

## ANIMAL SCIENCE

**Title:** Using objective mechanical and physiologic measurement to build robust producer tools for detecting, scoring and treating lameness in sows” - NPB# 09-073

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**Institution:** Iowa State University

**Date Submitted:** August 3, 2011

### Industry Summary:

The main objectives of this study were: 1) To produce a robust observational lameness scoring system with accompanied visual educational material, (2) to assess sodium salicylate and flunixin meglumine (Banamine®) for pain mitigation in sows with lameness and (3) to validate an objective measuring tool; the “crate adapted static force plate” (CASFP) as an objective assessment tool for sow lameness. Twenty four clinically normal sows were purchased from a Midwestern facility and acclimated to CASFP in the lab. Sows were temporarily made lame on one of four feet, and were randomly assigned to one of two analgesic treatment groups (NSAIDs) or a control treatment. Forty-eight hours after lameness was induced NSAID treatments were initiated and were given daily for four consecutive days. CASFP and lameness scores were recorded on the day before sows were lame (Day -1: when they should have been clinically sound), the day after they were made lame (Day +1: when they should have been most lame), and the last day of the treatment regimen (Day +6: when they should have the most benefit from the treatment). Lameness was assessed both subjectively and objectively. Lameness scoring systems are designed to categorize the degree of lameness typically expressed during locomotion. There are two main **subjective** scoring systems used in assessing lameness of livestock: numerical rating scale (NRS) and visual analog scale (VAS). For the purposes of our study we used a numerical rating 4 point scale (NRS) developed by Zinpro. The embedded microcomputer-based CASFP was developed at Iowa State University to **objectively** identify varying severities of lameness among sows. This force plate measures mean weight (kg) of each individual foot and was developed to be sensitive enough to recognize lameness undetectable by subjective scoring. The results of this study confirm that the Zinpro NRS locomotion scoring system is repeatable, and user friendly approach for diagnosing lameness in sows with 71.4% observer agreeability. A library of approximately 150 hours of sow gait video footage in HD format was created, which demonstrates a wide range of clinical severities and can be used to train producers and veterinarians to recognize various severities of lameness. There was no significant difference between mean weights (kg) placed on each foot among treatment (control, sodium salicylate, Banamine) groups recorded on the last day of treatment (Day +6). CASFP for all four feet was analyzed statistically for each individual foot (left front (LF), right front (RF), left rear (LR), right rear (RR)) and was compared to the other non-injected feet on Day -1 (sound day) and Day +1 (lame day). When the LF and RF feet were injected, there was a significant decrease in the weight being placed on the injected foot on Day +1 ( $P < 0.05$ ). The majority of sows returned to soundness

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by Day+6 however some sows did continue to exhibit lameness past Day +6. In conclusion, based on the main objectives addressed in this paper we have: (1) validated a robust observational lameness scoring system and created a vast library of visual material for education (2) confirmed that sodium salicylate and flunixin meglumine at the dose and length given did not provide significant pain relief for lameness using this model of lameness (3) and validated the CASFP as an objective assessment tool for sow lameness. Questions about the trial, conclusions, or access to the video library can be addressed to Dr. Locke Karriker using email: karriker@iastate.edu or by phone: 515-294-2283.

