RESEARCH REPORT

SWINE HEALTH

Title: Evaluation of risk factors and control programs related to the production of PRRSV-free offspring from infected herds – **NPB #98-240**

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Abstract

Several studies were conducted to identify risk factors and control measures that influence the production of PRRSV-free pigs from infected breeding herds and to attempt eradication via intensive vaccination with a killed virus vaccine. A serological survey was conducted in 35 herds to determine if infected herds were producing PRRSV-free pigs. The cooperating veterinarian predicted the status of the herd correctly in 70% of the herds and the status of herds changed over time. Surveys of these 35 herds and a mail survey of 91 herds were done to determine the association of various disease control, risk factors and management practices with the production of PRRSV-free pigs. Factors that were significantly associated included distance to nearest herd, the time from purchase to actual entry into the breeding herd (isolation, acclimatization, "cool down"), and the PRRSV status of the herd of origin for purchased animals.

Intensive vaccination with killed vaccine was attempted in three, relatively small farrow-to-finish operations with an initial goal of producing PRRSV-free nursery pigs and eventually entire herd eradication. All sows were vaccinated twice followed by quarterly boosters and pigs were vaccinated at weaning and one month later. All herds noted improved overall herd health and achieved the goal of producing PRRSV-free nursery pigs. One herd successfully eradicated PRRSV from the finisher. The repeated vaccination with the killed vaccine appeared to maintain antibody titers in the sows at a higher level than no vaccination or repeated vaccination with modified live products. This strategy shows promise but needs further research to demonstrate its effectiveness and value, especially in larger herds.

Introduction- Porcine reproductive and respiratory syndrome virus (PRRSV) has emerged as the most important swine disease throughout the world. The ultimate frustration with PRRSV is the unprecedented variation in nearly all facets of the disease

including severity of clinical disease (none to severe, respiratory vs. reproductive), response to vaccination (dramatic improvement to making situation worse), duration and level of serum immune responses (difficult to establish exposure and immune status), transmission (pig-to-pig, dam-to-pig, herd-to-herd) and prevention/control procedures used in the industry (no consist recommendations from veterinarians and vaccine manufacturers).

PRRSV is uniquely capable of maintaining itself in the swine population because of its ability to change its genetic structure rapidly (1). This ability to mutate and change its antigenic structure presumably allows PRRSV to circumvent population immunity. These continual mutations also impact virulence and perhaps transmission. Quite possibly the riddle of PRRSV will never be sufficiently solved to the point where control by vaccination and management is predictable and cost effective. Eventually, eradication may be the only feasible method to effectively control PRRSV.

Eradication of PRRSV from entire herds has been done by complete depopulation followed by re-population with negative pigs. In addition, Freese and Joo (1994) reported the spontaneous disappearance of PRRSV antibodies in an infected herd but it is unknown whether this herd was actually free of virus (2). Dee and co-workers (1994 and 1997) have successfully eliminated PRRSV from endemically contaminated nursery facilities although re-infection of pigs, apparently from shedding sows, occurred in several herds over the study period (3,4). Dee and co-workers (1997) also apparently eliminated PRRSV from a finishing floor by vaccinating all pigs within this multiple room barn followed by unidirectional flow of groups through the facility (5).

With pseudorabies virus (PRV) eradication programs, an essential first step was to eliminate infection in the offspring via vaccination along with within herd biosecurity measures and vaccination of the breeding herd to prevent vertical transmission. The situation with PRRSV is different in that circulation of virus within a breeding herd appears to be more random although several factors appear to promote circulation including the existence of susceptible sub-populations and the introduction of gilts and boars that are either actively shedding virus or are fully susceptible and shed large amount of virus when they eventually become infected (6). Because of the apparent unpredictable circulation of virus in the breeding herd, sow-to-pig transmission is also unpredictable. Vaccination may not influence the rate of transmission in the herd and a modified-live virus vaccine has been shown to spread from vaccinated pigs to non-vaccinated pigs. In some situations, vaccine virus spread has been associated with the development of clinical disease. Killed vaccines including a licensed product and several autogenous preparations are available. Their effectiveness with respect to reducing PRRSV transmission is unknown.

Most producers and veterinarians would agree that prevention of sow-to-pig transmission of PRRSV is desirable in most herds, especially those that incur production losses in the nursery and finishing phases. To date, risk factors related to preventing sow-to-pig transmission have not been well studied. We proposed that evaluation of risk factors and PRRSV control programs that are related to the production of seronegative, virus free offspring would be an important first step in developing improved methods for controlling PRRSV and perhaps eventually eradicating the disease. We also proposed to test the effectiveness of using killed virus vaccine and unidirectional pig flow for eradicating PRRSV.

