

FINAL Report

URINARY TRACT INFECTIONS IN LACTATING SOWS: OUTCOME AND EFFECT ON PRODUCTION

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Background

Few studies previously evaluated the role of urinary tract infections (UTI) in sow performance in the USA. UTI include cystitis (inflammation of the urinary bladder) and pyelonephritis (inflammation of the kidney). Our studies (Almond and Stevens, 1995) confirmed European reports that revealed 22 to 40% of sows in confinement operations are affected with UTI. The proportion of sow deaths attributable to cystitis/pyelonephritis varies from 10% to greater than 40% in Europe, Canada, and the USA (Christensen et al., 1995; Sanz et al., 2002).

Also, UTI diminish lactational performance by sows. Inadequate water intake is a major risk factor for developing UTI (Mroz et al., 1995). However, producers and veterinarians often assume that drinkers provide adequate water to meet the needs of lactating sows. Our current understanding of UTI in lactating sows is limited, and urinalysis values for lactating sows were previously unavailable.

The revised objectives of this study were:

- Establish urinalysis values and characterize urine abnormalities in lactating sows.
- Evaluate the influence of other factors (drinker flow rate etc) on urinalysis values.
- Establish if urinary tract infections, which were initiated in lactation, persist in weaned sows and in gestation.
- Determine if urinary tract infections are detrimental to sow performance.
- Determine if urinary tract infections resolve without intervention and treatment.

Materials and Methods

Farms:

The study initially was designed to be conducted on one sow farm. Due to the opportunity to include additional farms, the study was conducted on three sow farms with 350 (LWFL farm), 2400 (HR farm), and 7500 sows (PR farm), respectively. Each farm used a 3-week lactation

period. Sows were fed three times/day on each farm. The LWFL and HR farms fed sows at approximately 6:30, 9:00 and 12:00 h. The PR farm fed sows twice in the morning and then in the late afternoon/early evening. All farrowing barns were equipped with nipple drinkers in individual stalls. For the HR and LWFL farms, gestation stalls were fitted with drinkers. Troughs were filled with water three times each day in gestation facilities of the PR farm.

Urine Sampling and Analysis: For the PR farm, urine samples were collected from sows in the same breeding group during in late gestation (n=224), one day after farrowing (n=52), 10-14 days of lactation (n=64), during the weaning-to-service interval (n=85) and at days 25-30 of the subsequent gestation (n=141). Based on the urine analyses of samples collected in late gestation, all efforts were made to identify sows (cases) with UTI and match them with control sows (controls) without UTI. Urine samples were collected from sows in mid-lactation on the LWFL (n=56) and HR farms (n=184).

All samples were refrigerated and urinalysis performed within 24 hrs of collection. Samples were evaluated using established procedures (Almond and Stevens, 1995). Urine reagent sticks were used to determine urine pH and to detect urine glucose, bilirubin, ketones, blood, protein, urobilinogen, nitrite and leukocytes. Specific gravity was determined using a refractometer and urine sediment was evaluated with standard procedures to quantify white blood cells (WBC), triple phosphate crystals and other urine constituents. Bacterial cultures were performed on urine samples with any abnormalities detected with the reagent strips or sediment examination

Animal Health and Additional Demographic Information:

Antibiotic treatments of sows, clinical disease problems and sow mortality were recorded by farm personnel. Sow performance (litter size [PBA, Stillborn, mummies], farrowing rate, pigs weaned, weaning-to-service interval) and culling/removal reasons were compared between the cases and controls. For each sampled sow in the HR and LWFL farms, drinker flow rates, crate design, floor type, and barn ventilation (curtain-sided barns versus cool cells) were recorded.

Statistical Analysis and Evaluation:

A scoring system was used to quantitate color changes on urine dipsticks, quantity of cells and other abnormalities in urine sediment and bacteriology culture results. For farrowing rates, litter sizes and other performance data, the data was analyzed with epidemiologic measures of association (Chi square; Martin et al., 1987). Analyses of variance were used for urinalysis parameters (Statistix, 8th Edition: SAS; Proc GLM). Means were compared with Tukey's test.

Results

Urine SG and pH:

Urine specific gravity (SG) and pH differed ($P<.05$) among farms, and production stages within the PR farm (Figures 1 and 2). Urine specific gravity consistently was greater in lactating sows than in gestating sows. Urine pH was lower ($P<.05$) in samples collected from the PR lactating sows than in samples from the LWFL or HR farms, or gestating sows. In the PR farm, case and control sows had urine pH measurements of less than 7 in lactation. In contrast, urine pH was alkaline (>7) in gestation and during the post-weaning interval. Urine specific gravity increased during lactation and then decreased during the post-weaning interval.

