Porcine Epidemic Diarrhea virus (PEDv), Delta corona (SDCv) and PED variant (PDCoV)

September 20th 2014
Madras Workshop

Dr. Steve Henry, Abilene Animal Hospital PA, Abilene KS
Something new....
porcine coronaviruses from Asia

• PEDv entered the US in April 2013; how it entered still unknown
• PED virus genome closely related to Asian strains; specifically a strain in China’s Anhui Province
• Later in 2013 a genetic variant to PEDv was identified, differed from ‘classic’ and is PDCoV
• Now a third (Asian?) coronavirus, delta coronavirus (SDCv), is causing outbreaks in US, now in KS herds
It’s not just us...

- South Korea in December 2013
  Says it’s a U.S. strain
- Taiwan in October/November 2013
- Mexico in June 2013
- Peru in September 2013
- Dominican Republic
- Canada Jan 2014
- Columbia in March 2014

- **All going through similar events**

  Dr. Paul Yeske, Leman 2014
“Slow down! What are coronaviruses?”

(Stick with me – sorry, this is not simple.)
Coronaviruses

**Alphacoronavirus**: pigs - TGEv, PRCv, PEDv; cats – Feline Infectious Peritonitis

- Antibody cross-reactive between TGEv and PRCv
- No antibody cross-protection between TGEv and PEDv

**Betacoronavirus**: pigs - PHEv; humans – SARS, MERS; cattle - calf diarrhea and Winter Dysentery in dairy cows

**Deltacoronavirus**: pigs - SDCv; avian viruses

**Gammacoronavirus**: avian – infectious bronchitis
Basic PEDv information

Need to know about porcine coronaviruses

• Porcine coronaviruses do not affect people
• PEDv and deltacoronavirus are not food safety concerns
• They do not affect other species, just pigs
• PEDv is NOT a new virus - Europe and Asia for some years; delta also previously known
  – Cross-protection is limited or absent
• There are no effective vaccines or treatments
• Clearly some portal or fomite is open into the US, globalizing these swine diseases
Pathology of PEDv

*How does it work?*

- Highly infectious and pathogenic, brief incubation period ~24 hours
- Destroys the mature enterocytes lining the small intestine -> severe watery diarrhea and dehydration
- All ages of pigs are affected, adults become immune, temporarily, after recovery
- Death loss of ~100% in nursing pigs; little death loss in weaned and older pigs but morbidity, suffering, weight loss
Impact of acute infection

- Farrowing – infection spreads rapidly, death within 24 hours for baby pigs; <3wks of age nearly all die
- Farrowing – 100% of piglets continue die for 3 weeks and then slow improvement as recovered, immune sows begin to farrow.
- Piglet survival back to roughly normal levels in 5 weeks = “best case”
- Older pigs generally recover rapidly
- To estimate losses – roughly 5 weeks of piglets or 10% of annual production
“Why is PED so deadly for baby pigs and not for older animals?”
Mature enterocytes are the permissive (target) cell for PEDv
Enterocytes – what is happening with PED
Immunohistochemistry (IHC)

1. Normal neonatal pig: Healthy, long intestinal villi

2. Early PEDv infection (~8 hrs PI): Infected cells (brown stain) line the villi

3. Late PEDv infection (~36 hrs PI): Severe villus atrophy & loss of absorptive epithelium

4. Late PEDv infection (~36 hrs PI): Few infected cells remain (brown stain) & absorptive cells destroyed

(Source: Schwartz, Madson, Magstad et al.)
“So just how bad is this outbreak? How many pigs have died? What impact is this disease having on food supplies?”
Cases confirmed in 30 states.
Perspective on the US swine industry

- Standing inventory of all swine ~65 million
- Sows (breeding herd) ~5.65 million
- Market ~110 million head per year

- “Best estimate” of baby pig losses thus far ~7 million
- “Best estimate” is that 50-60% of nation’s sows have been affected
Cases confirmed in 30 states. Pigs now old enough to be marketed. Supply effect?
“How do farms become infected? How does the virus survive? What must we know to protect farms that aren’t yet infected?”
PEDv infection and environment

• High virus levels in diarrhea; feces are the principal vector. A fecal-oral disease.
• Can survive in manure storage, damp manure for at least 28 days (Goyal)
• Very small amount needed to infect (one thimbleful of diarrhea has enough virus to infect entire US pig population!)
• Contaminated transport, even aerosol
• Feed – especially plasma, porcine products
• Survival increases dramatically in cold weather
Environmental survival – Sagar Goyal (U Mn)
Pork Board Grant #13-215

• **Survival of PEDV in fresh feces:** up to 7d at 104°, 122°, 140° F @ RH 30, 50 and 70%

• **Survival of PEDV in slurry:** at least 28d at 40° and -4°F, 14d at 77°F

• **Survival of PEDV in drinking and recycled water:** Infectious PEDV was detected after 1 week in both drinking and recycled water.

