

Title: Impact of pig farm density on incidence of PRRS in a cohort of sow herds – NPB #12-139

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Industry Summary:

This project was designed to measure the incidence of PRRS infection in a cohort of US sow herds. Additionally, it sought to conduct a risk assessment based on the density of swine farms around a sow herd and the odds of reporting a new PRRS infection between 2009 and 2013. Finally, an air sampling project was undertaken within high density regions to attempt to describe the frequency of detection of PRRS using previously validated collection methods.

Objective 1 was to document, describe and study patterns of PRRS in the US sow herd. This project showed a highly repeatable pattern of infections was observed between 2009 and 2012. In each of the first four years of this study, the number of new PRRS infections was very low during the summer months, and then rapidly increased during the fall and winter. Using a statistical method to monitor these infections, we have documented the onset of the annual PRRS epidemic in the middle week of October. Additionally, we were able to show clustering of reported new PRRS infections in Northern/Northwestern Iowa. The results of this objective have been published in National Hog Farmer, presented at several scientific presentations, and are due to be published in peer review literature in January 2015.

Strikingly, the pattern of PRRS infections was very different in 2013. This year, the onset of the annual PRRS epidemic was delayed 2-3 weeks. Additionally, significantly fewer new PRRS infections were reported overall. Interestingly, the clustering of new infections remained in the same area as previously documented. The results of this year of the project are being reported separately in peer reviewed literature, discussed at scientific presentations and reported in National Hog Farmer. It is suspected that the introduction of porcine epidemic diarrhea virus into the US sow herd in late 2012, early 2013 might play a role in this pattern and studies are being conducted to analyze patterns of herds infected with one, both or neither of these diseases.

These research results were submitted in fulfillment of checkoff-funded research projects. This report is published directly as submitted by the project's principal investigator. This report has not been peer-reviewed.

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Taken together, this objective has documented a highly repeatable pattern in PRRS infections. Knowing that the PRRS virus epidemic is looming, has motivated swine producers to increase biosecurity practices and prepare thoroughly before the fall epidemic.

Objective 2 was to conduct a risk assessment based on density of swine farms around a sow herd and the odds of reporting a new infection. We utilized data from the Production Animal Disease Risk Assessment Program (PADRAP) which has a count of farms at various distances from the sow farm completing the survey. These data are then used to compute the odds of reporting a new infection each year. In this study we found that as number of farms increased, so did the odds of reporting a new PRRS infection. There are, however, some important limitations of this study. First, it is extremely difficult to obtain PRRS status of neighboring farms. Additionally, it is difficult to know for how long these farms would have active infection that could generate a plume of aerosol virus. Furthermore, there is some data to suggest that different strains of PRRS are more or less likely to transmit by air, and we do not have strain data in this study. Finally, some of the PADRAP data used in this study is more than 5 years old. We have concern that the number of neighboring swine farms may have changed since the data was collected.

Overall, this objective quantified the additional risk added to sow farms that have several other swine farms around them as identified by the PADRAP score. It may help larger producers with many sow farms direct limited time and money resources to herds at highest risk. Additionally, it may help spur farms in these regions to maintain a highly vigilant bio-security program. The results of this study are part of a larger, ongoing study that is identifying factors that explain the repeatable patterns of PRRS infections. As such, it will be published in peer review literature and presented at scientific conferences.

Objective 3 was to design a study to measure the frequency and diversity of PRRS detected in air samples. In this study, we selected 8 filtered sow farms in high density regions to collect air samples at during the PRRS epidemic in 2012 and 2013. Over the 6 month duration of this study 241 samples were collected, and all of them tested negative for PRRS. Unfortunately we are not able to draw meaningful conclusions about the frequency of PRRS in the air because of concerns of the ability of the aerosol sampling device. These results are in stark contrast to other work where a high proportion of samples tested positive for PRRS. From this project, it is clear more sensitive collection devices should be validated and this work is ongoing.

The results of our efforts within this project are prepared for publication in peer reviewed literature.