Urine Constituents:

Table 1 provides the results determined with urine dip-sticks. It previously was established that dip-sticks were unreliable for detecting leukocytes and blood in swine urine. Comparison of the urine sediment results to dip-stick results confirmed the lack of consistency in results for leukocyte and red blood cell (RBC) determinations. Therefore, values shown in the figures reflect the sediment cytology.

Based on the results shown in Table 2, abnormal urine constituents clearly were evident during lactation and during the post-weaning stages of production in the PR farm. Approximately 50% of the sows had urinalysis results indicative of UTI. In particular, the high WBC counts emphasized the presence of UTI in case sows. These sows also had significant bacteriuria, with mixed infections. The common use of antibiotics in the immediate post-partum period interfered with the bacteriological results of sow urine collected one day post farrowing. However, the high levels of protein and WBC's revealed that UTI also were present in these sows.

For each farm, over 40% of urine samples from lactating sows had white blood cell (WBC) counts ($> 5-10$ cells/10hpf – Score ≥ 2) considered indicative of inflammation (Figure 3). Samples collected from sows in late gestation showed much lower numbers of WBC. Crystalluria, including triple phosphate and calcium oxylate crystals, was evident in approximately 15% of all urine samples (Figure 4).

Epithelial cells were common in the urine sediment of samples collected from lactating and gestating sows (Table 1). Most notable are the greater ($P<.05$) number of epithelial cells in urine from lactating sows from the LWFL and HR farm than the PR farm. The vast majority of samples contained bacteria. Cultures and colony counts were performed on the samples collected from the PR farm. Most sows also had significant bacteriuria ($>10^5$ cfu/ml) with mixed infections (*E. coli*, *Proteus* spp, *Staphylococcus* etc). The culture results were comparable to the urine sediment results in that more than 80% of the samples had large numbers of bacteria upon sediment examination and these samples also had high colony counts when cultured.

Drinker Flow Rates:

Urine SG and pH did not appear to be associated with parity (Figures 5 and 6). Drinker flow rates varied greatly from drinker to drinker within the houses as well as between farms (Figure 7). Drinker flow rate and ventilation system (assessed in the HR and LWFL farms) did not appear to influence SG, pH, WBC, crystals, and bacterial counts. It should be noted that drinker flow rates were consistently greater than 700 ml/min.

Production Parameters:

In regard to production parameters in the PR farm (Table 3), the control sows *tended* to have greater pigs born alive/litter from the first farrowing and reduced weaning-to-service intervals. These results must be viewed with caution, since numerous other factors, which were not measured in this study, contribute to litter size. Considerable cross-fostering of piglets occurred between sows and thus, pigs weaned per litter may not be the best estimate of preweaning mortality. For the second farrowing, there were no differences between case and control sows. Other production parameters also were similar between case and control sows. The overall mortality and reasons for removal did not differ between groups. Penicillin administration was common in sows within the first few days after farrowing. For case and control sows, 68% and

54% were treated with penicillin (and oxytocin), respectively. The penicillin treatments were given for post-parturient dysgalactia and not directed at UTI. Performance records for the sows in the HR and LWFL farms are provided in Table 4. As shown in the PR farm, the reproductive performance of case and control sows did not differ.

Discussion

Based on the results, it is evident that UTI are relatively common in sows. The prevalence of UTI in gestating sows was similar to previous reports; however, the present results indicate that UTI apparently are more common in lactation. The causes for UTI in lactation are speculative. Initially, we anticipated that sows with UTI during late lactation would most likely represent the vast majority of sows with UTI in lactation. Our observations did not reveal that a gestating sow with UTI was at greater risk of UTI during lactation. In addition, many sows with UTI, as diagnosed with urine constituents, did not consistently test positive. *This infers that in some sows, the UTI may resolve without intervention.* In contrast, a percentage of animals did have UTI on two or more samples and the UTI did not resolve; however, the UTI did not interfere with their subsequent reproductive performance.

Other factors clearly must contribute to UTI in lactating sows. As shown in the results, the high specific gravity (Figure 1) demonstrates that lactating sows are concentrating their urine in an effort to conserve water. Lactating sows urinate infrequently and their urine is concentrated as indicated by specific gravity. Therefore, it is not surprising that UTI are common in lactating sows – the beneficial effect of frequent urination with high volumes of urine are lost during lactation. After the piglets were weaned from the sows, it was noted that specific gravity decreased and thereby indicating that the sows were drinking more water, and their water demands had diminished.

