

# Swine Welfare Research:

A review of research dedicated to emerging animal welfare issues



The Pork Checkoff Swine Welfare Committee is committed to promoting the pork industry's tradition of responsible animal care through the application of scientifically sound animal care practices. The objectives of the committee are to:

- Advance producers' awareness of emerging animal welfare issues
- Provide information and education that improves producers' animal care skills
- Support scientific research that enhances animal welfare
- Provide information that enhances the public's understanding and awareness of producers' commitment to providing humane care.

The Pork Checkoff provides funding to universities and other institutions to conduct research on behalf of the industry and strives to distribute the results to its stakeholders, the U.S. pork producers.

## Pork Checkoff Swine Welfare Committee

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*Bayes Purebreds*

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*University of Illinois*

Randy Salsbery  
*Salsbery Pork Producers*

Steve Weaver  
*Weaver Farms*

Claude Williamson  
*Wapinitia Farms*

**Dear pork producer and others concerned about swine welfare:**

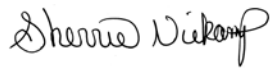
Today's pork consumers are no longer only concerned with the price, quality and safety of the products pork producers provide for them. Increasingly, the average consumer is concerned about where their meat comes from and how it was raised. They want the assurance that the animals that have become their food were well cared for and raised in a humane manner.

The purpose of the Pork Checkoff is to contribute to the success of all pork producers by managing issues related to research, education and product promotion. Therefore, it is our mission to provide you, the producer, with current scientifically sound information about new and existing production practices and technologies in the swine industry. Often times, the performance of the pig can be directly related to its well-being, so it is important to understand how to provide for the well-being of the pig when implementing new technologies and practices.

Each year the Pork Checkoff Swine Welfare Committee which is primarily made up of producers sets swine welfare research priorities for the industry. For 2006, those priorities were gestational sow housing, transportation/ handling of pigs, on-farm euthanasia, production practices and farrowing systems. The committee chooses to invest Checkoff dollars into scientifically valid proposals that will advance the success of the pork industry.

Over the past four years, many research projects designed to provide answers to swine welfare issues have been funded and completed. It is my pleasure to provide you with the first Pork Checkoff publication highlighting these completed works.

Sincerely,



Sherrie Niekamp  
Director, Swine Welfare

# Gestational Sow Housing



The use of traditional gestational sow housing systems have been criticized by many animal rights groups. They claim that housing sows individually and not allowing them to turn around compromises their welfare. To address these challenges, researchers are comparing the well-being of sows housed individually to that of sows housed in group settings.

Over the years, the pork industry has progressed to producing a leaner, faster growing finisher pig. As a result, the sows that produce these offspring have also become leaner and faster growing. There is now a need to reevaluate the pregnant sow and how to house her.

Additionally, there are an increasing number of producers who are utilizing different technologies and beginning to house their gestating sows in groups. Researchers are now exploring optimal management practices for group sow housing to maximize production while providing for the well-being of the sow

## Effects of Space Allowance on Group-Housed Dry Sows

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- ▶ Despite the differences found between sows kept in stalls and those in groups during gestation, neither housing alternative appears to compromise sows' well-being as assessed by various physiologic, behavior and performance/ productivity measures.

These experiments were designed to determine the effect of (1) differential effects of individual stalls and group pens, and (2) impacts of space allowance for group-kept dry sows while keeping group size constant on dry sow performance, productivity and health.

This study focused on the effects of grouping and floor space allowance on numerous physiological and productivity indicators of sow welfare. Sows were either housed in individual stalls or in groups at 15, 25, or 35 ft<sup>2</sup>/sow beginning at day 30 of gestation.

There were many significant treatment, parity, day, and interactions on the various measures assessed in this study. These data provide further support that sow performance and productivity between those kept in stalls and groups is similar. Overall, despite the differences found between sows kept in stalls and those in groups during gestation, neither housing alternative appears to compromise sows' well-being as assessed by various physiologic, behavior and performance/ productivity measures.

Despite these differences most often values for all treatment groups were within acceptable ranges. On the other hand, among group-kept sows, it does appear that those kept at 15 ft<sup>2</sup>/sow, well-being could be compromised. It is obvious that lesion scores are greatly influenced by floor-space allowance and potentially days of gestation. More importantly, sows kept in groups at 15 ft<sup>2</sup>/sow had higher body lesion scores than those kept at other space allowances. If lesion scores are an indicator of well-being, one would not suggest keeping sows in groups at 15 ft<sup>2</sup>/sow.

Immune response between sows kept in stalls and groups and among groups at different space allowances existed. However, these differences did not compromise their performance or productivity. There are still questions that remain to be answered about the impact of gestation environment on sow well-being.

This research project attempted to see how existing commercial group housing systems with ESFs could be made more welfare friendly by modifying the size and structure of the groups of sows housed in them.

Sows housed in dynamic, two-time mixing, and static groups of different sizes in pens with ESFs were evaluated in terms of salivary cortisol concentrations, injuries and behavior. Production performance and longevity were also evaluated to study the effect of group size and structure on sow well-being. The economic implications of changing group sizes and structure were also studied.

The groups studied showed no difference in terms of major welfare indicators such as cortisol concentrations and number of total aggressive interactions. However, total injury scores were higher and number of non-agonistic social interactions were lower in the dynamic group, suggesting that the well-being of sows in the dynamic group was compromised compared to the other groups.

The production performance of sows was similar among the groups. Although, subgroup formation was visible in dynamic groups it was apparent only in lying behavior during the period of the study. However, free intermingling of sows might have happened later during their stay in the group. The time required for routine management was higher in the dynamic group. As observed in the present study and in many previous studies, aggression at mixing and competition for feeder entry are the major threats to the welfare of sows in group systems with ESFs regardless of the difference in group size and structure.