**Keywords:**

welfare, lameness, sodium salicylate, flunixin meglumine, pain, lameness scoring

**Scientific Abstract: (one page)**

Objectives of this study were to: (1) validate a lameness scoring system and provide a supplemental visual library for future training, (2) to assess sodium salicylate and flunixin meglumine (Banamine®) for pain mitigation in sows with induced transient lameness (3) and validate the CASFP as an objective assessment tool for sow lameness. Twenty four mixed parity crossbred sows were anesthetized and injected with amphotericin B in the distal interdigital space of both claws of one chosen leg to temporarily induce lameness. Sows were randomly assigned to one of two analgesic treatment groups or a control treatment: 1. Sodium Salicylate (orally 35mg/kg q.12.h + 0.04 ml/kg sterile saline IM q.24.h), 2. Flunixin meglumine (2.2 mg/kg IM q.24.h), or 3. Control (0.04 ml/kg sterile saline IM q.24.h). Forty-eight hours post-induction, NSAID treatments began daily for four consecutive days (Day +2 to Day +5). Sodium salicylate was orally top-dressed twice/day with an IM injection of sterile saline once/day for handling consistency. Flunixin meglumine was injected IM once/day. Sterile saline was injected IM once/day. Lameness was evaluated using both subjective and objective measures. Lameness was subjectively assessed using a numerical rating lameness scoring system consisting of 4 categories ranging from 0 (no lameness) to 3 (severe lameness). Observers were trained using video with verbal description of ideal sows per category. Lameness scores were assessed at 2 day intervals throughout the 21 day trial. Sows were objectively assessed using the CASFP. Data was collected on Day -1 (sound day), Day +1 (lame day) and Day+6 (last day of treatment) relative to induction (Day 0). Observers agreed on the correct category of lameness 71.4% of the time. The average weighted Kappa was 0.7049 with a range of 0.3529 to 0.8897. There was no significant difference in the deviations between adjacent scores ( $p < 0.0001$ ). In addition the production of a library of approximately 150 hours of sow gait video footage in HD format which demonstrates a range of clinical severities can be used to train producers and veterinarians to recognize various severities of lameness. Proc Mixed of SAS 9.2 was used to analyze the difference between sound leg and lame leg. CASFP data for all four feet was analyzed statistically for each individual foot (LF, RF, LR, and RR) and was compared to the other non-injected feet. CASFP measurements on Day +6 showed no significant difference between weights (kg) placed on the plate among treatment (control, sodium salicylate, Banamine) groups. This lameness assessment tool was not able differentiate a possible effect of NSAID treatment to mitigate pain response from Day+1 to Day+6. CASFP data was analyzed on Day -1 (sound day) and Day +1 (lame day) and compared the effect of individually injected feet. When the LF and RF feet were injected, there was a significant decrease in the weight being placed on the injected foot on Day +1 ( $P < 0.05$ ). This data confirms that the CASFP is a objective assessment tool for sow lameness.

**Introduction: An overview of the researchable question and its importance to producers**

Pain and lameness are issues in the swine industry that affect animal welfare and decrease productivity. However there are currently no FDA approved treatments for pain in swine. The FDA has articulated the need for objective assessments of pain in order to evaluate efficacy of pain mitigation. Identifying and validating objective tools such as the CASFP will allow for progress in the approval process and will provide producers with legal tools to address industry and public expectations that pain is managed appropriately in swine. Producers have also requested the need for subjective and objective tools to be used on farm to assess lameness in sows. Providing farm friendly tools, such as a scoring system or visual library, allows producers can educate their workers to diagnose, treat and prevent lameness before the sow has to be removed from production.

## **Objectives:**

Our objective was to produce four deliverables: 1) To produce a robust observational lameness scoring system which will allow earlier and more reliable management decisions to be made about lame sows. (2) To assess the value of sodium salicylate and flunixin meglumine as pain treatments in cases of lameness. (3) To validate an objective measuring tool; the “crate adapted static force plate” as an objective assessment tool for sow lameness (this will allow specific, naturally occurring lesions to be correlated with lameness in a follow up study) and (4) To produce a library of visual products including video and still photos with corresponding objective measurements that will be available to train and test farm employees on objective and validated sow lameness assessments.

## **Materials and Methods:**

The protocol for this experiment was approved by the Iowa State University Institutional Animal Care and Use Committee.

### *Experimental Design*

A repeated measures design compared responses for each sow during sound (Day-1), most lame (Day+1), and analgesia/placebo treatment days (Day+6), relative to lameness induction (Day0). Sows were randomly assigned to one of two analgesic treatment groups or a placebo control treatment: 1. Sodium Salicylate (35mg/kg q.12.h orally + 0.04 ml/kg sterile saline IM q.24.h), 2. Flunixin meglumine (2.2 mg/kg IM q.24.h), or 3. Control (0.04 ml/kg IM q.24.h sterile saline).