The lack of influence of drinker flow rate on SG was surprising; however, the vast majority of drinkers delivered > 700 ml/min. The high SG may reflect the physiological response of lactating sows to conserve water for milk production or insufficient water intake. Additional management factors, such as feeding practices, also may be critical for water intake by lactating sows. Since sows must stand to drink from most conventional water systems, most drinking occurs around feeding times when sows are encouraged to stand. The subclinical UTI, as detected with urinalysis methods, did not interfere with sow reproductive performance, as farrowing rates and litter sizes were similar in sows with or without UTI in the PR farm. However, future studies assessing lactational performance as measured by birth weight and weaning weight of piglets would be beneficial.

Overall, marginal differences in production and performance were noted between case and control sows. In fact, farrowing rates and litter sizes on the second (subsequent) litter were the same. It was apparent that a single or even multiple episodes of UTI does not necessarily affect the performance of sows. The mortality, including the case sows, was considerably lower than industry averages, particularly for a herd of this size. Recorded treatments were restricted to the sows in the farrowing house with postpartum administration of penicillin representing a fairly routine procedure. Additional treatments and medications in gestation were rare.

In summary, the present study did not demonstrate a clear association between UTI and sow productivity. The prevalence of cystitis, as diagnosed with urinalysis methods, was comparable to previous reports. Compared to industry averages, sow mortality was surprisingly low. Although several reports indicate that UTI are an important factor in sow mortality, the present results indicate that the “subclinical” UTI are not typically detected by farm personnel and that affected sows often continue to provide adequate reproductive performance. We suspect that many sows have cystitis to varying degrees and unless the infection ascends to the kidney, the infection does not become life-threatening. Despite the high frequency of abnormal urine samples in lactation, these sows either recovered by early gestation or continued as subclinical animals.

Conclusions

Previous studies revealed that 22% to 40% of sows in confinement operations are affected with urinary tract infections (UTI), which contribute to sow mortality. This study was designed to determine if UTI are detrimental to sow performance and to identify the stage of the production cycle that sows are at greatest risk of acquiring UTI. The study was conducted on commercial sow farms. Our results demonstrated that abnormal urine samples were more common in sows during lactation and postweaning than in gestating sows. Some sows appeared to recover from the UTI with the sole intervention of increased access to water in the gestation/breeding facilities. We suspect that many sows have cystitis to varying degrees and remain “subclinical”. Unless the infection ascends to the kidney, the infection is not necessarily life-threatening and remains undetected. Surprisingly, the subclinical UTI, as detected with urinalysis methods, do not appear to interfere with sow reproductive performance. Urine abnormalities, indicative of UTI, are common in sows; however, it is evident that further refinements of urinalysis methods are required to adequately predict the outcome of UTI.

References

1. Christensen, G., L. Vraa-Anderson, and J. Mousing. 1995. Causes of mortality among sows in Danish pig herds. *Veterinary Record* 137: 395-399.
2. Mroz, Z., A. W. Jongbloed, N. P. Lenis, and K. Vreman. 1995. Water in pig nutrition: physiology, allowances and environmental implications. *Nutrition Research Reviews* 8:137-164.
3. Gill, B. P. 1989. Water use by pigs managed under various conditions of housing, feeding, and nutrition. PhD Thesis, Polytechnic of the South West, Plymouth. (As referenced in Mroz et al. 1995)
4. Madec, F., R. Cariolet, R. Dantzer. 1986. Relevance of some behavioural criteria concerning the sow in intensive pig farming and veterinary practice. *Annales de Recherches Veterinaires* 17: 177-184.
5. Bollwahn, W., G. Arnhofer. 1989. The importance of exogenous factors on the composition of the urine of breeding sows. *Tierarztl Prax* 17: 43-46.
6. Almond, G. W., J. B. Stevens. 1995. Urinalysis techniques for swine practitioners. *Compendium on Continuing Educations for the Practicing Veterinarian* 17: 121-129.

Figure 1a: Urine specific gravity (mean + SEM) in samples collected from lactating sows (LWFL, HR, PR) and sows in late gestation (PR-Gestation). Bars with different letters differ ($P < .05$).