It may not be possible to improve group housing systems with ESFs without addressing these issues. Changing group size and structure alone may not bring better welfare. Pen and feeder designs, as well as measures to reduce aggression at mixing and hunger are crucial to improve welfare. Ensuring control of access to the feeder at the gate rather than only at the point of feed delivery may reduce the aggression associated with feeder entry. Similarly, providing manipulable materials such as a small quantity of straw may help to divert the attention of sows at mixing and may reduce hunger to some extent. Pre-exposure of sows by maintaining sub-groups of sows in adjacent pens may reduce aggression at mixing.

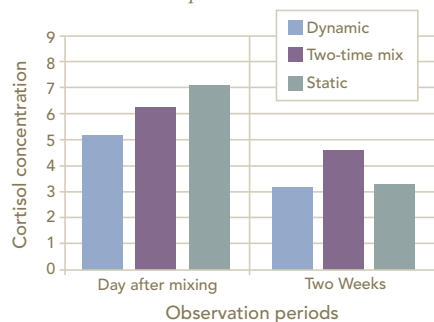
## Evaluation of the Effect of Group Size and Structure on Welfare of Gestating Sows in Pens with Electronic Sow Feeders (ESFs).

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- Changing group size and structure alone may not bring better welfare. Pen and feeder designs, as well as measures to reduce aggression at mixing and hunger are crucial to improve welfare.

Pre-exposure of sows by maintaining sub-groups of sows in adjacent pens may reduce aggression at mixing.

Figure 1: Cortisol concentration (ng/ml) among sows (Mean and SE) in housing systems at observation time points



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## The Effects of Feeding Schedule on Body Condition, Aggressiveness, and Reproductive Failure in Group Housed Gestating Sows

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- ▶ Increasing feeding frequency did not improve overall weight gain, weight variation, reproductive performance or overall removal rate of group housed gestating sows or gilts.

Determining the welfare status of gestating sows can be challenging because of the complexities between different gestation housing environments and challenges quantifying measures of welfare. A common problem with group housing of gestating sows is a condition commonly known as “boss sow” syndrome. This occurs when dominant sows that are high on the social order consume more feed than desired at the expense of other sows in the group. In this project, the researchers increased feeding frequency of sows from two to six times per day and spaced the feedings at a designed interval in an attempt to induce the sense of satiety of the boss sows and reduce variation in sow weight gain within each pen.

Increasing feeding frequency did not improve overall weight gain, weight variation, reproductive performance or overall removal rate of group housed gestating sows or gilts. There was a small reduction in skin and vulva lesions and structural scores, but an increase in vocalization for sows fed six times per day. In summary, increasing the feeding frequency from two to six times per day does not appear to have a dramatic negative or positive impact on performance or welfare of group housed gilts and sows.

# Handling and Transportation

The well-being of the pig extends beyond the barn. Utilizing proper handling and transport practices for animals in all phases of production is vital to reduce the occurrence of stressful experiences for the pig. Following proper handling and transportation practices can decrease the number of pigs that arrive dead, injured or fatigued at their destination, as well as improve the quality of our industry's product.

The Trucker Quality Assurance program was designed to highlight best practices when handling and transporting pigs. The practices highlighted include stocking density, preparing a truck for transport in extreme temperatures, and handling techniques that facilitate low-stress movement. These practices are based on the results of scientific research.

Ongoing research is evaluating the components of transporting pigs in all stages of production to provide information for continuous improvement. Specifically, researchers are continuously looking for ways to decrease the incidence of fatigued pigs.

A fatigued pig is defined as a pig that has temporarily lost the ability or want to walk but has a reasonable expectation to recover full locomotion following a period of rest. While not considered a food safety risk, the incidence of a fatigued pig raises welfare concerns for the pig. Additionally, there is an economic cost to the producer when a pig becomes fatigued during transport or upon arrival at the packing plant. Factors such as season, temperature during transport, transport time, truck design and how the pigs are housed during finishing are being evaluated for their influence on the occurrence of fatigue.

This research was conducted to evaluate the effect of three seasons of the year (fall, summer and winter); how pigs were handled on-farm (conventional and passive); transport stocking densities (tight (0.4 m<sup>2</sup>/pig) and loose (0.5 m<sup>2</sup>/pig)) and two resting periods at the plant prior to harvest (45 minutes and 3 hours) on digestive tract temperature and cortisol in the blood of market hogs.

The day before handling and transport, a computer-activated temperature-logging device (Ibutton), was fed to the market hogs. At harvest, blood was collected for testing cortisol. Ibuttons were collected from the gut after harvest.

Overall, pigs harvested in the winter began the day trying to maintain heat and body temperature, so they had the highest digestive tract temperatures prior to handling and trucking. By the time they were harvested, their activity raised their temperature, and they no longer needed to conserve heat, making their digestive tract temperature decrease. Pigs harvested in the summer began the day trying to get rid of body heat (cool down), so they had the lowest digestive tract temperatures prior to handling and trucking. By the time they were harvested, their activity combined with heat stress raised their body temperature to a point that they were not able to get rid of all the added body heat. This resulted in the highest digestive tract temperatures during the resting period prior to harvest.

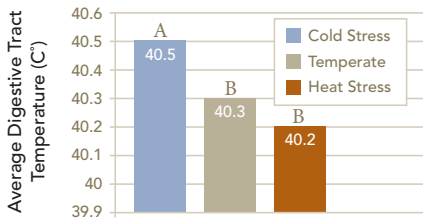
Additionally, digestive tract temperatures and blood cortisol concentrations were higher from the pigs given the longer pre-harvest resting period, especially during

**Core body temperature, stress hormone level, and pork quality differences of market weight pigs relative to seasonal environment, on-farm handling intensity, transport stocking density, and time in lairage**