### *Animals and Housing*

Twenty four clinically normal culled sows were purchased from a private commercial producer in Iowa, temporarily made lame on one of four feet, assessed using the CASFP, and assigned locomotion scores. The average weight of sows was 189.6 kg±26.2 (Mean±S.D.). Cull sows were mixed parities, and were all crossbred sows.

To avoid confounding injury due to aggression, sows were individually housed in a research unit located at the Iowa State University College of Veterinary Medicine in Ames, IA. Each sow was individually housed in concrete pens providing 28 ft<sup>2</sup> (2.6 m<sup>2</sup>) per animal. Pens contained a rubber mat to minimize the impact of pressure from the concrete floor. Pens were set up in two rows with a central aisle allowing for nose to nose contact with cohorts. Sows had ad libitum access to water and were fed six pounds gestation feed with no antibiotics per day. A commercially available, FDA approved estrus suppressant, 0.22% Altrenogest (Matrix®, Intervet/Schering-Plough Animal Health, Millsboro, DE, USA) was orally top-dressed on the pigs' daily feed.

### *Induction of Lameness*

Feed was withheld from the sows 18 hours prior to anesthesia, and water withheld 1 hour prior to anesthesia to reduce the possibility of vomiting and aspiration during the anesthesia and recovery periods. Sows were restrained with a wire hog snare and anesthetized (2.2 mg/kg Xylazine, 1.1 mg/kg Ketamine and 2.2 mg/kg Telazol injected intramuscularly). Following sedation, the animal was placed in lateral recumbency and the assigned limb was washed with mild soap and water and surgically scrubbed for preparation for amphotericin B injection. The assigned leg was injected in the distal interdigital space on both medial and lateral claws with 10mg amphotericin B (total volume of 1 ml in each claw) to induce lameness in that leg. Sows were monitored constantly until they returned to standing. Respiration was monitored, as was rectal temperature. Core temperature was regulated with heating mats and blankets as warranted.

### *Experimental Design*

The inducible lameness model facilitated data collection on the same sow when both sound and lame, reducing the total number of sows required for the experiment. Sows were acclimated for assessment tests and to handling prior to the trial. Sows were randomly assigned to one of four lameness groups corresponding to the sows' four legs. Sows were assessed on day -1, day +1 and day +6 for lameness using the CASFP and assessed

at two day intervals by 5 blind evaluators using NRS scoring system. During both test trials, trial schedule was staggered and observers were blind to sow identification so that it was not possible for observers to predict when sows should be lame or sound.

#### *Assessment Tests*

All assessment tests were completed within the sow lab in a modified gestation crate (2' x 6') outside of the sows' home pens and in a carpet covered walking track around the perimeter of all sows' home pen. Sows were fed while in the gestation crate during testing. Assessment tests were administered on Day-1, Day+1, and Day+6 relative to lameness induction (Day0)

#### *Lameness Scoring*

For the purposes of our study the 4 point NRS developed by Zinpro was used. The scoring system consisted of 4 categories ranging from 0 (no lameness) to 3 (severe lameness). Observers reviewed the scoring systems and video examples of each score for the NRS before scoring individual sows. Lameness scores were assessed at two day intervals by 5 blinded evaluators. Evaluators were presented with sows individually with a variety of clinical conditions for each sow per day. Sows walked around the carpet covered track at their own speed and will as observers scored the animals live. This live scoring served to confirm that the induction of lameness was successful and a population of lame animals was created for further evaluation. Statistical analysis of this live scoring did not occur.

After live animal work, video that was captured of the various lameness states was used to build a web-based platform to train and test caretakers. Seventeen caretakers used the web-based platform to assess and score sows. The agreement of these observers was statistically tested and those results are reported below.