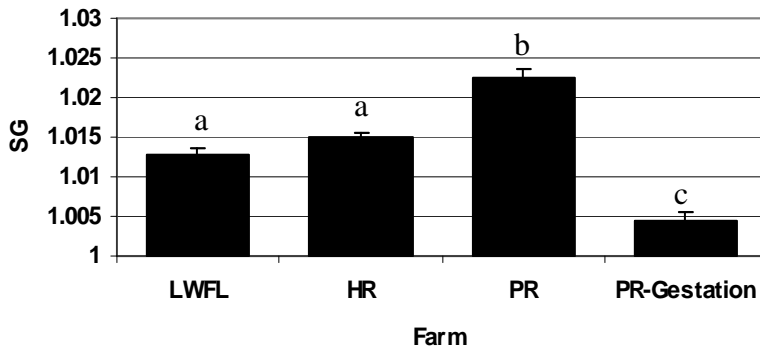


Figure 1b. Urine specific gravity in samples collected from sows at various stages of production at the PR farm. Values are provided for all sows (overall) and sows (cases) with or without (controls) urinary tract infections. (LG – late gestation; Far – 1 day after farrowing; Lact – days 10-14 of lactation; PW – 4-6 days after weaning; EG – early gestation).

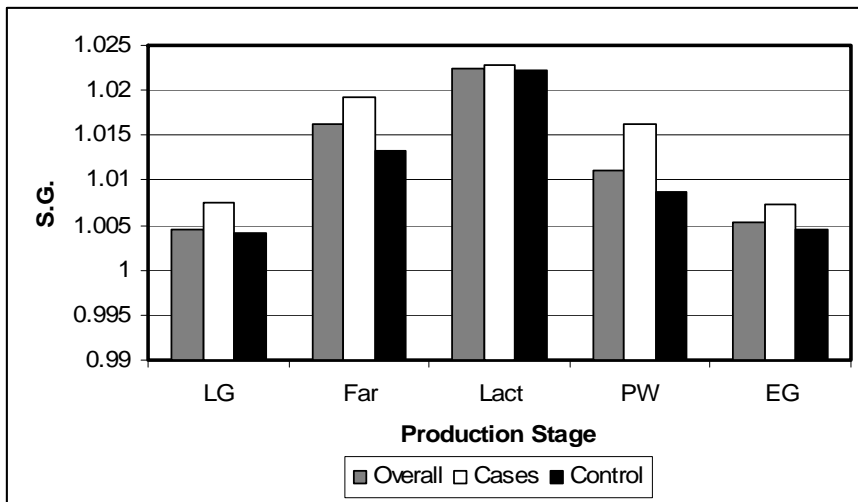


Figure 2a: Urine pH (mean + SEM) in samples collected from lactating sows (LWFL, HR, PR) and sows in late gestation (PR-Gestation). Bars with different letters differ ($P < .05$).

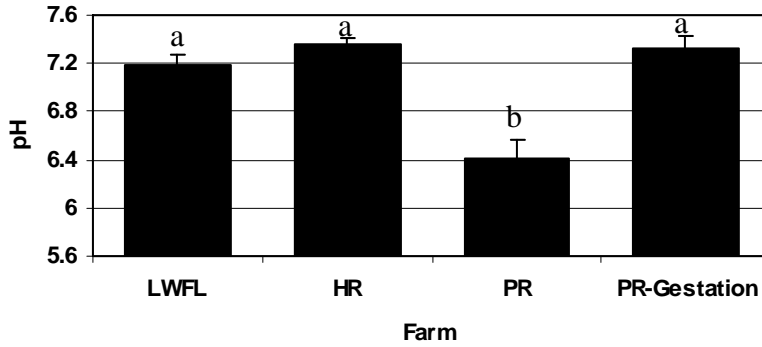


Figure 2b. Mean pH of urine samples collected from sows at different stages of production in the PR farm. Values are provided for all sows (overall) and sows (cases) with or without (controls) urinary tract infections. (LG – late gestation; Far – 1 day after farrowing; Lact – days 10-14 of lactation; PW – 4-6 days after weaning; EG – early gestation).

