Lameness, Pain and Behavior

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Introduction

Lameness has a significant impact on animal welfare. The results of a recent survey conducted by our research group indicate that 84% of sows at slaughter had one or more foot lesions (Knauer et al., 2007). Lameness is therefore considered one of the most important causes of culling sows in the United States. Furthermore, the exit of gilts and sows from the breeding herd prior to return on their economic inputs results in a net monetary loss for the farm. Stalder et al., (2004) noted that improving longevity by .10 parities (from 3.4 to 4.4 average parity at culling) is worth ~$23 million/year to the U.S. pork industry. Science-based guidance for the industry on optimal housing, management and treatment of lame pigs is deficient. There are no approved drug treatments for analgesia use in lame swine, and the identification and validation of robust, repeatable pain measurements is fundamental for the development of effective analgesic drug regimens and management strategies for use in lame pigs (AVMA; 2010; FDA, 2010). Research to address the limited knowledge in this area is essential to formulating science-based recommendations for pig producers. This will become especially important if legislative actions succeed in preventing downed animals from entering the human food chain (Prevention of Farm Animal Cruelty Act and the Healthy School Meals Act) regardless of etiology.

Pain and behavior

In veterinary medicine, changes in an animal's behavior are often used as the first clinical signs of illness, injury or pain. Good stockpeople develop an "eye" for the animals in their care, and become highly skilled at picking up subtle changes in behavior patterns at the individual animal or pen level. Animal behavior is a key parameter to evaluate animal welfare since it accurately reflects the animal's integrated response to its situation (Broom, 1991; Dawkins, 1980) but the characteristics of subjective emotional states such as fear and pain sensation or perception are such that they can only be measured indirectly in humans or animals.

Pain is defined by the International Association for the Study of Pain (IASP) *as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage."* The IASP adds, "The inability to communicate verbally does not negate the possibility that an individual is experiencing pain and is in need of appropriate pain-relieving treatment." This is an important point, especially when discussing pain in animals, and even more so in food-producing

animals, such as pigs. Animals can visibly communicate their pain to us only through physical signs. Behavior commonly associated with pain in swine include: vocalization, abnormal standing posture, decreased body weight, reluctance to move, decreased appetite, restlessness, head turning and limping (Hay et al., 2003; Leidig et al., 2009; Weary et al., 1998). Furthermore, when a pig is lame the stride length shortens, movements are more "stiff" and the animal has a lowered ability to accelerate and change direction (Corr, 2003). Locomotor disorders can be associated with neurological disorders, lesions of the hoof or limb, or a mechanical-structural problem, trauma, or metabolic and infectious disease (Main et al., 2000; Smith, 1988; Wells, 1984).

Are lame animals in pain?

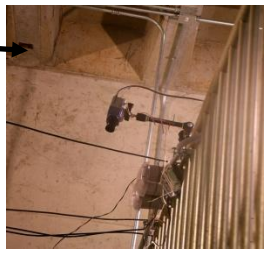
Classical work by McGeown et al., (1999) and Danbury et al., (2000) posed the question "*are broiler birds in pain through lameness and if so will they choose a feed laced with a non-steroidal anti-inflammatory drug (NSAID) drug?"* These bodies of work concluded that broilers that were assigned high lameness scores negotiated an obstacle course faster after the administration of a NSAID drug. Lame birds significantly selected more drugged feed than sound birds, and as the severity of the lameness increased they consumed significantly more of the drugged feed. Well-being was compromised in broiler birds that were unable to reach food and water and they died from starvation and dehydration. Work addressing pig analgesic drugs and/or environmental preferences when pigs are experiencing differing levels of lameness pain has not been addressed. In regard to swine welfare, this information is critical when considering treatment options that a producer or veterinarian may employ.

Technologies to detect lameness pain in pigs at Iowa State University (ISU)

Numerical rating scoring and visual analog scoring systems are common in production systems, but are highly subjective with varying degrees of inter- and intra- observer correlation. Therefore, the swine intensives study laboratory at ISU was created in 2009 through internal and external funds garnered by Anna Johnson, Locke Karriker, Ken Stalder, Hans Coetzee and Suzanne Millman. The aim of this laboratory is to validate repeatable, objective and robust tools that can be implemented on farms to assist in detecting and treating lameness pain in pigs (http://vetmed.iastate.edu/research/labs/SwineLab). Behavior in home pens, behavioral kinematics whilst walking and standing and reactions that indicate sensitivity to pain allow us a non-invasive analysis of pain lameness that can be correlated with the other diagnostic tools (i.e. performance, anatomy, health and physiology).