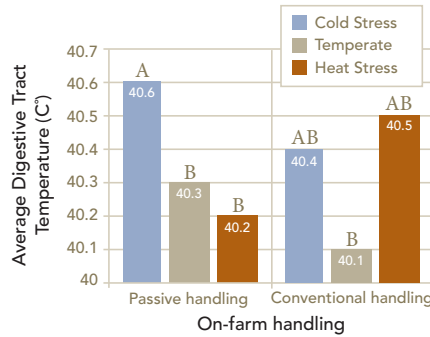
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- Collectively, it appears that during times of summer heat stress, pigs should not be allowed to rest as long to prevent further fighting and restlessness at the plant

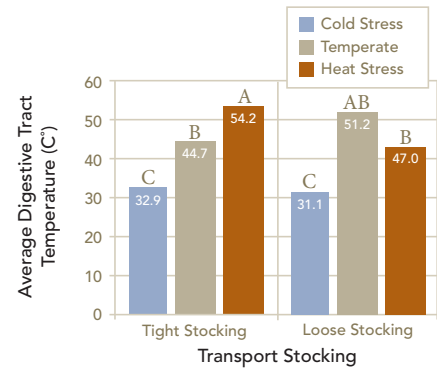
the summer harvest. Collectively, it appears that during times of summer heat stress, pigs should not be allowed to rest as long to prevent further fighting and restlessness at the plant. The other solution may be to rest the pigs longer than 3 hours prior to harvest to allow them to more fully recuperate from previous stresses. However, that conclusion cannot be made from this experiment since we did not evaluate body temperature of the pigs at the packing plant for more than 3 hours.



**Figure 2.** Main effect of seasonal environment on average digestive tract temperature of market hogs ( $P = 0.008$ ) prior to load-out (0245 to 0359 h). Means lacking a common letter differ ( $P < 0.04$ ).



**Figure 3.** Interactive effect of seasonal environment and on-farm handling intensity on average digestive tract temperature of market hogs ( $P = 0.018$ ) during load-out (0400 to 0530 h). Means lacking a common letter differ ( $P < 0.05$ ).



**Figure 4.** Interactive effect of seasonal environment and transport stocking density on blood serum cortisol levels. ( $P = 0.005$ ). Bars lacking a common letter differ ( $P < 0.021$ ).

This study, involving 109 trailer-loads of pigs and a total of 17,256 animals was carried out to evaluate the effects of trailer design (pot-belly vs. straight-deck) and season (spring vs. summer vs. fall vs. winter) on the incidence of transport losses, physical indicators of stress and carcass-trim loss. In addition, a subset of 42 loads was used to evaluate the effect of distance moved by the pigs prior to loading [short (<24 meters) vs. long (47 to 67 meters)] on transport losses.

The environmental conditions on the trailer during transportation differed between the two designs; temperatures were lower (by 1.8°C on average) and relative humidity was higher (by 3.8 percent on average) for the pot-belly compared to the straight-deck design. Also, it took longer to unload the pot-belly trailers at the plant than the straight-deck trailers (35.8 vs. 20.2 minutes, respectively).

After unloading, the incidence of physical indicators of stress such as open-mouth breathing and skin discoloration, were generally higher in pigs transported on pot-belly than it was for pigs in straight-deck trailers; however, this treatment difference was dependent on the season of transportation. There was no effect of trailer design on the incidence of dead or non-ambulatory pigs after unloading at the plant. Pigs moved the long compared to the short distance prior to loading exhibited a higher incidence of open-mouth breathing and skin discoloration and tended to have a higher incidence of non-ambulatory animals at the farm. However, there was no effect of distance moved prior to loading on the incidence of dead and non-ambulatory animals at the plant.

The results of this study suggest that transporting pigs in pot-belly rather than straight-deck trailers increases the stress level exhibited by pigs after unloading at the plant, but does not increase the incidence of transport losses. However, from an animal well-being stand point, any factor that increases stress on an animal during transportation is considered negative.

## Effects of Trailer Design, Season, and Distance Moved During Loading on the Welfare of Market Weight Pigs at the Packing Plant

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- The results of this study suggest that transporting pigs in pot-belly rather than straight-deck trailers increases the stress level exhibited by pigs after unloading at the plant, but does not increase the incidence of transport losses.

**Table 1. Effects of season and trailer design on transport losses at the plant and carcass trim loss**

Variable	Season						Trailer Design			
	Spring	Summer	Fall	Winter	Pooled SEM	P value	Pot-belly	Straight x-deck	Pooled SEM	P value
Number of trailer loads	28	27	26	28	–	–	53	56	–	–
Non-ambulatory at farm, %	0.13	0.14	0.02	0.14	0.05	0.26	0.12	0.10	0.04	0.73
Deaths on arrival at plant, %	0.35	0.39	0.29	0.37	0.09	0.67	0.35	0.35	0.06	0.67
Non-ambulatory at plant, %	0.42 <sup>c</sup>	0.35 <sup>c</sup>	0.60 <sup>c,d</sup>	0.66 <sup>d</sup>	0.11	0.03	0.57	0.46	0.08	0.61
Fatigued, %	0.35	0.30	0.47	0.55	0.10	0.18	0.43	0.41	0.07	0.95
Injured, %	0.07	0.04	0.11	0.11	0.04	0.33	0.09	0.08	0.03	0.76
Total losses at plant, % <sup>a</sup>	0.77	0.82	0.99	1.03	0.16	0.38	0.96	0.85	0.11	0.82
Carcass trim loss, % <sup>b</sup>	8.01	7.01	6.44	6.42	0.59	0.37	6.72	7.29	0.42	0.43

<sup>a</sup>Total losses = non-ambulatory pigs at the plant + deaths on arrival

<sup>b</sup>Carcass trim loss = percentage of carcasses that required trim

<sup>c,d</sup>Treatment means within a row with different superscripts differ (P < 0.05)



## Production Practices

As with any successful business, it is important for a pork production operation to strive for continuous improvement. The pork industry in general has worked to continually improve the quality of pork products that supply consumers' demand. In doing so, the genetic makeup of the pig has changed, as well as many of the production practices used to raise a safe, wholesome product. Researchers are continually reevaluating existing production practices, equipment and standards to ensure that they satisfy the physiological and behavioral needs of today's pigs.

