table>

K-State / AAH / PIC / Henrys Limited
Effect of PCV₂ Vaccination and Genetic Line on Fat Depth at Off Test

Adjusted to a Common Off Test Weight

Control = 11.3
Vaccinate = 11.6

Trt P = .62 Genetic P = .002 Trt x Genetic P = .79

Depth, mm

AxAX

AxB

BxA

BxB

K-State
AAH
PIC
HENRYS LIMITED
Effect of PCV$_2$ Vaccination and Genetic Line on Loin Depth at Off Test

Trt $P < .01$ Genetic $P < .01$ Trt x Genetic $P = .32$

- Control = 65.9
- Vaccinate = 66.9

<table>
<thead>
<tr>
<th></th>
<th>AxA</th>
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<th>BxA</th>
<th>BxB</th>
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<tbody>
<tr>
<td>Control</td>
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<td>Vaccinate</td>
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<td>66.9</td>
<td>69.0</td>
<td>69.6</td>
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Effect of PCV₂ Vaccination and Genetic Line on Loin Depth at Off Test

Adjusted to a Common Off Test Weight

Trt $P = .29$ Genetic $P < .01$ Trt x Genetic $P = .82$

Control = 65.6
Vaccinate = 66.0

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K-State
HENRYS LIMITED
Effect of PCV2 Vaccination and Genetic Line on Wean to Finish ADG

Trt $P < .01$  Genetic $P < .01$  Trt x Genetic $P = .04$

<table>
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<tr>
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<th>Control</th>
<th>Vaccinate</th>
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<td>1.63</td>
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<td>1.71</td>
</tr>
<tr>
<td>BxB</td>
<td>1.60</td>
<td>1.63</td>
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</table>

K-State / AAH / PIC / Henryrys Limited
Effect of PCV$_2$ Vaccination and Genetic Line on Finisher ADG

Trt $P < .01$  Genetic $P = .03$  Trt x Genetic $P = .05$

<table>
<thead>
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<th>Genetic Line</th>
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<tbody>
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<td>Vaccinate</td>
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<td>BxB</td>
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<td></td>
<td>1.95</td>
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</tbody>
</table>

K-State

K-STATE

HENRYS LIMITED
Off Test Weight Histogram – AxA

- Control Avg = 201
- Vaccinate Avg = 221

Frequency

Weight Category, lb

<140 160 180 200 220 240 260 280 300 >300

K-State / AAH / PIC / HENRYS LIMITED
Off Test Weight Histogram – BxB

- Control Avg=221
- Vaccinate Avg=226

Frequency vs. Weight Category, lb

Weight Category, lb: <140, 160, 180, 200, 220, 240, 260, 280, 300, >300

Frequency (%):
- 45%
- 40%
- 35%
- 30%
- 25%
- 20%
- 15%
- 10%
- 5%
- 0%
Maternal Immunity

“What role does maternal immunity play in the vaccination of the young pig?”
Maternal antibody impact on vaccine response

• IFA antibody titers compared over time
  − Pre-vaccination at 21 days of age
  − 60 day sample (~3 weeks after second vaccination)
  − 150 day sample at off-test

• Field virus infections occurred early in controls in this farm

• Work is ongoing to relate QPCR to antibody to growth response
<table>
<thead>
<tr>
<th>Trial Tag</th>
<th>Group</th>
<th>IFA Titer (3/15/07) (Bleed 1)</th>
<th>IFA Titer (4/23/07) (Bleed 2)</th>
<th>IFA Titer (7/23/07) (Bleed 3)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>IFA Titer (7/23/07) (Bleed 3)</td>
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</table>
Now I am reduced to guessing – until PCR is complete

<table>
<thead>
<tr>
<th>Trial Tag</th>
<th>Group</th>
<th>IFA Titer (3/15/07) (Bleed 1)</th>
<th>IFA Titer (4/23/07) (Bleed 2)</th>
<th>IFA Titer (7/23/07) (Bleed 3)</th>
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</table>
Maternal antibody study-the RIGHT (aka Dritz) way

- Study begins next week
- “Does maternal antibody block benefits of vaccine for growth AND antibody production?”
- K-State & Arizona Pork Producers
The B&K Livestock comparative vaccine & antibody trial
Comparative trial, vaccine and dose

- 620 weaned pigs from sow farm to off-site nursery finisher
- History of severe PCV losses in previous groups
- 6 groups of 15 pigs each selected at random for treatment, no non-vaccinated controls (welfare)
  - BI full dose, BI half dose groups
  - Intervet full dose, Intervet half dose groups
  - Ft Dodge full dose, half dose groups
- Sampled at 3, 5, 11 and 18 weeks of age
- Little wild-type virus present in this study
Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)

Full and Half Dose Combined

Trt x Age $P < .01$

Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)
Full and Half Dose Combined

Trt x Age $P < .01$
Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)