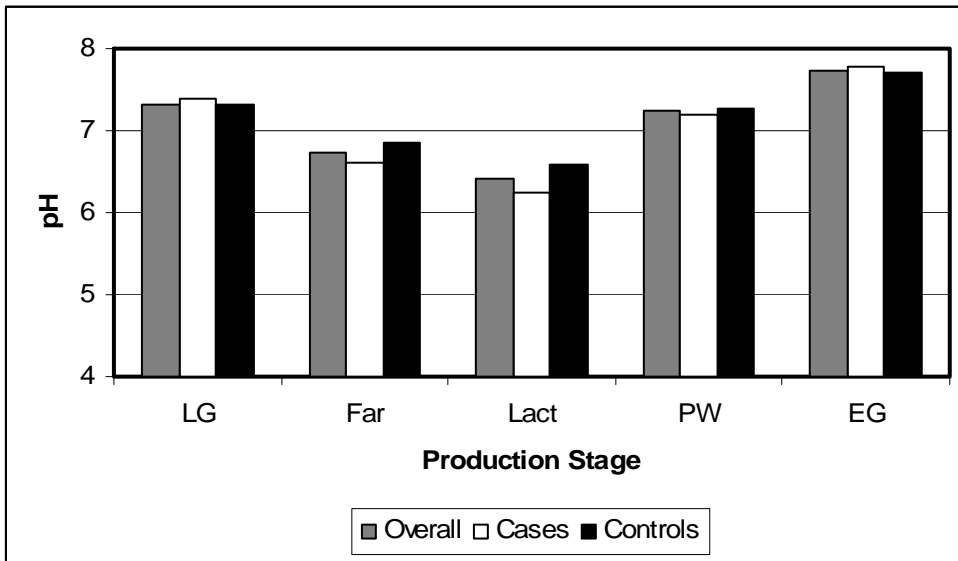


Figure 3: Percentages of urine samples with WBC, as determined by analysis of urine sediment. For the white blood cells (WBC), a score of ≥ 2 (5-10 cells/high power field) is considered abnormal.

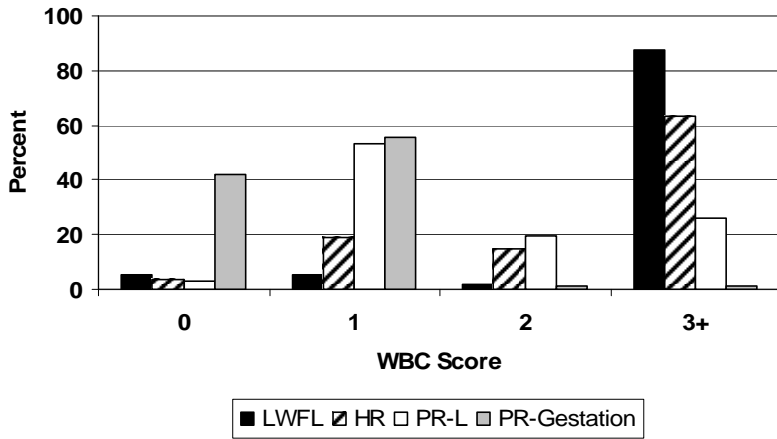


Figure 4: Percentages of urine samples with crystalluria, as determined by analysis of urine sediment. For crystals, a score of ≥ 2 (5-10 cells/high power field) is considered abnormal.

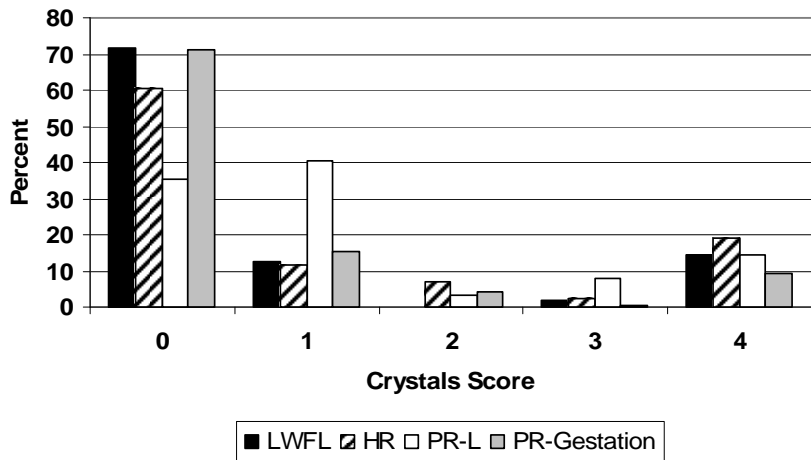


Figure 5: Urine specific gravity in different parities of lactating sows (HR and LWFL farms). The specific gravity also is shown for sows housed in facilities with curtain or cool-cell ventilation. The P5+ sows tended to have lower urine specific gravity than P-1, P-2 and P-4 sows.