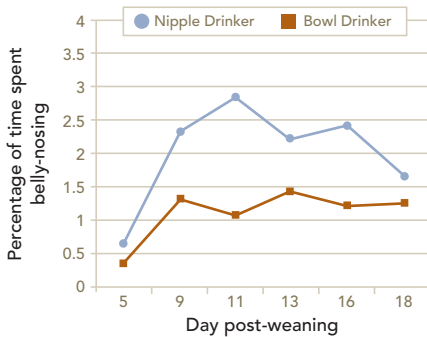
Additionally, researchers are working to develop new production technologies and management practices that further improve the health and well-being of the pig while potentially decreasing labor time and costs.

### Factors Affecting the Behavior of Early-Weaned Piglets

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- There was no relationship between pre-weaning nursing behavior and the amount of time that piglets spent belly-nosing post-weaning.

Although water usage remained over twice as high for piglets with nipple drinkers throughout the trial, there were no overall differences in feed intake or differences in average daily gain.



**Figure 5.** Average percentage of time that piglets provided water from nipples or bowls engaged in belly-nosing on various days post-weaning.

The behavior of early-weaned piglets is characterized by a delay in the onset of feeding, excessive drinking and the possible development of behavior problems such as belly-nosing or sucking on the ears or tails of penmates. Although the specific causes of these behaviors are unknown, they are thought to be related to the piglets' experiences on the sow and their desire to suck or massage the udder. This project involved two experiments aimed at examining the relationships among nursing, feeding, drinking, and post-weaning behavior problems in early-weaned piglets.

In the first experiment, the researchers attempted to determine whether nursing behavior of individual piglets on the sow was related to their tendency to perform belly-nosing behavior post-weaning. There was no relationship between pre-weaning nursing behavior and the amount of time that piglets spent belly-nosing post-weaning ( $P>0.10$ ).

Weaning weight was not associated with either pre- or post-weaning behavior ( $P>0.10$ ). However, there was a relationship between belly-nosing and average daily gain post-weaning, with those piglets that spent more time belly-nosing having lower weight gains ( $P<0.01$ ).

In the second experiment, the researchers examined how playback of sow nursing grunts and type of drinker in the nursery affected piglet behavior and performance. The broadcast sound vocalizations had no effect on either piglet behavior ( $P>0.05$ ) or performance ( $P>0.05$ ).

However, type of drinker affected behavior, feed intake and water usage. During the first 48 hours post-weaning, piglets with nipple drinkers spent more time at the drinker (nipple=26.1 minutes; bowl=14.5 minutes;  $P<0.01$ ), used three times more water (nipple=2.1 liters; bowl=0.7 liters;  $P<0.01$ ) and had lower feed intake (nipple=44.4 grams; bowl=61.7 grams;  $P<0.05$ ) than piglets provided water bowls. Over the course of the trial, piglets with nipple drinkers performed more belly-nosing than those drinking from bowls (nipple = 2.0 % of the time; bowl = 1.1 % of the time;  $P<0.01$ ). Although water usage remained over twice as high for piglets with nipple drinkers throughout the trial, there were no overall differences in feed intake or differences in average daily gain

Animals adapt more readily to photoperiod cues than other environmental cues because photoperiod is more predictable and consistent over time. These experiments were designed to determine the effect of experiment 1 photoperiod manipulation pre- and post-gestation on sow and piglet performance and immune response and experiment 2 photoperiod manipulation on early-weaning success in piglets. Previous work has shown limited (if any) affects of photoperiod on pig physiology and performance. However, these data begin to provide support that photoperiod can potentially be used to manipulate physiology and performance as well as counteract the negative effects of stress.

In experiment 1, sows were exposed to either long day (LD, 16 hours of light: 8 hours of dark) or short day (SD, 8 hours of light: 16 hours of dark) photoperiod at day 90 of gestation. At farrowing, half of the sows remained on their gestation treatment (L:L; S:S) and the other half were switched to the opposite treatment (L: S or S:L).

The late-gestational photoperiod treatment applied to sows in this study might have been insufficient to completely alter immune function during gestation but sufficient to influence endocrine and performance measures at farrowing and throughout lactation. However, additional research is warranted to determine the influence of previous photoperiod experience on these responses and to determine the optimal period during gestation that photoperiod exposure should begin and that will influence these responses long-term.

More importantly, the effect of manipulation of photoperiod on a sow during gestation may ultimately influence the immune status of her piglets, thus enhancing the ability of piglets to resist infection until weaning (Figure 6). Based on these data, we believe that manipulation of photoperiod might be useful for altering sow productivity and piglet immune function as well as their response to stress.

In experiment 2, all sows were subjected to SD from day 90 of gestation until the end of lactation. Piglets were weaned at 14, 21 and 28 days of age and assigned to either LD or SD until 10 weeks of age. Although piglets weaned at 28 days and kept on a long day may have less stimulated innate immune responses than those in other treatment groups, they did have the greatest average daily gain from 6 to 10 weeks of age (Figure 7). Perhaps these piglets were able to use more metabolic energy for growth rather than having to divert it for use in maintaining baseline immune function and regulation.