Objectives- The overall goal of our efforts is to develop control programs that will lead to the predictable production of PRRSV-free pigs from infected sow herds. In order to achieve this goal, we proposed the following objectives:

1) Describe and quantify risk factors, control programs and monitoring procedures related to producing PRRSV-free offspring from infected breeding herds by surveying swine practitioners.
2) Describe and compare risk factors and control programs in herds producing PRRSV seronegative versus seropositive pigs as determined by serological monitoring.
3) Determine if PRRSV can be eradicated from farrow-to-finish operations by blanket vaccination with a commercially available, killed virus vaccine along with unidirectional pig flow in the nursery and finishing production phases.

Procedures- The study was conducted in four parts. Initially, a post-card survey was conducted to recruit herds and veterinarians for subsequent phases. This brief questionnaire inquired about the feasibility of producing PRRSV-free weaned pigs and the responses were stratified by sow herd size.

Based on the initial survey, 40 herds serviced by 20 veterinarians were recruited for Objective 2, comparing risk factors for producing PRRSV-free weaned pigs as determined by serological monitoring of the pigs at weaning and as they exit the nursery (approximately 9 weeks of age). Each veterinarian identified two cooperating herds; one herd that was believed to produce PRRSV-free weaned pigs and one herd that did not. To verify this predicted status and monitor for changes in status, the herds were serotested twice, approximately 6 months apart. Each time, 30 four-week-old pigs, 30 nine-week-old pigs and 15 sows were tested for PRRSV antibody by ELISA. The actual status of the herd was determined by the results from the older nursery pigs. A herd was classified as producing PRRSV-free pigs if the percentage of seronegative pigs was $\geq$ 90% either at both tests or at the second test. The cooperating veterinarian completed a survey form that inquired about a number of factors related to general and PRRSV-specific disease control practices, risk factors and management procedures. The results were analyzed with respect to how these factors influenced whether the herd was producing PRRSV-free pigs or not.

For Objective 1, describe and quantify risk factors and control programs related to producing PRRSV- free offspring from infected breeding herds, swine practitioners identified in the post card survey and others were mailed a survey similar to the one used for Objective 2. The veterinarians were prompted to complete one survey form that described a herd that they provided services to. The veterinarian was directed to complete the survey for either a positive or negative herd to insure that the herds surveyed would be balanced by status. If the veterinarian did not have a herd available (usually a herd producing PRRSV-free pigs), they could switch their responses to another herd (often a positive herd). As in Objective 2, the data was analyzed with respect to the herd status provided by the veterinarian.

To analyze the surveys, the data was entered into a spreadsheet. Forms with excessive missing data or confusing responses were completely eliminated (approximately 10%). The survey used in Objective 1 asked very detailed questions that allowed for classification of herd attributes such as various combinations of sources of replacement animals, facility management and PRRSV vaccination programs. The data was summarized using a microcomputer statistical program. Based on an initial review, selected factors were subjected to statistical analysis by the Chi square test, Fisher' Exact test and the Kruskal-Wallis non-parametric ANOVA.

For objective 3, to determine if PRRSV can be eradicated from farrow-to-finish operations by blanket vaccination with a commercially-available, killed virus vaccine, three herds in Northwest Iowa were recruited as cooperators along with their local veterinarians. Herd T contained 80 sows, farrowed 5 times per year and all phases of

production were contained on one site. Herd S contained 60 sows, farrowed 4 times per year and all phases of production were contained on one site except for several adjacent sites used for breeding stock that were waiting to be sold. Herd K contained 150 sows and farrowed every 28 days (5 groups of sows, 3 week lactation). For this herd, one site contained the breeding herd and nursery pigs and another site contained the finishing pigs (one barn with 4 rooms). The vaccination and monitoring procedures were similar in all herds. Blood testing was done periodically to monitor PRRSV transmission. Serum was tested for PRRSV antibodies by ELISA. A commercial killed virus vaccine (PRRomiSe- Bayer Animal Health) was used at the recommended 2 ml dose. At the start of the study, all breeding animals and nursery pigs were vaccinated twice at a 3-4 week interval. Thereafter, gilts were vaccinated twice prior to breeding, sows and boars once quarterly and the pigs at weaning and 3-5 weeks later. Herd K administered a modified live vaccine (Prime-Pac PRRS- Schering-Plough Animal Health) to breeding gilts at selection and the killed vaccine 3-4 weeks later. Herd S administered vaccine prior to farrowing if the quarterly vaccines did not coincide with farrowing. All herds were completely closed to outside animals and replacement boars and gilts were produced internally.