#### *Crate Adapted Static Force Plate:*

The embedded microcomputer-based force plate system was developed at Iowa State University to objectively identify varying severities of lameness among sows. This force plate was developed to be sensitive enough to recognize lameness undetectable to the subjective eye. The force plate was designed with a total dimension of 1524 × 565 × 106 mm (length × width × height), with 6.4-mm thick aluminum plating comprising the top and bottom plate. A semi-flexible epoxy (FlexCoat, Vanberg Specialized Coatings, Lenexa, Kans.) was mixed with sand to mimic the floor type that a sow would stand on daily. Sows were walked into a standard gestation crate with the flooring replaced by the static force plate. Sows were fed a standard diet that complies with Iowa State Animal Care and Use Committee and remained in the crate for 15 minutes. This plate measures the mean weight (kg) of each foot independently and was able to detect weight shifting activities with the sow standing. A video camera recorded side profiles as they stood on the force plate. Data was collected on sows on Day -1, Day +1, and Day +6 in relation to induction day (Day 0).

#### *NSAIDs:*

Forty eight hours after induction, NSAID treatments were initiated and were given daily for four consecutive days (Day+2 – Day+6). Sodium salicylate treatment was a 35 mg/kg oral top-dressing for feed twice per treatment day, and sows were also administered an intramuscular injection of 0.04 ml/kg sterile saline once per day in the morning, to provide consistent handling for all treatments. Flunixin meglumine (Banamine) treatment was administered as a 2.2 mg/kg intramuscular injection once per day in the morning. Control treatment was administered as an intramuscular injection of 0.04 ml/kg sterile saline once per day in the morning.

#### *Statistical Analysis*

Intraclass and Pearson correlation coefficients were calculated between subjective lameness scoring methods to determine agreement between and within observers. Standard error of prediction and standard error of repeatability values were calculated to estimate the accuracy of subjective scoring to the true force values and the repeatability of those subjective scores over multiple rounds. ANOVA was performed for the effects of lameness on subjective scoring methods. Proc Mixed of SAS 9.2 was used to analyze the difference between

sound leg and lame leg. CASFP data for all four feet was analyzed statistically for each individual foot (LF, RF, LR, RR) and was compared to the other non-injected feet.

### **Results: report your research results by objective**

Our objective was to produce four deliverables: 1) to validate a robust observational lameness scoring, (2) to assess the value of sodium salicylate and flunixin meglumine as pain treatments in cases of lameness, (3) to validate an objective measuring tool; the CASFP as an objective assessment tool for sow lameness, and (4) to produce a library of video and photographs for training farmers and veterinarians for lameness detection. Further detailed discussion follows but in summary, we produced all deliverables: (1) Zinpro 4 point lameness scoring system was validated as a robust observational lameness scoring system. (2) Neither sodium salicylate nor flunixin meglumine were observed to reduce lameness compared to untreated animals in this particular study. (3) The CASFP was validated as an objective assessment tool for the identification of lame sows. (4) Approximately 150 hours of video was obtained and archived that included the same sow in several states of lameness. This library will be an asset for on farm education as well as continuing education and testing of producers, workers and veterinarians to help diagnose, treat and prevent lameness in a sow before she has to be removed from production.

#### *Lameness*

Lameness induction led to significant decrease in mean weight (kg) placed on the force plate for all four feet when comparing data collected on Day -1 with Day +1 ( $P \leq 0.05$ ). Maximum lameness effect occurred twenty-four hours post-induction. Sows were still able to walk and bear weight on lame legs, but had a decreased desire to do so. Induced feet showed no gross physical differences compared to sound limbs.

#### *Lameness Scoring*

Seventeen observers were used to assess lame sows using video collected throughout the trial and all observers were trained previously using visual images and descriptions of all 4 lameness categories. The inter-observer reliability for individual sows was high. Observers agreed on the correct category 71.4% of the time, were one category away 27.4% of the time, and where two categories away 1.2% of the time. The average weighted Kappa was 0.7049 with a range of 0.3529 to 0.8897 (figure 3). There was no significant difference in the deviations between adjacent scores ( $p < 0.0001$ ). The Cochran-Mantel-Haenszel statistic showed no significance among the different scoring categories ( $p < 0.0001$ ). Participants were able to group the sows correctly even when just comparing the middle scores of 1 and 2 justified by Wilcoxon statistic ( $z = 0.03$ ). Observers' agreed at a comparable but slightly better average (71.4%) than similar studies in dairy cattle (68%). This data revealed a significant agreement among observers ( $p < 0.0001$ ). It is important to note that clinically lame sows were almost always identified by all observers as lame and each observer was able to categorize them within one point of their true locomotion score 98% of the time.