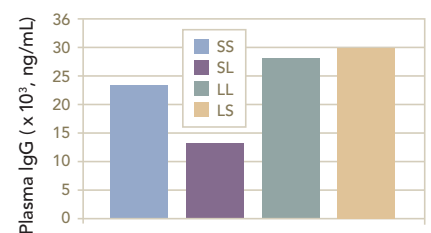
Piglets weaned at 14 days and kept on 8 hours of light daily lagged in body weight and average daily gain in the nursery, suggesting that these piglets consumed less feed or diverted less metabolic energy away from growth in order to maintain their immune response and thus continued to be at a disadvantage. Support of continued immune development postweaning may be more costly in terms of a biological cost to the piglet that is weaned at 14 days of age compared with a piglet weaned at 28 days. Moreover, a piglet weaned at 14 days and kept on a short day apparently is at a greater disadvantage relative to its long day counterpart because at the end of the 10-week period it still lagged in body weight. More importantly, it is unknown if the results observed here were further influenced by the direction of change from a short-day photoperiod pre-weaning

## Impact of Early-Weaning and Photoperiod Manipulation on Sow and Piglet Welfare

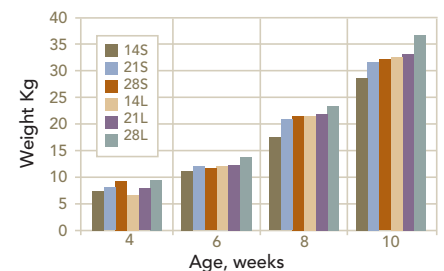
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**Figure 6.** Piglets subject to LD during gestation had higher plasma IgG at 7 days of age ( $P < 0.005$ )



**Figure 7.** Pigs weaned at 28d of age and maintained on long day photoperiod were heavier at all ages ( $P < 0.0001$ )

## Floor Space Requirements for Grow/Finish Pigs in Large Groups

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- Under restricted space allowances, the gains of pigs in large groups were negatively affected much earlier on than for pigs in small groups.

There was limited evidence, and none related to productivity, that pigs in large groups were able to use space more efficiently under crowded conditions than were pigs in small groups.

to long-day photoperiod that some piglets experienced post-weaning. More research is required to evaluate this as well as to identify the mechanisms responsible for photoperiodic effects on growth and energy partitioning that may have caused the piglet responses found here.

The effects of group size and floor space allowance on productivity, health and well-being were tested on 1728 grow-finish barrows of PIC genetics. Group sizes were 18 (small) and 108 (large) pigs per pen, and space allowances were 0.52 m<sup>2</sup>/pig (crowded) and 0.78 m<sup>2</sup>/pig (uncrowded), creating four experimental treatments: small crowded, small uncrowded, large crowded and large uncrowded.

Pigs housed in crowded groups had poorer performance than uncrowded pigs. Overall, average daily gain was 4.2 percent lower for crowded pigs than uncrowded pigs. During the final week of the trial, when the pigs were most crowded, the difference was 9.8 percent. Final body weights differed by 2.1 percent. Although crowded pigs spent less time at the feeder, had fewer meals and had longer latencies between their meals than uncrowded pigs, average daily feed intake (ADFI) values did not differ. Overall feed efficiency was reduced by 6.6 percent in the crowded treatment pigs.

Measurement of cortisol concentrations in the saliva, which are indicative of the level of stress a pig is experiencing, indicated that neither the group sizes nor space allowances used in the current study affected the stress level of the pigs. Postural behavior, carcass measurements, injuries, morbidity and mortality were unaffected by space allowance as well.

Pigs housed in large groups had poorer performance than pigs housed in small groups. Overall, the average daily gain of large group pigs was 3.5 percent less than that of small group pigs and final body weights differed by 3.0 percent. Average daily gain differences were most evident during the first two weeks of the trial, at which time the difference was 5.4 percent. The 3.3 percent difference in initial body weights indicated that setbacks may have been occurring at group formation. Feed efficiency also differed, with pigs in large groups being 6.0 percent less efficient than pigs in small groups.

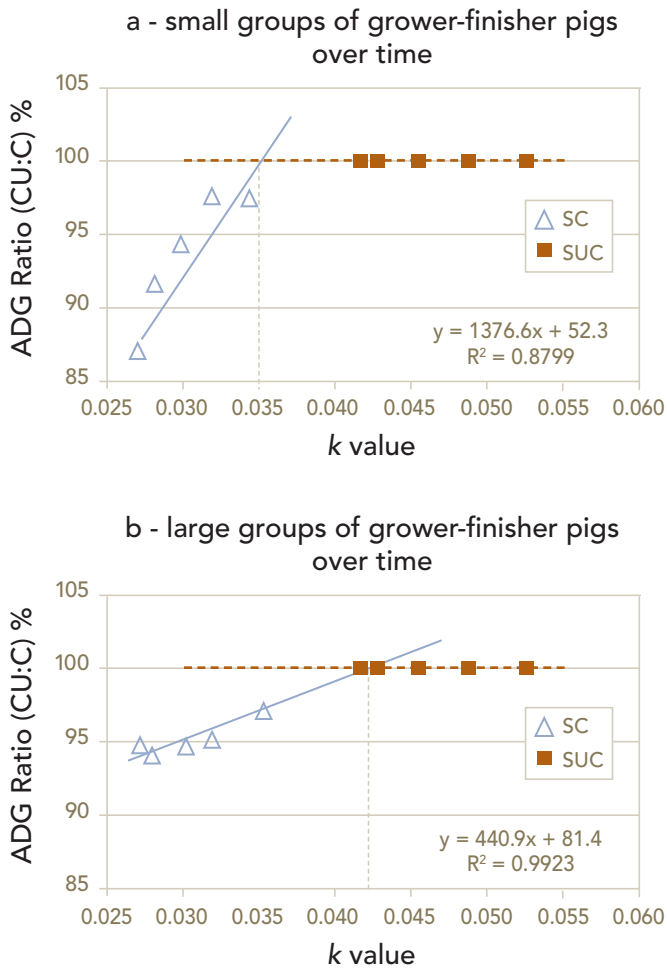
Although large group pigs experienced more lameness and leg sores throughout the trial, the number of animals requiring treatment with antibiotics or requiring removal from the trial did not differ between the group sizes. Stress levels and carcass measurements did not differ.

Large group housing for grow-finish pigs is not as detrimental to pig performance and vitality as once presumed. Pigs in large groups do not seem to suffer reduced welfare as long as regular and thorough health checks are performed. Deleterious effects of large groups were generally confined to the initial adaptation period. Marginal losses occurring at that time are most likely to be recovered through reduced input and labor costs associated with large group housing.