Keywords:

PRRS, Epidemiology, Risk, Density, Aerosol transmission

Scientific Abstract:

PRRS continues to be a significant problem in the United States swine industry yet several important epidemiological factors have yet to be elucidated. Therefore the objectives of this project were to document, describe and study the patterns of PRRS in the US. Additionally, we sought to describe the impact of neighboring swine farm density on the odds of reporting a new PRRS infection, and finally, we attempted to describe the frequency and diversity of aerosolized PRRS around sow farms in swine dense regions.

In this project, a highly repeatable and consistent pattern of PRRS infections was documented between 2009 and 2012. In 2013, the patterns changed, and additional work is ongoing to elucidate these factors driving this

change. Additionally, positive associations between neighboring swine farm density and reporting new PRRS infections were detected. Finally, using previously published methods, we were not able to detect aerosolized PRRS in 241 samples collected over a 6 month period during the 2012 PRRS epidemic.

Introduction:

Despite best efforts from the scientific community, Porcine Reproductive and Respiratory Syndrome (PRRS) continues to be a devastating disease to the swine industry. The cost of PRRS has been estimated at \$560 million¹ to \$664 million² annually. Producers and veterinary practitioners have become increasingly frustrated with the variable results of their attempts to control the virus in herds and efforts to keep negative herds free from virus.

This project proposes to measure the incidence rate of PRRS infection in a cohort of US sow herds. We will develop a risk score based on the density of swine farms and their infection status around a sow herd. The development of this risk score will include filtered and non-filtered farms which will allow for comparison of the rate of infection. We will also sample air within high density regions and compare the frequency of detection to a low density region. Taken together, this project will increase our understanding of the impact of density on incidence of infection and generate information that will assist producers in the decision whether to filter a sow farm.

In the fall and winter of 2011, we began a pilot project to develop a database of volunteer sow herds within the US. The project has continued to expand, and presently includes 371 sow farms having approximately 1.25 million sows (estimated 21% of the US sow herd). Veterinarians working with these farms report their PRRS status on a weekly basis. In addition to weekly status updates, participants also agreed to share geographical location of the sow sites. This unique agreement allows the first efforts to investigate and describe patterns of PRRS dissemination among sow herds in the study. It will be possible to describe these patterns in regions of varying density and risk. These data may be able to reveal where the PRRS season begins and ends. Below is a chart that shows the cumulative incidence of PRRS infection during the last three years. The similarity among the years gives a visual depiction of how this disease continues to create losses for the industry, in spite of control measures.

This project will also develop an aerosolized virus surveillance system. By collecting air samples at specific herds in different density regions, a description of the frequency and types of viruses will be developed. This will be the first efforts at attempting this, and the database of sow herds will allow for a unique, density based surveillance system. This information could be shared with producers and veterinarians in real time and, similar to other data produced by this study, may provide important information used to guide farm level decision making.

This project addresses a key issue affecting swine production, builds upon previous effort supported by these grants, and seeks to utilize a multidisciplinary approach to fulfilling the objectives. Experts in the fields of epidemiology, spatial analysis, agri-business, as well as veterinarians in private practice and US swine producers have committed to assisting this project. The participants share a desire to develop a method of identifying an expanded set of key risk factors to facilitate prediction of PRRS infection. The ability to develop

a surveillance method in different regions of risk to understand patterns in airborne PRRS viruses has not been attempted before, and could prove to be an enlightening piece of this project.

The short term benefit to the pork industry is a better understanding of the epidemiology and field ecology of PRRS. The long term benefit will prove to be using these data to guide the process of selecting and implementing prevention and control strategies at the farm level. Ultimately, this will help maintain the US as a world leader in pork production by helping to secure the production of a sustainable, high quality, affordable pork supply.

Objectives:

The objectives of this project are to:

1. Measure incidence of PRRS infection in a cohort of US sow herds,
2. Conduct a risk assessment based on the density of swine farms around a sow herd and the odds of reporting a new PRRS infection between 2009 and 2013
3. Describe frequency and diversity of air borne PRRS within high density regions

Materials and Methods:

Objective 1: Measure Incidence of PRRS infection in a cohort of US sow herds –

A cohort of 1.2 million sows (estimated 21% of US sow inventory) on 371 farms, representing 15 production systems was used for this study. Veterinarians providing service to these farms report change in PRRS status, and new infections on a weekly basis. PRRS status is recorded according to the AASV guidelines³.