Results- For the initial post card survey, 96 veterinarians servicing a total of 4,948 herds responded. Of these herds, 77.7% were PRRSV positive. Their perception of whether these positive herds had characteristics that would enable production of PRRSV-free pigs was 53.6% for herds <1000 sows and 42.8% for herds >1000 sows. Because the herds were not identified, it is possible that some herds were double counted if serviced by more than one veterinarian.

For objective 2, we ended with usable data from 35 herds, 17 producing positive pigs and 18 producing negative pigs. Table 1 presents data comparing the predicted (by the cooperating veterinarian) herd status versus the actual status based on the serotesting. Misclassification was common; 3 of 18 herds considered positive produced negative pigs at both tests and 5 of 19 negative herds produced positive pigs at both tests. This table also shows how the herds were classified for the analysis of the survey. Table 2 presents data on the influence of serotesting frequency on herd classification. Testing frequency appeared to have little impact on predicting the serostatus of the nursery pigs at the first test. Table 3 presents sow serology data. Negative serostatus was assigned if all 15 sows tested were negative. Of the 4 herds with negative sows at the beginning, 2 had positive sows at the end and one of these herds had gone from producing negative to producing positive pigs.

Survey results for Objective 2 are presented in Tables 4 (continuous variables) and 5 (categorical variables). Variables were selected to provide general characteristics of the study herds, illustrate the usage of procedures commonly thought to assist with disease control and/or present factors that were found to be significant ($P<.05$) or nearly significant ($P<.10$). Factors that appeared to be increase the likelihood of producing PRRSV-free pigs included all-in, all-out pig flow in the nursery, not using modified live virus vaccine in the sow herd, isolation, and longer distances between the test herd and the nearest herd. Because of constraints due to the expense of the serological monitoring, the sample size (number of herds) for conducting this analysis was limited. The results reveal the difficulties in accurately assigning herd status based on serological testing. This could be especially true in field situations where sample size is often less than the 30 pigs sampled in this study. The results and conduct of this study were useful in developing the survey instrument used in Objective 1.

For Objective 1, the mail survey, 91 usable surveys were evaluated; 44 herds were believed to produce negative pigs and 47 believed to be producing positive pigs.

Because serological testing was not required for this classification, misclassification by the responding veterinarian is likely based on the results from Objective 2. Survey results are presented in Tables 6 (continuous variables) and 7 (categorical variables). The same strategy for selecting factors for presentation was used. Factors that appeared to be positively associated with the production of PRRS-free pigs included total preparation days (isolation, acclimatization, "cool down") prior to entering the breeding herd, days gilts were held in isolation, and PRRSV free status of purchased or internally replaced animals. Distance to the nearest herd was negatively associated. Other interesting data included 40.6% of semen sources were PRRS positive, the PRRS status of the closest herd was unknown 51.6% of the time, and isolation, acclimatization and a "cool down" period were used for incoming gilts 78.0%, 84.4%, and 37.4% of the time, respectively. The large variety of disease control and management strategies made it difficult to identify congruent management schemes that were used across several herds. The lack of knowledge about neighboring herds was interesting, somewhat surprising and especially alarming with respect to controlling the area spread of diseases.

For Objective 3, eradication using killed vaccine, all herds noted improvements in overall health status, especially related to respiratory disease. Herd K reported time to market decreased by approximately 3-4 weeks. All producers would like to continue the intensive vaccination program including the pig vaccinations although the expense of vaccinating all pigs twice is probably prohibitive. In all herds, vaccination of sows appeared to increase titers and most sows tested were seropositive. In Herd S, 57 sows were tested over the entire study; 54 (95%) were seropositive and the average S/P ratio was 1.16. In herd T, 63 of 69 (91%) sows were seropositive and the average S/P was 1.12. In Herd K, 73 of 89 (82%) were seropositive, the average S/P was .86, and the younger sows tended to be negative. With respect to producing PRRS-free pigs from the breeding herd, all herds were successful. Herds S and T began produced negative pigs as soon as the intensive vaccination program had been instituted. In Herd K, the herd with the most intensive pig flow, PRRSV-free pigs were not produced until the third monthly weaning group. Two vaccinations of the pigs with the killed vaccine did not induce measurable titers. With respect to maintaining the PRRSV-free status through the finishing phase, only Herd S was successful. Twice during the study, it appeared that the finishers in Herd K were staying negative but the situation reversed back to a pattern of the pigs becoming infected within 1 month after entering the finisher. Both Herds K and T are contemplating a depopulation of their finishing facilities to eradicate PRRSV from that phase of their operations.