Under restricted space allowances, the gains of pigs in large groups were negatively affected much earlier on than for pigs in small groups. However, the effect

of space restriction on gains of pigs in large groups is much more gradual over time, and the net effect of crowding at the end of the trial was similar among pigs in large and small groups. There was limited evidence, and none related to productivity, that pigs in large groups were able to use space more efficiently under crowded conditions than were pigs in small groups.

**Figure 8:** Broken line analysis showing the ratio of ADG in the crowded treatment to ADG in the uncrowded treatment for both (a) small and (b) large groups of grower-finisher pigs over time.



# On-Farm Euthanasia

There will be a time when every operation will have pigs that do not respond to care and treatment. Pigs that do not respond to care or are unlikely to recover should be euthanized in a timely and humane manner. Humane euthanasia is defined as humane death occurring with minimal pain or distress. It can sometimes be difficult to make the decision between continuing to treat a pig or to euthanize it. Researchers are working to develop decision-making criteria to help producers provide for the well-being of their pigs.

## Developing criteria for timely euthanasia decision-making

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- **After adopting the light euthanasia protocol, pigs that are weak, lame, with 2 or more conditions or prolapses have a low dollar value and high adverse welfare score (indicating poor welfare).**

Generally, an animal should be culled when it is no longer profitable or euthanized when it is inhumane to let it live. The difficulty all farm managers encounter is defining when animals become uneconomic and whether to treat or euthanize the casualty animal. Individual managers usually resort to a very subjective assessment often heavily weighted by the perceived ability of the animal to return a profit.

Focus groups of farm managers have told us that having clear criteria for when to euthanize an animal would help reduce some of the job stress they feel. Therefore, the objective of this study was to provide the economic and welfare information necessary to help producers decide whether they should euthanize a casualty nursery pig or keep it.

A total of 51,041 nursery age pigs in 47 batches were screened upon entering 5 farms. Batches of pigs were assigned to protocols that required many, some or few casualty pigs to be euthanized upon entering the nursery (heavy, medium and light euthanasia protocols, respectively; Table 2). Casualty pigs with conditions not triggering immediate euthanasia were ear-tagged and monitored and costs recorded. Thereafter, pigs were observed daily, adverse welfare status assessed and pigs euthanized if warranted. Tagged pigs were assigned an economic value based on their weight less the costs incurred.

The mean value (in dollars, \$) for pigs, by farm under the light protocol, ranged from \$10.81 to \$48.99. For the heavy protocol it ranged from \$0 (reflecting all pigs were euthanized) to \$46.66 (reflecting the survival and high value of the 310 pigs with repaired ruptures on that particular farm). In the heavy protocol most study pigs were euthanized giving a zero value for both welfare and economic value.

The mean welfare score for pigs, by farm under the light protocol, ranged from 73.51 to 112.86. For the heavy protocol it ranged from 0 (reflecting all pigs were euthanized) to 59.68 again reflecting the survival and daily accumulation of the welfare score of the 310 pigs with repaired ruptures on that particular farm). Generally, the dollar value numerically decreased and the welfare score increased for the medium compared to the light protocol pigs.

The comparison of economic value and welfare score by protocol and condition is illustrated in the scatterplots, Figures 9A-C. For the light protocol, 4 conditions (prolapse, weak, lame and the presence of two or more casualty conditions) are in the top left quadrant indicating a low value/high welfare score. For the medium protocol, the presence of two or more casualty conditions is the only condition

associated with a low value/high welfare score, with a value of 126 (note the different scale of the y axes in Figures 9A and 9B).

In conclusion, after adopting the light euthanasia protocol, pigs that are weak, lame, with 2 or more conditions or prolapses have a low dollar value and high adverse welfare score (indicating poor welfare). Managers can increase farm welfare at least cost by immediately euthanating most of these pigs. As more pigs are euthanized (progressing from light, to medium, to heavy) the value of casualty pigs decreases 11-fold (\$18.44 to \$1.61) and adverse welfare improves 7-fold (score 80 to 11). Farms vary in the prevalence of casualty conditions and managers need to focus on the conditions on their farms and adjust their protocol accordingly.

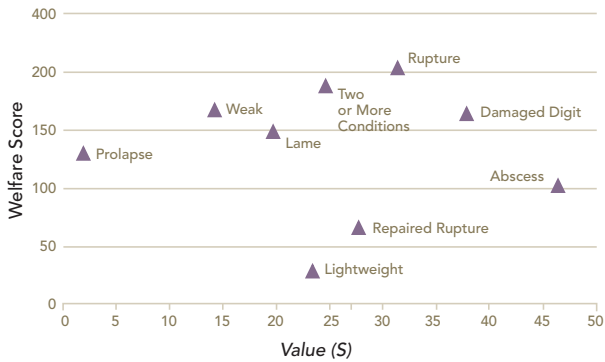
**Table 2. Criteria for euthanasia by treatment protocol.**

CONDITION		Welfare Score	Euthanasia		
			Light	Medium	Heavy
<b>Weak pig:</b>					
A	Can get to feed and water with difficulty	3	No	No	Yes
B	Unable to use 2 legs	10	No	Yes	Yes
C	Unable to use 3 or 4 legs	10	Yes	Yes	Yes
<b>Lame: e.g., swollen joint(s)</b>					
A	1 leg joint swollen and limping on 1 leg	3	No	No	Yes
B	2 or more joints swollen and limping on 1 leg	5	No	Yes	Yes
C	2 or more joints swollen and limping on 2 or more legs	8	Yes	Yes	Yes
<b>Damaged digit:</b>					
A	1 digit mildly damaged (don't tag)	1	No	No	No
B	1 digit severely damaged	3	No	No	Yes
C	2 digits damaged and with open wounds	6	No	Yes	Yes
<b>Recently broken leg:</b>					
A	Suspect broken leg	4	No	No	Yes
B	Leg obviously broken	10	No	Yes	Yes
C	Compound fracture	10	Yes	Yes	Yes
<b>Tail bitten:</b>					
A	Tail bitten only (don't tag)	1	No	No	No
B	Tail end bloody, infected	3	No	No	Yes
C	Tail end bloody, infected and most of it missing	5	No	Yes	Yes
D	Tail-head open wound, no tail	7	Yes	Yes	Yes