Incidence of new infection is calculated as the proportion of new infections reported in the cohort. Annual, as well as quarterly incidence rates are compared using chi square.

Onset of the PRRS epidemic is estimated using Exponentially Weighted Moving Average⁴. Each week the number of new cases are plotted against an epidemic threshold and when the cases exceeds the threshold, the epidemic is signaled.

Cluster analysis was performed using spatial scan statistics⁵ to identify areas where observed number of PRRS cases are higher than what would be expected by random chance alone. In this study we used a Bernoulli model that scanned for areas of high rates, 50% of the population at risk under a circular spatial scanning window with no geographic overlap.

Objective 2: 1. Conduct a risk assessment based on the density of swine farms around a sow herd and the odds of reporting a new PRRS infection between 2009 and 2013 –

The Production Animal Risk Assessment Program (PADRAP) was used to identify farms within a 5 mile radius of each sow farm. The odds of a farm reporting a new infection in each of the years of the study was estimated using a logistic regression model. Here, each farm, j , reported infection in year i (yes or no) and number of farms within 1, 3 and five miles were used as response and explanatory variables, respectively.

Objective 3:

Study Population – Two groups of four farms were selected for this trial. Only farms employing bio-aerosol filtration⁶⁻⁸ were selected for this study due to the presumed increased risk PRRSV bio-aerosols exposure. All farms were required to wean piglets into off-site facilities. All farms were required to have at least 10 other pig sites within a 3 mile radius. Within each group, farms were required to be within 20 miles of each other, but not less than 3 miles.

Study design – Samples were collected approximately every two weeks between October 1st, 2012 and March 30th, 2013. At each collection, wind direction was established and collectors were placed approximately 10 meters from the upwind side of the barn and at least 10 meters from any object that could interfere with wind flow (ie liquid propane tanks, other buildings, tree lines, etc).

Samples – Two cyclonic collectors (Midwest Microtek, Brookings, South Dakota, USA) capable of moving an estimated 400 liters of air per hour were placed approximately 0.5 meter off the ground and at least 3 meters from each other situated in a line perpendicular to the wind direction. Collectors were operated for 30 minutes and the remaining liquid media was poured into a sterile Tube and placed immediately onto dry ice. After each collection, the collectors were disassembled and cleaned in the field using 70% ethanol solution.

On all collection dates, a group of four farms was visited twice yielding a total of 16 samples. A rotating schedule was developed so that first samples of the day were collected at a different farm each week.

A 1.0 ml aliquot of each sample were sent to the University of Minnesota Veterinary Diagnostic Laboratory and tested for the presence of European and North American PRRSV ribonucleic acid by polymerase chain reaction.

Results:

Objective 1: From 2009 – 2012, there were no significant differences in the cumulative incidence (figure 1, red lines), yet in 2013 significantly fewer PRRS infections were reported (figure 1, green line). Additionally, the onset of the PRRS epidemic was documented during the idle week of October each year from 2009 to 2012, yet in 2013 the signal for the onset of the epidemic was delayed approximately 3 weeks (figure 2). Finally, the spatial scan statistic showed a consistent location of a significant cluster each year from 2009 - 2012 (figure 3, red lines) and again in 2013, where the location of the clustered appeared to be relatively the same (figure 2, green lines).

Objective 2: A total of 113 farms had completed PADRAP surveys and were used in this analysis. Among these farms, there was an average of 2.8 farms (95% CI = 2.1 – 3.5) farms within three miles. For each year of the study, there were significant associations between number of neighboring farms within 3 miles and the odds of reporting a new infection were found in 4 of the 5 study years. For each additional farm within 3 miles of a sow farm, in 2009 the odds of reporting a new PRRS infection increased by 21% ($p = 0.004$), in 2010 the odds were increased by 17% ($p = 0.009$), in 2011 the odds were increased by 17% ($p = 0.009$), and in 2013 odds were increased by 14% ($p = 0.022$). In 2012, there was no significant association detected.

Objective 3: A Total of 241 samples were collected from October 1, 2012 through March 30th, 2013. Of these, 0 samples tested positive for PRRS by PCR. During the study, one farm reported a new PRRS infection. A

biosecurity review of the site failed to find any known biosecurity breaches and the new infection was attributed to air leakage around filter boxes that transmitted infectious PRRS.