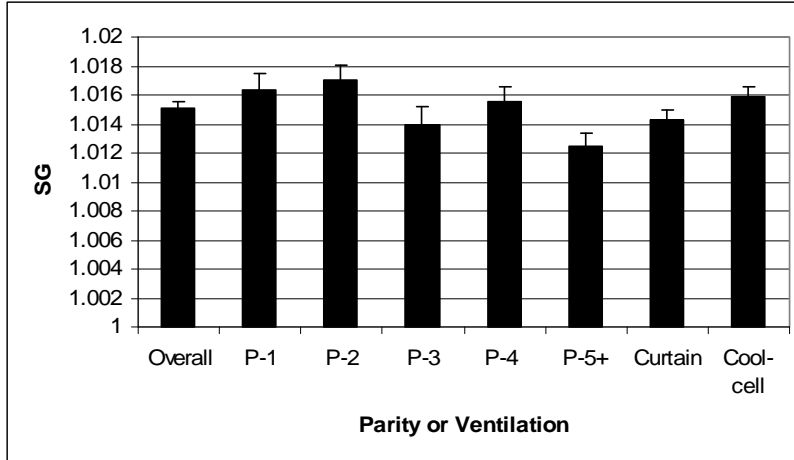


Figure 6: Urine pH in different parities of lactating sows (HR and LWFL farms). The specific gravity also is shown for sows housed in facilities with curtain or cool-cell ventilation. No differences were apparent.

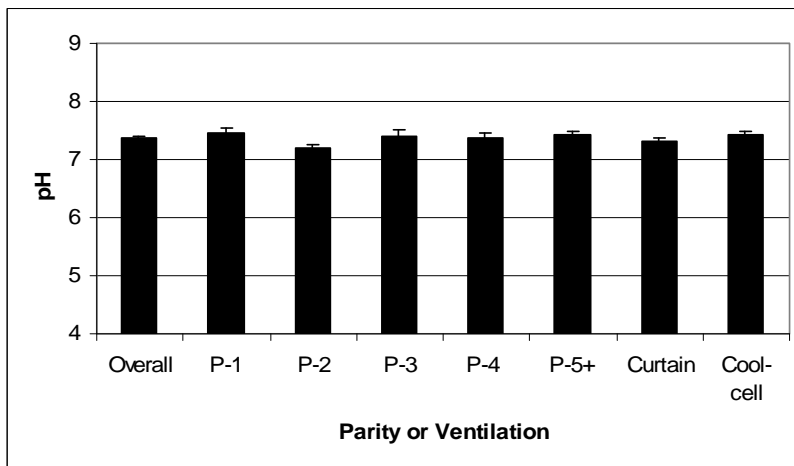


Figure 7: Urine specific gravity (SG; y axis) plotted against drinker flow rate.

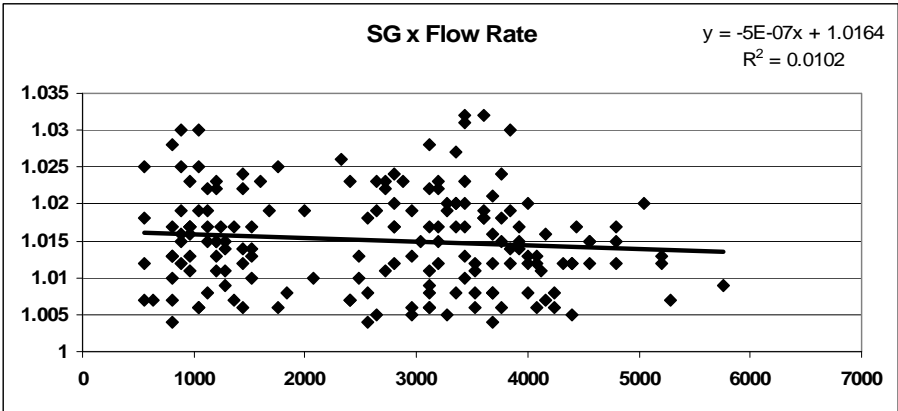


Table 1: Urinalysis results for lactating sows and sows in late gestation. For protein, nitrite and ketones, a score of 0 is considerable normal. The values represent the percentage of samples collected during the respective stages.