Figure 1. Swine intensives laboratory at Iowa State University

CCTV Cameras

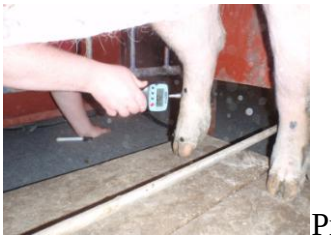


Home pen

Embedded microcomputer-based force plate system

GAITFour

Plantar test (thermal sensitivity)



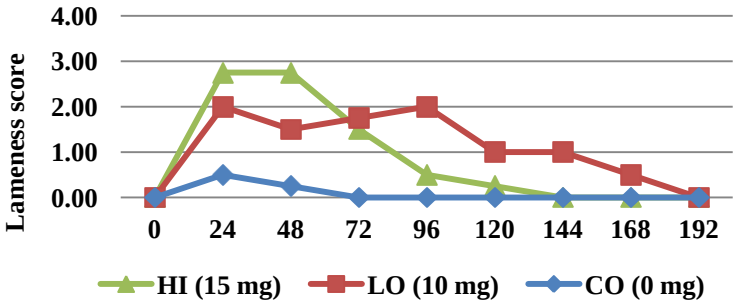
Pressure algometer (pressure sensititivty)

Induction of lameness

Most research has focused on behavioral or physiological changes associated with acute pain (Anil et al., 2002; Ting et al., 2003; Stilwell et al., 2008). These changes can be complex, with natural variation between animals complicating the differentiation of pain from other factors such as stress (Anderson and Muir, 2005). Induction of lameness allows for controlled evaluation of lameness pain in animals because pre- and post lameness measurements can be taken from the same animal, thereby reducing the confounding effects of individual differences. This approach has been published by Kotschwar et al., (2009). The authors concluded that the amphotericin B-induced synovitis-arthritis model was a useful tool for studying changes associated with lameness in cattle through the use of pressure mats, heart rate and visual scoring of lameness. Preliminary work

from our group has compared gait scoring of six sows when sound and made lame using this transient chemically induced model. Results indicate that at 24 hours post injection, the average lameness scores were 2.75, 2.00, and 0.50 for the HI, LO and CO sows respectively (Figure 2). The CO sows' average returned to 0 at 72 hours post injection, HI sows' average returned to 0 at 144 hours, and LO sows' average score returned to 0 at 192 hours post injection.

Figure 2. Average lameness scores by hours post injection and dose in sows injected intra-articularly with amphotericin B.



On the GAITFour system, the total number of sensors activated (SEN) decreased for the amphotericin treated feet suggesting a smaller footprint and pressure was shifted to the non-treated foot at 48 hours post injection. These changes resolved by 144 hours post injection (Table 1).

Table 1: Objective Gait Analysis Parameters Least Square Means (±SE) for the Investigation of Amphotericin B Induced Lameness in Sows (HI and LO treatments combined)

	HPI**		
	0	**48**	**144**
SEN count	30.6[a] ± 1.75	26.9[b] ± 1.73	29.7[a] ± 1.76
DIFF Max	8.16[a] ± 3.06	-11.02[b] ± 2.89	11.06[a] ± 3.16