Discussion:

The results of objective 1 indicate a highly repeatable temporal and spatial pattern in PRRS infections. This data suggests a particular region in north central Iowa that is consistently in the cluster of new infections. Studies could be conducted to understand why this pattern is so repeatable. It could be speculated that this area has the highest density of swine herds and therefore is more likely to have herds that report new infections. It could also be speculated that there are production companies in this region that have decided to manage PRRS differently than others. It could also be related to other characteristics, such as higher density of slaughter and packing plants in this region and therefore more transportation of potentially infectious animals.

Additional studies are needed to elucidate the striking reduction of incidence recorded in 2013. The first objective would be to determine if these observations are spurious, (ie due to changes in diagnostic rigor on farms, or changes to reporting) or true. If true, then several mechanisms might explain this. For example, 2013 and 2014 is when PED was first detected in the US. Speculations regarding the role of this virus and its effect on swine production have been proposed. Alternatively, there could have been increased awareness and biosecurity preparation in light of the pending PRRS epidemic. These measures could explain the reduction in number of new infections reported.

The relationship of density and new PRRS infections has been speculated in the past, and documented with this cohort. These data might suggest additional biosecurity measures (ie filtration) may be required at farms with higher numbers of swine farm within 3 miles.

Finally, while we failed to detect aerosolized PRRS in our study, we cannot conclude that aerosol transmission does not occur. Potential limitations of this study are that from a global perspective, is the amount of time and volume of air sampled is relatively small. Additionally, there are known issues with sensitivity of the collection device used. It is unclear exactly why the results of this study differ so dramatically from what has been (at least anecdotally) reported, but one might speculate timing and location of these samples could explain the differences. It seems that additional work to validate more sensitive equipment might be justifiable.

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Figure 1: Cumulative incidence of PRRS infections for years 2009 – 2012 (red lines) and 2013 (green line)