Summary- The results of these studies reveal that there is no clear cut method for controlling or eliminating PRRSV from herds or producing PRRSV-free pigs. The first priorities of a PRRSV control program are avoidance of reproductive problems and infection of nursery pigs with less emphasis on preventing infection in the finishers. The experiences in Herd K support this statement in that finishing herd performance improved significantly even though the pigs became infected in the finisher. Of course, vaccination with the killed vaccine may have reduced or prevented the clinical disease associated with infection. The surveys suggest that factors related to handling gilts and boars prior to entering the breeding herd influence the ability of a herd to produce PRRSV-free pigs. These factors have been reported anecdotally to be useful and our data supports these claims. The amount of preparation time (isolation, acclimatization, "cool down") needs to be prolonged as much as possible. One herd reported that gilts are not introduced to the main breeding herd until they are due to farrow. The PRRS status of breeding stock also appears to have some influence. This may be related to

the possibility of introducing new strains. Finally, the distance to the nearest herd seemed to influence the herd status, as expected and supports the notion that PRRSV occurs from herd-to-herd via unknown means. Of some concern was the finding that the PRRSV status of the nearest herd was unknown to the veterinarian 51.6% of the time. This seems rather high and will need to be improved if PRRSV eradication programs are instituted in light of the growing support that area spread does occur.

References

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Table 1: Predicted serostatus/production of PRRS negative pigs compared with the actual status at the beginning and end

Predicted	Status - Number of herds Actual by serotesting* Beginning	Ending	Survey Status
Positive - 18	Positive -13	Positive -6	Positive**
		Negative -5	Negative
		Not done -2	Positive
	Negative -4	Positive -1	Positive
		Negative -3	Negative
		Not done -0	-----
	Not done -1	Positive -1	Positive
Negative -19	Positive -8	Positive -5	Positive**
		Negative -2	Negative
		Not done -1	Positive
	Negative -10	Positive -3	Positive
		Negative -6	Negative
		Not done -1	Negative
	Not done -1	Negative -1	Negative

* Thirty late nursery age pigs were serotested.

** One herd not included in analysis of survey data.

Table 2: Frequency of PRRS serological monitoring compared to predicting the serological status of nursery pigs

Status			Serological monitoring frequency in months				
Predicted	**Difference**	**Actual[a]**	**0-3**	**3-6**	**6-12**	**None**	**Total**
Positive		Positive	6	1	1	4	12
		Negative	3	1	0	0	4
Negative		Positive	4	2	0	1	7
		Negative	5	3	1	1	10
	No difference		11	4	2	5	22
	Different		7	3	0	1	11

[a] Based on the initial serotest.

Table 3: Serostatus of sows from a PRRS positive herd at a six month interval*

Status - Number of herds	
Initial Serostatus	**Ending Serostatus**
Positive - 31	Positive - 29
	Negative - 0
	Not done - 2
Negative - 4	Positive - 2[a]
	Negative - 2[b]
Not done - 2	Positive - 2

* Fifteen sows were serotested each time.
[a] Survey status of herds was one positive and one negative.
[b] Survey (actual) status of both herds was negative.

Table 4: Summary of control and risk factors by PRRS status of weaned pigs - serological survey, continuous variables.

Variable	Mean ± std dev (Min, Max) by herd status Positive pigs	Negative pigs
Herd size (no. sows)	802.7 ± 720.1 (120, 2400)	1050.0 ± 787.7 (65, 2400)
Distance to nearest herd (mile)[a]	1.3 ± 1.1 (.1, 4.0)	1.9 ± 1.1 (.5, 4.5)
Number of herds within 2 miles	4.7 ± 5.5 (0, 20)	2.5 ± 2.9 (0, 11)
Age of gilts at entry (weeks)	22.6 ± 9.7 (3, 33)	27.7 ± 5.4 (16, 40)
Months since initial outbreak	59.3 ± 31.9 (10, 111)	48.2 ± 28.4 (13, 135)
Severity of initial outbreak	12.7 ± 3.3 (6, 18)	11.0 ± 4.6 (7, 18)
Duration of producing negative pigs	-----	14.3 ± 12.5 (6, 48)
Weaning age (days)	19.5 ± 3.9 (14,30)	18.7 ± 4.4 (12, 31)

[a] P = .08 by non-parametric ANOVA.