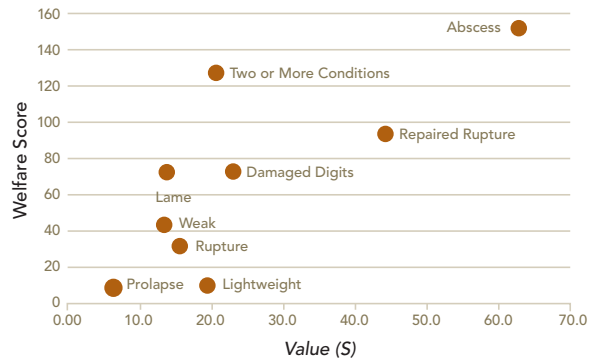
CONDITION		Welfare Score	Euthanasia		
			Light	Medium	Heavy
<b>Ear- or flank-bitten:</b>					
<b>A</b>	One or both ears (flanks) bitten, both mild (don't tag)	1	No	No	No
<b>B</b>	One or both ears (flanks) bitten, one more than mild	1	No	No	Yes
<b>C</b>	One ear (flank) bloody, infected and necrotic	5	No	Yes	Yes
<b>D</b>	Both ears (flanks) bloody, infected and necrotic	6	Yes	Yes	Yes
<b>Beaten-up pig, numerous superficial skin wounds</b>					
<b>A</b>	Skin wounds on one side only (don't tag)	2	No	No	No
<b>B</b>	Skin wounds on both sides but not on all 4 quarters (don't tag)	3	No	No	No
<b>C</b>	Skin wounds on both sides and all 4 quarters affected	4	No	No	Yes
<b>D</b>	Skin wounds on both sides, all 4 quarters affected and wounds are infected	6	No	Yes	Yes
<b>Rectal prolapse</b>					
<b>A</b>	Recent, undamaged and occasionally protruding (don't tag)	1	No	No	No
<b>B</b>	Recent, damaged and protruding	4	No	No	Yes
<b>C</b>	Recent, damaged and protruding for 2 or more days	7	No	Yes	Yes
<b>Ruptures (scrotal and umbilical)</b>					
<b>A</b>	Rupture is present but small	1	No	No	Yes
<b>B</b>	Rupture is large but the pig has no problem moving	3	No	Yes	Yes
<b>C</b>	Rupture is large infected/ulcerated, impedes mobility	8	Yes	Yes	Yes
<b>Repaired Ruptures (scrotal and umbilical)</b>					
<b>A</b>	Repaired rupture is healing but has mild swelling	1	No	No	No
<b>B</b>	Repaired rupture has obvious swelling but is healing	2	No	No	No
<b>C</b>	Repaired rupture has serious swelling with exudate	5	No	No	Yes
<b>Weight compromised (include runts):</b>					
<b>A</b>	Less than 40% under normal barn average weight (don't tag)	0	No	No	No
<b>B</b>	40-49% under normal barn average weight	1	No	No	Yes
<b>C</b>	50-59% under normal barn average weight	2	No	Yes	Yes
<b>D</b>	More than 60% under normal barn average weight	3	Yes	Yes	Yes
<b>Abscess (including inguinal, scrotal, jowl):</b>					
<b>A</b>	Any abscess, grape to golf ball size	1	No	No	Yes
<b>B</b>	Any abscess, golf ball to fist size	2	No	Yes	Yes
<b>C</b>	Any abscess, fist size or bigger	3	Yes	Yes	Yes

CONDITION		Welfare Score	Euthanasia		
			Light	Medium	Heavy
<b>Respiratory:</b>					
A	Just coughing and/or sneezing (don't tag)	1	No	No	No
B	Difficulty breathing, thumping for 3 days	7	No	No	Yes
C	Difficulty breathing, thumping for 5 days or more	8	No	Yes	Yes
D	Severe difficulty breathing, open mouth, thumping for 2 days or more	10	Yes	Yes	Yes
<b>Gastrointestinal:</b>					
A	Loose stools (don't tag)	1	No	No	No
B	Profuse diarrhea	5	No	No	No
C	Profuse diarrhea with dehydration	8	No	No	Yes
D	Profuse diarrhea with straining and dehydration	8	No	Yes	Yes

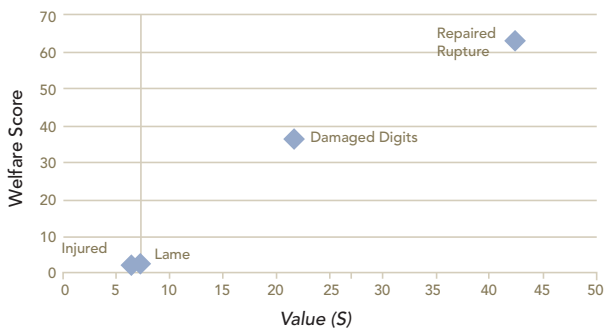
**Figure 9A. Economic Value and Welfare Cost by Condition (reason) for the Light Protocol Least-Squared Means**



**Figure 9B. Economic Value and Welfare Cost by Condition (reason) for the Medium Protocol Least-Squared Means**



**Figure 9C. Economic Value and Welfare Cost by Condition (reason) for the Heavy Protocol Least-Squared Means**



# Completed Swine Welfare Research Projects

The following are the objectives and short outcomes of all completed projects funded between 2002 and 2005. Projects marked with an asterisk (\*) have been further highlighted in this publication.