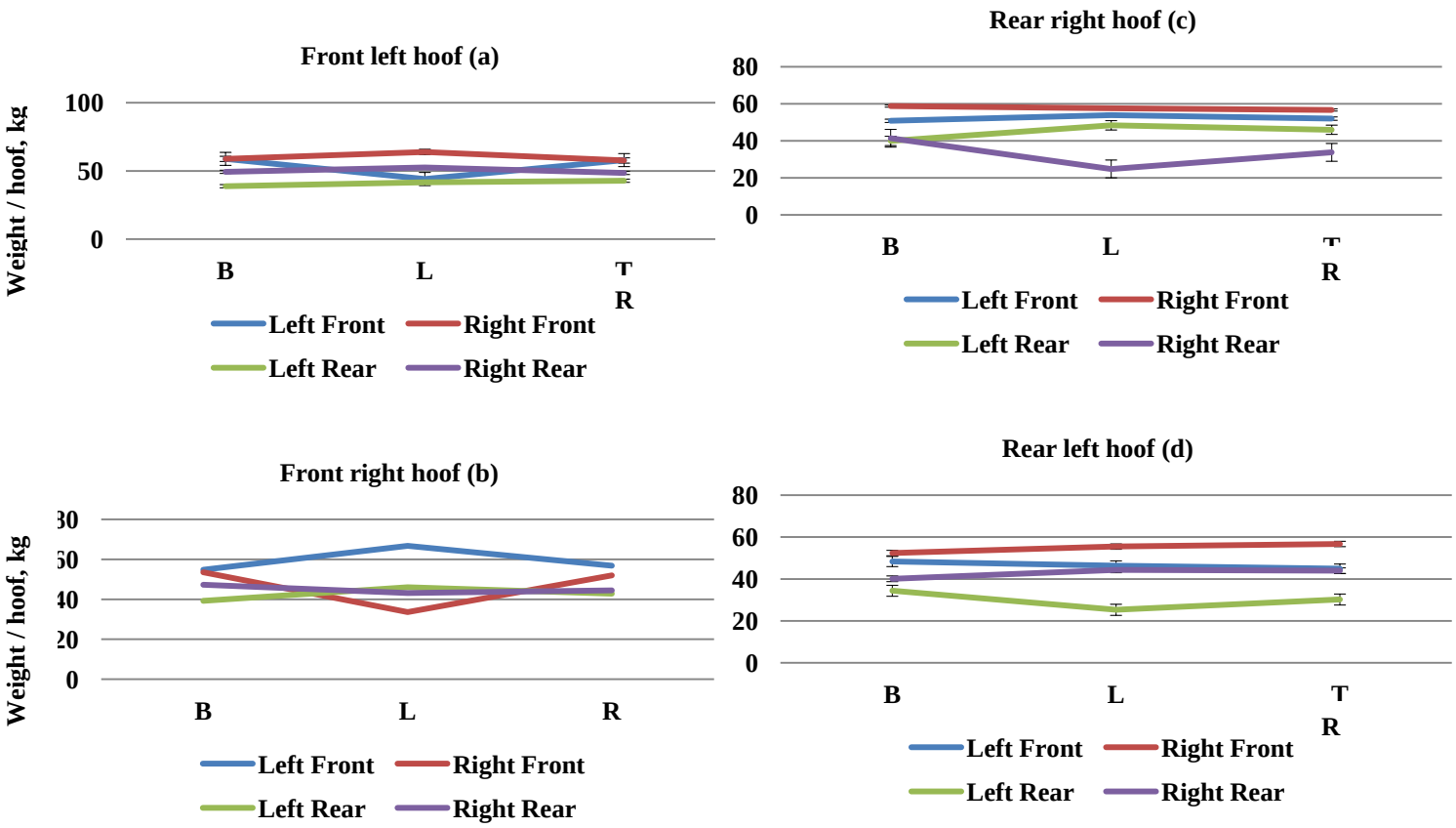
*Different row superscripts indicate difference at $P \leq 0.05$.
**HPI = Hours Post Injection.
SEN=number of sensors activated by amphotericin treated foot on the pressure mat.
DIFF=calculated difference between the MAX pressure of treated versus untreated rear feet.

Additional work characterized differences in weight bearing with the induction of lameness (amphotericin B chemical synovitis/arthritis model) in sows. The diagnostic tool to be tested was a prototype embedded micro-computer based force plate system built by the research team. A total of 24 clinically normal, mixed parity, mixed breed sows were used. Four treatments were compared, sows that were injected on the front left hoof (n = 6), front right hoof (n = 6), rear right hoof (n = 6) and rear left hoof (n = 6). Each sow served

as her own control and weight carried by each of all four legs was measured individually at all time periods. When clinically sound (baseline; B) sows placed equal amount of weight over the four hooves. However, on the day after injection when they were clinically the most severely lame, (L) regardless of the hoof treated, sows placed less weight on that injected hoof and dispersed their weight over the three unaffected hooves. Seven days after injection, lameness had resolved (R) clinically, and sows were again placing equal weight over their four hooves as measured on the prototype (Figure 3).

In addition we were able to accurately inject into the interphalangeal joint space using 10 mg of Amphotericin B that induced a transient lameness model (Figure 3).

Figure 3. Sows were injected in the distal interphangeal joints with 10mg amphotericin B in either the front left hoof (a), front right hoof (b), rear right hoof (c) or rear left hoof (d). All lame days were different from baseline and resolution in all hooves at $P<0.05$.



Conclusions

The long-term goal of our research group is to validate objective tools to assess pain. These tools will be used to develop management strategies and to screen analgesics that have shown efficacy in other species for pharmacokinetic profiles in swine. This would allow for treatment in a production setting, and to establish efficacious analgesic drug regimens for various painful production outcomes in pigs and determine refinements to housing in order to facilitate convalescence and comfort in lame swine. In response to the urgent need for pain-mitigation strategies in American livestock production, we will continue to evaluate an innovative lameness model in pigs and the effect of pain mitigation strategies including environmental modification and analgesic drug administration.

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