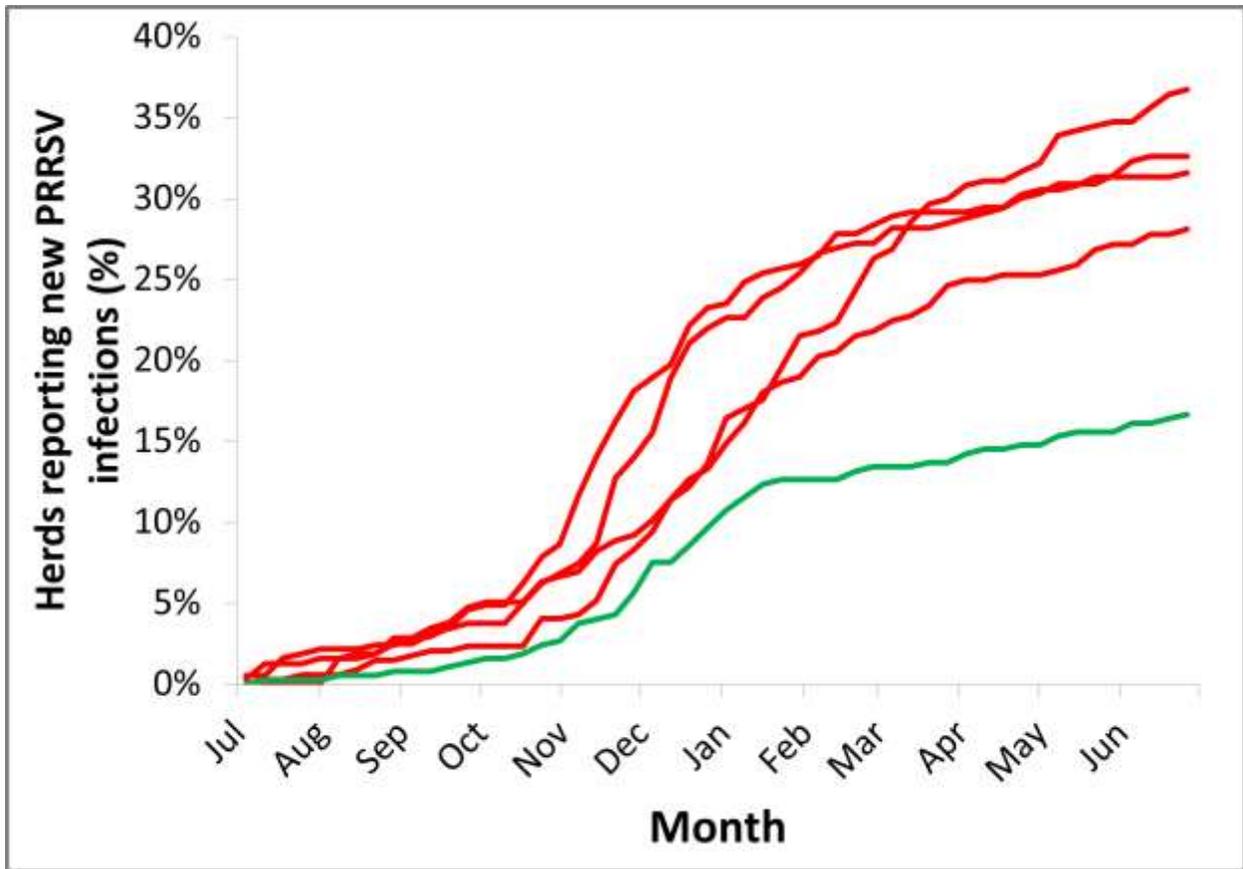


Figure 2: Epidemic analysis for years 2009 – 2013. Date of epidemic onset in boxes.

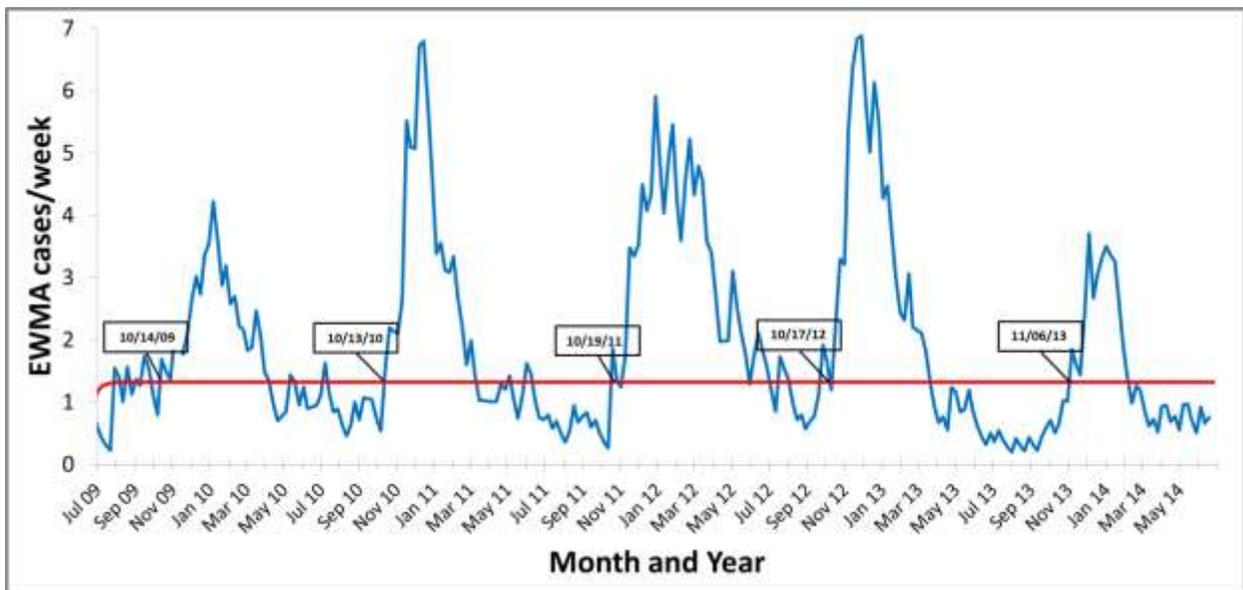


Figure 3: cluster analysis for years 2009 – 2012 (red lines) and 2013 (green line).