| Urine Constituent | Score | Farm | | | |
|-------------------------|-------|----------|----------|----------|--------------|
| | | LWFL | HR | PR | PR-Gestation |
| Dipstick Results | | | | | |
| Leukocytes | 0 | 67.85714 | 98.91304 | 91.93548 | 32.14286 |
| | 1 | 8.928571 | 0.543478 | 4.83871 | 60.26786 |
| | 2+ | 23.21429 | 0.543478 | 3.225806 | 7.589286 |
| Nitrite | 0 | 98.21429 | 100 | 98.3871 | 92.85714 |
| | 1 | 1.785714 | 0 | 1.612903 | 7.142857 |
| Protein | 0 | 87.5 | 98.91304 | 91.93548 | 95.98214 |
| | 1 | 12.5 | 1.086957 | 6.451613 | 3.571429 |
| | 2+ | 0 | 0 | 1.612903 | 0.446429 |
| Blood | 0 | 92.85714 | 91.30435 | 95.16129 | 100 |
| | 1 | 1.785714 | 4.347826 | 4.83871 | 0 |
| | 2+ | 5.36 | 4.35 | 0 | 0 |
| Ketones | 0 | 96.42857 | 99.45652 | 100 | 97.76786 |
| | 1 | 3.571429 | 0.543478 | 0 | 2.232143 |
| Sediment Results | | | | | |
| Epithelial cells | 0 | 12.5 | 14.67391 | 45.16129 | 25.44643 |
| | 1 | 33.92857 | 36.95652 | 53.22581 | 74.55357 |
| | 2 | 16.07143 | 15.76087 | 0 | 0 |
| | 3+ | 37.5 | 32.6087 | 3.225806 | 0 |
| RBC | 0 | 75 | 47.28261 | 90.32258 | 99.55357 |
| | 1 | 12.5 | 47.82609 | 11.29032 | 0.446429 |
| | 2+ | 12.5 | 4.891304 | 0 | 0 |
| Bacteria | 0 | 21.42857 | 5.434783 | 14.51613 | 7.589286 |
| | 1 | 17.85714 | 23.91304 | 22.58065 | 15.625 |
| | 2+ | 60.71429 | 70.65217 | 64.51613 | 76.78571 |

| PRODUCTION STAGE | | | | | | | | | | | |
|--------------------------|-------------------------------------|----------------|-----------------------------------|----------------|-------------------------------------|----------------|---------------------------------|----------------|--------------------------------------|----------------|--------------|
| Urine Constituent | Late Gestation (90-95 d) | | One Day Post Farrowing | | Late Lactation (d 10-14) | | Post-weaning (4-6 d) | | Early Gestation (25-30 d) | | |
| PROTEIN | Score | Control | Cases | Control | Cases | Control | Cases | Control | Cases | Control | Cases |
| | 0 | 99.5 | 69.2 | 100 | 36 | 100 | 83.3 | 96.6 | 29.6 | 100 | 84.6 |
| | 1 | 0.5 | 26.9 | 0 | 52 | 0 | 13.3 | 3.4 | 40.7 | 0 | 15.4 |
| | ≥2 | 0 | 3.8 | 0 | 12 | 0 | 3.3 | 0 | 29.6 | 0 | 0 |
| KETONES | Score | Control | Cases | Control | Cases | Control | Cases | Control | Cases | Control | Cases |
| | 0 | 97.5 | 100 | 88.9 | 64 | 100 | 100 | 93.1 | 63.0 | 99.0 | 100 |
| | 1 | 2.5 | 0 | 7.4 | 24 | 0 | 0 | 5.2 | 11.1 | 0 | 0 |
| | ≥2 | 0 | 0 | 3.7 | 12 | 0 | 0 | 1.7 | 25.9 | 1.0 | 0 |
| WBC | Score | Control | Cases | Control | Cases | Control | Cases | Control | Cases | Control | Cases |
| | 0 | 42.9 | 34.6 | 11.1 | 0 | 6.3 | 0 | 22.5 | 3.7 | 20.6 | 0 |
| | 1 | 57.1 | 46.2 | 88.9 | 60 | 93.7 | 10 | 58.6 | 11.1 | 50 | 2.6 |
| | ≥2 | 0 | 19.2 | 0.0 | 40 | 0 | 80 | 18.9 | 85.2 | 28.4 | 97.4 |
| CRYSTALS | Score | Control | Cases | Control | Cases | Control | Cases | Control | Cases | Control | Cases |
| | 0 | 73.2 | 53.8 | 55.6 | 52 | 40.6 | 30 | 79.3 | 59.3 | 79.4 | 64.1 |
| | 1 | 14.6 | 19.2 | 40.7 | 40 | 34.4 | 46.7 | 12.1 | 18.5 | 7.8 | 5.1 |
| | ≥2 | 12.2 | 26.9 | 3.7 | 8 | 25.1 | 23.3 | 8.7 | 22.2 | 12.8 | 30.8 |

Table 2. Urinalysis results for sows at different stages of production in the PR farm. For protein and ketones, a score of 0 is considerable normal. For the white blood cells (WBC) and triple phosphate crystals, a score of ≥ 2 is considered abnormal. The values represent the percentage of samples collected during the respective stages.