• **Survival of PEDV in animal feed:** At room temperature, PEDV RNA was not degraded in wet feed for 28 days. In dry feed, however, the virus survived for only 1 week but not for 2, 3, 4, and 5 weeks.

• **Infectious dose of PEDV:** Serial 10-fold dilutions of PEDv (clarified homogenate of intestinal mucosa from infected piglet) were prepared. Dilution at $10^{-6}$ (a million to one) produced infection. *(approx 1 teaspoonful in 1,300 gallons of water)*

• **Stable in the environment under normal temperature ranges**
Vectors are of great concern

Vectors = mechanical carrying of virus place to place

• Transporting dead animals believed to be high transmission risk – i.e. rendering (*push for on-farm composting!*)

• Manure application and contamination are a considered high risk

• Contaminated vehicles, *people* tracking virus especially a concern with ice/snow/mud if contaminated with manure

• Aerosol of manure “dust” appears possible
Decontamination of facilities

“Cannot disinfect dirty – CLEAN first!”

• **Hot water** washing with detergent is recommended
  – Milk fat is hard to remove from surfaces without heat
  – Detergents saponify fats i.e. Barnstorm, Biogel

• Emptying slurry from pits is a first step

• Cleaning and disinfection – some disinfectants are highly effective (but not Lysol....)

• Thinking about ‘categories of disinfectants…..
<table>
<thead>
<tr>
<th>Characteristics of Selected Disinfectants against PEDv and PRRSv</th>
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<tbody>
<tr>
<td><strong>Disinfectant Category</strong></td>
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<tr>
<td>Sample Trade Names</td>
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<tr>
<td>PEDv and PRRS viruses</td>
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<tr>
<td>Efficacy with organic matter</td>
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<tr>
<td>Efficacy with Hard Water</td>
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<td>Efficacy with Soap, Detergents</td>
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Disinfectants – how to decide?

• “Need it now...” = oxidizing agents
  – Virkon S®, Accel® - facilities, vehicles, equipment, materials
  – Bleach (8.25%) – facilities with caution

• “Need it tomorrow...can dry...” = aldehydes
  – Synergize®, DC&R® - facilities

• “Tough to clean....” = whitewash
  – Old-time oxidizing method
  – Ca(OH)₂ 100# in 50gal water ± salt
  – Over-night mixing required
Risk management

• Cleaning and disinfection – most disinfectants are highly effective (but not Lysol….)

• Heat and drying - 160°F for 10 minutes; ‘trailer baker’ technology (Holtkamp)
Risk management

• Cleaning and disinfection – most disinfectants are highly effective (but not Lysol....)
• Heat and drying – 160°F for 10 minutes; ‘trailer baker’ technology
• Contamination – dead stock removal, transport, service personnel and equipment, animal collection points, harvest plants
Risk management

• Cleaning and disinfection – most disinfectants are highly effective (but not Lysol....)
• Heat and drying - 130°-150°F for 20 minutes; ‘trailer baker’ technology
• Contamination – dead stock removal, transport, service personnel and equipment, animal collection points, harvest plants
• Workers, staff, service, visitors.....
“OK. The worst happens, PED strikes our farm. How do we intervene?”
Acute PED – the first 3 weeks...

• Realize young, nursing piglets will die
  – Some pigs older than 10 days may survive
  – Comfort, don’t allow suffering, humane euthanasia (CO₂ chambers)

• Sows, pigs of all ages may develop diarrhea but recover in 3-5 days (may well go unobserved....)

• Must expose the breeding herd to live virus in order to stimulate effective immunity for the future
  – Collect acute phase diarrhea from piglets to expose the breeding herd; first 24 hours of diarrhea = lots of virus

• “Clean until it hurts!”
Exposing the pregnant breeding herd to PEDv to initiate immunity...

• No! It is not necessary to ‘grind up dead piglets’ to feed to the sows!!!! (in spite of sensational press to the contrary)

• Piglet diarrhea, from the first hours of infection, contains massive loads of virus – used to expose sows by oral exposure (i.e. spray on feed)

• Monitor each sow for illness
“Why?”

- the two tools to control PED -

1. **Immunity** - use of live virus exposure to build immunity in the sow and to stimulate IgG and IgA production in sow's milk.