Table 5: Summary of control and risk factors by PRRS status of weaned pigs - serological survey, categorical variables

Variable	% and rate by herd status: Positive Pigs %	Positive Pigs Rate	Negative Pigs %	Negative Pigs Rate
Weaned negative pigs in the past	64.7	11/17	--	--
Semen source PRRS positive	37.5	3/8	30.8	4/13
Nursery and breeding on same site	70.6	12/17	55.6	10/18
All-in, all-out nursery pig flow[a]	58.8	10/17	88.9	16/18
Modified live vaccine used in sows[a]	58.8	10/17	16.7	3/18
Modified live vaccine used in pigs	17.6	3/17	0.0	0/18
All breeding stock purchased	41.2	7/17	66.7	12/18
Seropositive breeding stock introduced	88.2	15/17	88.9	16/18
Acclimatization used	82.4	14/17	100.0	18/18
Modified live vaccine used in gilts	52.9	9/17	50.0	9/18
Isolation used[b]	70.6	12/17	94.4	17/18

[a] $P < .05$ by Fisher's Exact Test.

[b] $P < .10$ by Fisher's Exact Test.

Table 6: Summary of control and risk factors by PRRS status of weaned pigs - mail survey, continuous variables

Variable	Mean ± std. dev. (Min, Max) by herd status: Positive pigs	Negative pigs
Months considered negative	-	17.6 ± 12.3 (5, 72)
Preparation days prior to entry[a]	71.8 ± 41.0 (0, 140)	95.9 ± 62.0 (0, 260)
Months since initial outbreak	49.3 ± 34.5 (6, 128)	46.2 ± 25.1 (9, 110)
Distance to nearest herd (miles)	2.2 ± 5.8 (.2, 40)	3.1 ± 4.2 (.3, 20)
Number of herds within 2 miles[a]	2.6 ± 2.5 (0, 10)	1.6 ± 2.1 (0, 10)
Days in isolation (gilts)[b]	31.7 ± 23.4 (0, 91)	43.8 ± 37.8 (0, 196)
Days in acclimatization (gilts)	27.9 ± 22.6 (0, 112)	36.9 ± 33.3 (0, 140)
Age of gilts at entry (weeks)	27.0 ± 5.8 (9, 38)	27.8 ± 5.8 (8, 44)
Severity of initial outbreak	16.4 ± 5.4 (6, 24)	14.3 ± 4.92 (6, 24)

[a] Groups were significantly different ($p < .05$) by non-parametric ANOVA.
[b] Groups were significantly different ($p < .10$) by non-parametric ANOVA.

Table 7: Summary of control and risk factors by PRRS status of weaned pigs – mail survey, categorical variables

	% and rate by herd status			
	Positive pigs		Negative pigs	
Variable	*%*	*Rate*	*%*	*Rate*
Weaned negative pigs in the past	36.2	17/47	--	--
Semen source PRRS positive	43.8	14/32	37.0	10/27
Nursery and breeding on same site	57.8	26/45	43.9	18/41
Nursery and finishing on same site	47.7	21/44	48.8	20/41
All-in, all-out nursery pig flow	89.1	41/46	97.6	40/41
Closest herd PRRS positive	44.7	21/47	43.2	19/44
Closest herd status unknown	48.9	23/47	54.5	24/44
Trucks washed prior to entry	56.5	26/46	68.2	30/44
Modified live vaccine used in sows	38.3	18/47	38.6	17/44
Modified live vaccine used in pigs	15.2	7/46	4.8	2/42
All breeding stock purchased	47.8	22/46	45.2	19/42
Boars only purchased	37.0	17/46	42.9	18/42
Seropositive breeding stock introduced[a]	93.6	44/47	71.8	28/39
All seropositive gilts introduced[a]	70.2	33/47	35.9	14/39
Acclimatization used	80.9	38/47	88.4	38/43
Isolation used	78.7	37/47	77.3	34/44
“Cool down” phase used	42.6	20/47	31.8	14/44
Gilts vaccinated <60 days prior to entry	63.6	14/22	36.0	9/25
Gilts vaccinated >60 days prior to entry	36.4	8/22	64.0	16/25
Herd size > 1,000 sows	70.5	31/44	61.4	27/44
Herd size < 1,000 sows	29.5	13/44	38.6	17/44

[a] $P < .05$ by Fisher’s Exact Test.