A library of approximately 150 hours of sow gait video footage in HD format was created which demonstrates a range of clinical severities of lameness. This library can be used to train producers and veterinarians to recognize various severities of lameness. This library will be an asset for on farm education as well as continuing education and testing of producers, workers and veterinarians to help diagnose, treat and prevent lameness in a sow before she has to be removed from production.

#### *Crate Adapted Static Force Plate*

The purpose of this study was to validate CASFP as an on farm objective assessment tool for sow lameness. Proc Glimmix of SAS 9.2 was used to analyze the difference between sound leg and lame leg. CASFP data for all four feet was analyzed statistically for each individual foot (LF, RF, LR, RR) and was compared to the other non-injected feet on Day -1 (sound day) and Day +1 (lame day). When the LF and RF feet were injected, there was a significant decrease in the weight being placed on the injected foot on Day +1 ( $P < 0.05$ ). This data confirms that the CASFP is a validated objective assessment tool for sow lameness by demonstrating changes in

weight placement during lameness induction. The CASFP also displayed a significant shift in weight distribution which can be accounted for by the sows' behavioral compensation of the affected limb.

#### *NSAIDs:*

Our final research question looked for differences in NSAID pain mitigation. Means by treatment group on the last day of treatment (Day +6) for all three paired ratios found no significant difference. While these results should not be extrapolated freely to all painful states, the conclusions do suggest that at best the relative value is small in this particular type of lameness such that other treatment regimens and drug candidates should be evaluated.

#### **Discussion**

Both subjective and objective tools of assessment were validated during this study. The 4 point locomotion scoring system developed by Zinpro is a validated subjective tool that will allow reliable identification of lame sows. The development of a the visual library of approximately 150 hours of sow gait video footage in HD which demonstrates a range of clinical severities can be used to train producers and veterinarians to recognize various severities of lameness. The CASFP is an objective assessment tool that can be used on farm or in the lab to assess sow lameness by demonstrating changes in weight placement during lameness induction of individual sows. However, this lameness assessment tool was not able to differentiate a possible effect of NSAID treatment to mitigate pain response from Day+1 to Day+6. While these results should not be extrapolated freely to all painful states, the conclusions do suggest that at best the relative value of the drugs is small in this type of lameness and other concentrations, routes of administration and alternate drug candidates should be evaluated.

The trial work funded from this study yielded a number of contributions to the public domain of science:

1. Johnson, Karriker, Stalder, Millman and Coetzee were awarded \$700,000 from the USDA AFRI program to further study lameness and pain mitigation based in part on preliminary data collected from this study.
2. Cole Burrack presented "Investigations into the reliability of a sow lameness scoring tool" at the Iowa State Summer Scholars Research Session.
3. The design and validation of the "crate adapted static force plate" was peer reviewed and published: Sun G, Fitzgerald R, Stalder K, Karriker L, Johnson A, Hoff S. Development of an embedded microcomputer-based forceplate system for measuring sow weight distribution and detection of lameness. 2011. Applied Engineering in Agriculture. 27(3) 475-482.
4. **AS-Leaflet-R2626** Induction of a Transient Chemically Induced Lameness in the Sow. Detection Using Live Scoring and the GAITFour Sensor System (Authors: Anna K. Johnson, Kenneth J. Stalder, Locke A. Karriker, Johann Coetzee)
5. **AS-Leaflet-R2627** Swine Intensive Studies Laboratory at Iowa State University (Authors: Jillian LeKander, Mallory M. Salazar, Anna K. Johnson, Kenneth J. Stalder, Locke A. Karriker)
6. **AS-Leaflet-R2628** Designing an Objective Static Force Plate to Measure Severity of Lameness in Multi-Parity Sows (Authors: Amanda J. Elsbernd, Anna K. Johnson, Ken J. Stalder, Rob Fitzgerald, Locke A. Karriker, Steve Hoff, Gang Sun)
7. **AS-Leaflet-R2629** Induction of a Transient Chemically Induced Lameness in the Sow. Detection Using a Prototype Embedded Micro-computer-based Force Plate System, (Authors: Anna K. Johnson, Ken J. Stalder, Robert F. Fitzgerald, Steve Hoff, Gang Sun, Locke A. Karriker, Johann Coetzee)