Full Dose

Trt x Age x Dose $P = .21$

<table>
<thead>
<tr>
<th>Age, weeks</th>
<th>Boehring</th>
<th>FortDodg</th>
<th>Intervet</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>649</td>
<td>710</td>
<td>1078</td>
</tr>
<tr>
<td>5</td>
<td>410</td>
<td>383</td>
<td>875</td>
</tr>
<tr>
<td>11</td>
<td>272</td>
<td>283</td>
<td>1490</td>
</tr>
<tr>
<td>23</td>
<td>43</td>
<td>60</td>
<td>302</td>
</tr>
</tbody>
</table>

Legend:
- **Red**: Rohring
- **Blue**: FortDodg
- **Green**: Intervet
Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)

Half Dose

Trt x Age x Dose $P = .21$

<table>
<thead>
<tr>
<th>Age, weeks</th>
<th>Boehring</th>
<th>FortDodg</th>
<th>Intervet</th>
</tr>
</thead>
<tbody>
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<td>3</td>
<td>588</td>
<td>867</td>
<td>863</td>
</tr>
<tr>
<td>5</td>
<td>307</td>
<td>481</td>
<td>591</td>
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<tr>
<td>11</td>
<td>319</td>
<td>481</td>
<td>588</td>
</tr>
<tr>
<td>23</td>
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<td>64</td>
<td>48</td>
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</table>

$P = .21$
Intervet Vaccine - Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)

Trt x Age x Dose $P = .21$

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<thead>
<tr>
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<th>Full</th>
<th>Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1078</td>
<td>867</td>
</tr>
<tr>
<td>5</td>
<td>875</td>
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<td>11</td>
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<td>766</td>
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<td>302</td>
<td>70</td>
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</table>

K-State / AAH / Kansas Swine Alliance / B&K Livestock Farms Inc.
Fort Dodge Vaccine - Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)

Trt x Age x Dose $P = .21$

- **GMT**
  - 0
  - 500
  - 1000
  - 1500
  - 2000

- **Age, weeks**
  - 3
  - 5
  - 11
  - 23

- **Growth in GMT (Bleed x Treatment)**
  - **Full**
    - 710
    - 383
    - 283
    - 60
  - **Half**
    - 863
    - 591
    - 319
    - 64

- **K-State**
  - AAH
  - Kansas Swine Alliance
  - B&K Livestock Farms Inc.
BI Vaccine - Effect of PCV$_2$ Vaccine and Time on IFA GMT (Bleed x Treatment)

Trt x Age x Dose $P = .21$

**Age, weeks**

<table>
<thead>
<tr>
<th>Age, weeks</th>
<th>Full</th>
<th>Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>649</td>
<td>481</td>
</tr>
<tr>
<td>5</td>
<td>410</td>
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</tr>
<tr>
<td>11</td>
<td>272</td>
<td>307</td>
</tr>
<tr>
<td>23</td>
<td>43</td>
<td>48</td>
</tr>
</tbody>
</table>
Our Observations from the field

• Full doses are *absolutely* recommended if possible
  – Demonstrated antibody response is better
  – Clinically fewer lightweight pigs
  – Clinically fewer affected pigs than half dose

• Maternal passive immunity inhibits antibody response to vaccine
  – The younger the pig, higher the passive antibody and less likely to effectively immunize?
  – But must immunize before infected/viremic
  – Impact on performance trials to be done

• Two doses appear to produce a superior response over single dose
Summary: antibody results and questions for future research

• IFA has high correlation with SN

• Question of passive interference with immunization is not answered conclusively
  – Variation herd-to-herd and group-to-group
  – Why do some groups/pigs apparently fail?
  – Timing vaccinations, repeated doses?

• New antibody tests being developed
  – Quantitative DIVA, differential ELISA

• Essential for compliance, apparent failure and herd status/timing decisions
NPB
The Mega Study

“This multi-institutional research will develop much needed tools and build towards next generation circo virus vaccines.”
“PCVAD Induced Immune Dysfunction”

- To develop antibody tests that will differentiate viruses in an infection
- To discriminate vaccine responses from field viruses
- To quantitate the antibody response and define relevance
More Experience
From the Field
Placed since 7/1/06 - Mortality + Light-weight Culls (<225#) by placement date

Red diamonds = "Single Dose Ft Dodge"
Green diamonds = "Two Dose Intervet"
Blue diamonds = Non-vaccinates
Conclusions:

- Circovirus disease, with the immunologic and growth impacts, has changed our view of population health.
- Immunization success, and vaccine product diversity, is a wonderful beginning for disease management.
- Many questions are yet to be addressed, including possibilities for elimination from populations.
- Collaborative research efforts are critical to future progress.
What lies ahead?

• Vaccine
  – next generation vaccines?
  – Effect over time and the emergence of new “strains”?

• Maximizing benefit – the growth effect of PCV; can we immunize all animals?

• Sows and gilts – what to do and what not?

• Needed tools
  – KSU research, others
Thanks to our ever-growing team!
We’ve come a LONG way in a year!
It’s nice to see healthy pigs again.
Thanks to everyone for all their support
Thanks to our team for a slam dunk!

Any questions?