2. **Sanitation** - remove infectious virus from the piglet’s environment.
Lactogenic immunity

“the power of mother’s milk”

- Baby pigs are born with no protective antibodies to infectious disease
  - 6 layer placenta protects in the uterus
- Completely dependent on mother for antibody protection by:
  - Colostrum – first 2 days milk, IgG antibodies into circulation
  - Milk – continues through lactation, IgA antibody protects, capturing agents in baby pig intestine
Lactogenic immunity
“the power of mother’s milk”

• Substantial infection of sow’s intestine stimulates cell-mediated immunity
  – Lymphocytes from gut migrate to mammary gland, establish antibody-producing capability
  – The IgA antibody is secreted with milk to ‘capture’ virus
  – As long as antibody-rich milk flows, pigs are protected

• Much more complicated than colostrum alone
The PED Challenge

After the initial acute infection the farrowing environment is contaminated so....

• Every time a newborn piglet suckles an immune dam it ingests protection to PED.
• Every time a newborn piglet opens its mouth it ingests PED virus.
• Too much virus and not enough immunity equals diarrhea.
• This virus can easily overwhelm maternal protection!
Sanitation!!!

• Concentration of virus particles in piglet diarrhea is ~10,000 times that of adult diarrhea
• Farrowing area most contaminated
• Wash, detergent, re-wash, disinfect, dry
• Great care to not expose new litters
  – Closed room, ‘booted and suited’ caretakers
  – No piglet transfer or processing until youngest is 7 days old
  – Drying powder for scouring litters, Mistral®
The long term....

• Goal is to eliminate virus from infected maternity farms; sometimes possible?
• We do not know and time/experience will tell if endemic, repeated cycles of infection will be the reality
• Many efforts toward vaccine development; (Harris Vaccines, Zoetis conditional vaccines)
• Funds flowing to research
• USDA has declared PED a Reportable Disease
What is key about “reportable”? 

• Anyone with knowledge of infection must report to State or Federal veterinarian
• Laboratories must report positive results to State and Federal
• Does NOT restrict movement of animals in the case of PED
• Handled anonymously with Premise ID
• Laboratory testing is paid by USDA
How are herds recovering? Can the virus be eliminated?

### TTS - Results

| Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 | Week 15 | Week 16 | Week 17 | Week 18 | Week 19 | Week 20 | Week 21 | Week 22 | Week 23 | Week 24 | Week 25 | Week 26 | Week 27 | Week 28 | Week 29 | Week 30 |
|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Site 1 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 2 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 3 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 4 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 5 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 6 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 7 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 8 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 9 |        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 10|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 11|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 12|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 13|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 14|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 15|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 16|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 17|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 18|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 19|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 20|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 21|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Site 22|        |        |        |        |        |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |

- Tested: Positive
- Tested: Neg (too few litters)
- Tested: Negative
- Stable

Dr. Dane Goede, AD Leman Conf, Sept, 2014
“Anticipating shows, fairs, exhibitions, sales.....what to expect? What surprises await?”
There will be incidents and lots of questions....

- Infected fair pigs may have transient, watery diarrhea and recover quickly (looks like other diseases)
- This virus will be rapidly tracked under the traffic patterns at fairs (can’t disinfect your way out of that reality)
- Likely some (many?) pigs are already recovered and immune in some states, pigs move to shows!
- RISK is taking virus home if there are nursing litters on the farm
- **THERE IS NO RISK TO PEOPLE OR OTHER ANIMALS!**
Why is it hard to “control movement” of PEDv?

- Traditional regulatory methods don’t fit well...
  - Temperature of pigs, easy to measure, is useless as no fever elevation with PEDv in growing pigs
  - No simple screening tests to identify herd as an infection risk
  - Veterinary inspection and ‘health papers’ = no suspicious diarrhea on date of inspection; 30 day rule is valueless for PEDv
  - Asymptomatic pigs can shed virus
Cooperate with each other!

• Big risk is to breeders of show pigs – farrowing is time to “hunker down” and protect
  – If PED infection happens, work to clean up (take advantage of free testing)
  – Communicate with others, try not to spread

• 4-H pigs may get PED, will nearly all survive and recover with limited damage
  – Work on plans for tagging and identification that does not require concentrating pigs before shows
Finally....

• There are no effective vaccines.....yet
• And no effective treatments.....
• **BUT** there are many opportunistic purveyors of “Magic Fairy Dust” to take advantage of anxious pig owners
  – Pomegranate & Green Tea, Pepper Powder, Egg Yolk, etc, etc....
• Education---our job for the kids – protect them from the ‘wallet vacuum’ salesmen
Information on the PEDv crisis

- [www.aasv.org](http://www.aasv.org) Porcine Epidemic Diarrhea Information section

- For reference from web site:
  - Exhibition Recommendations
  - Disinfectants
  - Market Biosecurity
  - Transportation Biosecurity
  - Manure Hauling Biosecurity Guidelines