Table 3: Production parameters for PR sows with (cases) or without (control) urinary tract infections. Production data was collected for two successive farrowings.

| Production Parameter | Control Sows | Case Sows |
|--|---------------------|------------------|
| First Farrowing | | |
| Average Parity | 2.2 | 2.0 |
| Pigs Born Alive/Litter | 11.01 ± .3 | 10.49 ± .3 |
| Stillborn Pigs/Litter | 0.7 ± .1 | 0.9 ± .2 |
| Mummies/Litter | 0.14 ± .03 | 0.14 ± .03 |
| Pigs Weaned/Litter | 8.8 ± .17 | 9.01 ± .15 |
| Weaning-to-service interval (days) | 5.2 ± .23 | 6.2 ± .27 |
| Percent weaned & bred | 89.5 | 86.2 |
| Farrowing Rate – 1 st estrus (%) | 74.2 | 74.7 |
| Farrowing Rate -1 st & 2 nd estrus (%) | 86.7 | 85.3 |
| Not-in-pig (%) | 0 | 4.6 |
| Mortality in Lactation (%) | 1.4 | 0 |
| Mortality in Gestation (%) | 3.5 | 5.8 |
| Cull at Weaning (%) | 7.0 | 5.8 |
| Cull – Anestrous (%) | 4.2 | 6.9 |
| Cull – Repeat Breeder (%) | 3.5 | 4.6 |
| Cull – Abortion (%) | 2.8 | 1.2 |
| Second Farrowing | | |
| Pigs Born Alive/Litter | 9.6 ± .3 | 9.7 ± .4 |
| Stillborn Pigs/Litter | 0.7 ± 0.1 | 0.8 ± .1 |
| Mummies/Litter | 0.1 ± .01 | 0.1 ± .01 |

Table 4: Production parameters for sows with (cases) or without (control) urinary tract infections in the HR (80 controls, 76 cases) and LWFL farms (28 controls, 22 cases). Production data was collected for two successive farrowings. Accurate farrowing rates could not be determined; however, the number of sows remaining in the herd for each group is provided.

| HR FARM | Production Parameter | Control Sows | Case Sows |
|-------------------------|--|---------------------|------------------|
| First Farrowing | | | |
| | Average Parity | 3 ± .2 | 2.8 ± .2 |
| | Pigs Born Alive/Litter | 10.3 ± .4 | 10.1 ± .4 |
| | Stillborn Pigs/Litter | 1 ± .1 | 1 ± .2 |
| | Mummies/Litter | .6 ± .2 | .8 ± .2 |
| | Pigs Weaned/Litter | 8.5 ± .3 | 8.7 ± .3 |
| | Weaning-to-service interval (days) | 9.6 ± 1.4 | 7.5 ± .8 |
| | Percent weaned & farrowed 2 nd litter | 77.5 | 82.8 |
| Second Farrowing | | | |
| | Pigs Born Alive/Litter | 11 ± .4 | 10.6 ± .4 |
| | Stillborn Pigs/Litter | 1.1 ± 0.1 | 0.8 ± .1 |
| | Mummies/Litter | 0.1 ± .01 | 0.1 ± .01 |

| LWFL FARM | Production Parameter | Control Sows | Case Sows |
|-------------------------|--|---------------------|------------------|
| First Farrowing | | | |
| | Average Parity | 5 ± .6 | 5.5 ± .9 |
| | Pigs Born Alive/Litter | 10.9 ± .5 | 10.9 ± .7 |
| | Stillborn Pigs/Litter | 1.4 ± .3 | 1.5 ± .4 |
| | Mummies/Litter | .1 ± .07 | .1 ± .08 |
| | Pigs Weaned/Litter | 8.2 ± .5 | 6.9 ± 1 |
| | Weaning-to-service interval (days)** | NA | NA |
| | Percent weaned & farrowed 2 nd litter | 65 | 77 |
| Second Farrowing | | | |
| | Pigs Born Alive/Litter | 12.6 ± .6 | 10.3 ± .6 |
| | Stillborn Pigs/Litter | 1.7 ± .3 | 1.9 ± .4 |
| | Mummies/Litter | .2 ± .1 | .25 ± .1 |

** Due to the research studies on the LWFL farm, the initial post-weaning estrus was intentionally skipped on many sows, and thus the WSI was not calculated.