8. **AS-Leaflet-R2630** Testing the Feasibility of Injecting Joints in Sows for Therapy (Authors: Clayton McGargill, Locke A. Karriker, Jillian M. LeKander, Mallory M. Salazar, Anna K. Johnson, Ken J. Stalder, Johann Coetzee)
9. **AS-Leaflet-R2550** To Determine the Active and Inactive Hours for Sound Sows When Housed in Individual Pens (Authors: Allison M. Meiszberg, Anna K. Johnson, Kenneth J. Stalder, Locke A. Karriker)

Table 1. Mean weight (kg) placed on each foot adjusted for the effect of sow for the control sows				
Foot Treated	Foot	Walk Status		
		Baseline <sup>1</sup>	Worst Day Lame	Last day of treatment
LF	LF	59.33 <sup>a</sup>	44.41 <sup>b</sup>	58.39 <sup>a</sup>
	RF	59.30	64.40	58.11
	<u>LR ?</u>	39.12 <sup>a</sup>	41.96 <sup>ab</sup>	43.13 <sup>b</sup>
	RR	49.71	52.90	48.92
RF	LF	55.20	67.31	57.25
	RF	53.97 <sup>a</sup>	33.85 <sup>b</sup>	52.42 <sup>a</sup>
	LR	39.54	46.39	43.17
	RR	47.66	43.51	44.80
LR	LF	48.76	46.74	45.27
	<u>RF ?</u>	52.82 <sup>a</sup>	55.92 <sup>ab</sup>	57.19 <sup>b</sup>
	LR	34.67	25.51	30.47
	RR	40.43	44.71	44.32
RR	LF	51.24	54.34	52.42
	RF	59.26	58.08	57.13
	LR	40.28 <sup>a</sup>	48.78 <sup>b</sup>	46.3 <sup>b</sup>
	RR	41.71 <sup>a</sup>	25.01 <sup>b</sup>	34.03 <sup>c</sup>

<sup>1</sup>Means within a row with different superscripts are different (P<0.05).

Left front when injected affected the left front foot

Right front foot when injected decreased weight in right front only.

Left rear only decreased right front foot

Right rear foot affected the left rear and right rear foot- this data also suggests that some joints were no longer affected by the last day but some were still affected.

Table 2. Mean weight (kg) placed on each foot adjusted for the effect of sow for the control sows by treatment group on the last day of treatment				
Foot Treated	Foot	Treatment		
		Control <sup>1</sup>	Sodium <u>Salicyclate</u>	<u>Banamine</u>
LF	LF	51.39	60.89	60.15
	RF	60.89	59.34	65.54
	LR	40.54	47.38	46.37
	RR	42.93	40.58	45.61
RF	LF	62.24	57.29	59.45
	RF	57.96	53.10	56.87
	LR	44.48	45.06	44.18
	RR	39.48	41.07	44.31
LR	LF	59.86	44.33	55.13
	RF	57.58	58.72	60.62
	LR	44.84	44.02	44.70
	RR	40.64	30.45	38.02
RR	LF	50.63	53.26	59.30
	RF	53.39	57.15	62.22
	LR	36.92	36.56	36.52
	RR	40.19	42.94	50.71

<sup>1</sup>Means within a row with different superscripts are different (P<0.05).