## Gestational Sow Housing

### Enhancing sow welfare with high fiber diets and frequent feeding

Lee Johnston • University of Minnesota • johnstlj@mrs.umn.edu

A study was conducted to determine the effects of feeding a corn-soybean meal (control) diet or a corn-soybean meal-soybean hulls (high fiber) diet and feeding frequency (once vs. twice daily) on the well-being of gestating sows. Feeding a high fiber diet utilizing soybean hulls did not enhance the well-being of sows by reducing stereotypic behaviors, influencing salivary cortisol or improving reproductive performance. Soybean hulls may not be a useful source of fiber in gestating sow diets to improve litter size. #02-158

### Comparison of housing systems for gestating sows

John Deen • University of Minnesota • Deenx003@umn.edu

The objectives of this study were to measure the putative well-being indices of sows housed in individual stalls, groups with electronic sow feeders (ESFs) and groups in deep bedded hoops. The study also aimed to compare these alternative housing systems along with the costs of using and refining them and to provide guidance to producers and other members of the pork chain in discussing these issues. In conclusion, stalls indicated a benefit in terms of production and well-being at the expense of freedom of movement. The possibility of injuries consequent to aggression, at mixing and at the feeder, made the group pen system with ESFs a stressful type of accommodation for gestating sows. The deep-bedded hoop barns appear to reduce stress as seen by reduced salivary cortisol concentration and reduce injury levels; however, special attention is required to sort out issues related to higher return rates, smaller group size, labor requirement and waste management in these kinds of systems. #02-164

### Effects of space allowance on group-housed dry sows\*

Janeen Salak-Johnson • University of Illinois • johnso17@uiuc.edu

These experiments were designed to determine the effect of (1) differential effects of individual stalls and group pens, and (2) impacts of space allowance for group-kept dry sows while keeping group size constant on dry sow performance, productivity, behavior, and health. Overall, differences found between sows kept in stalls and those in groups during gestation do not appear to compromise their well-being. #02-173

### Development of computer templates to economically assess alternatives to individual housing of gestating sows

Don Levis • Ohio State University • dlevis@unlnotes.unl.edu

Three spreadsheets (Microsoft Excel 2000) were developed to evaluate the production and financial implications between the following types of housing systems for gestating sows: (1) remodeling of an existing individual stall gestation building into a facility that loosely houses sows in pens, (2) a new gestation facility that loosely houses sows in pens, and (3) a new hoop structure that loosely houses sows in pens and feeds the sows either indoors or outdoors. Within each spreadsheet, two options can be simultaneously evaluated. These spreadsheets will help pork producers evaluate various group-housing systems under the assumptions they enter. #02-178

### Influence of gestation housing on sow welfare and productivity

Roy Kirkwood • Michigan State University • Kirkwo10@msu.edu

The effects of the group housing of gestating sows and concurrent boar contact on sow aggression, salivary cortisol concentrations, body condition and fertility were examined. These data indicate that if sows are to be grouped during gestation, particular attention should be directed toward feeding management to avoid excessive aggression. Adverse effects of grouping (or aggression) on litter size may be ameliorated by direct boar contact in the immediate post-mixing period. #03-055

## **Evaluation of the effect of group size and structure on welfare of gestating sows in pens with electronic sow feeders (ESFs)\***

John Deen • University of Minnesota • deenx003@umn.edu

The present research was an attempt to see if existing commercial group sow housing systems with electronic sow feeders (ESFs) could be made more welfare friendly by modifying the size and structure of the groups of sows housed in them. The study and many previous studies show that aggression at mixing and competition for feeder entry are the major threats to the well-being of sows in group systems with ESFs, regardless of the difference in group size and structure. #03-098

## **The effects of feeding schedule on body condition, aggressiveness, and reproductive failure in group housed gestating sows\***

Mike Tokach • Kansas State University • mtokach@ksu.edu

In this project, feeding frequency of sows was increased from two to six times per day and feedings were spaced at a designed interval in an attempt to induce the sense of satiety of the “boss sows” and reduce variation in sow weight gain within each pen. In summary, increasing the feeding frequency from two to six times per day does not appear to have a dramatic negative or positive impact on performance or well-being of group-housed gilts and sows. #05-060

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## **Transportation**

### **Well-being of early-weaned piglets during transport: Assessment of seasonal effects on performance and behavior**

Nora Lewis • University of Manitoba • Nora\_lewis@umanitoba.ca

This study was designed to assess the impact of transport on the performance, behavior and physiology of early weaned piglets during summer, winter or fall. Transport in all seasons was found to affect behavior; winter transport also affected production. It is important to determine which stressors have the greatest impact in each season and develop strategies to reduce the effects of transport on animal well-being and production. #02-166

### **The epidemiology of mortality and injuries of weaned pigs during transportation**

Robert Morrison • University of Minnesota • bobm@umn.edu

The objective of this study was to describe the mortality / injury incidence rate in weaned pigs during transportation and its associated risk factors, particularly, the effect of trip distance. Under the conditions studied, transportation did not pose a high risk for injuries or deaths in the population studied. #03-146

### **The effect of space allowance and season on the welfare of early-weaned piglets under commercial and experimental transport conditions**

Nora Lewis • University of Manitoba • Nora\_lewis@umanitoba.ca

This project was designed to assess the impact of stocking density under different seasonal conditions on the performance, behavior and physiology of early-weaned piglets using controlled transport conditions and to develop guidelines for transporters and producers to ensure the well-being and future productivity of transported piglets. Higher temperatures associated with high density were more likely to be detrimental to the piglet during the summer heat. Higher densities in winter were not as clearly detrimental possibly because the piglets tend to huddle irrespective of space available. #03-147

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## Transportation *continued*

### **Effects of trailer design, season, and distance moved during loading on the welfare of market weight pigs at the packing plant\***

Mike Ellis • University of Illinois • Mellis7@uiuc.edu

This study evaluated the effects of trailer design (pot-belly vs. straight-deck) and season (spring vs. summer vs. fall vs. winter) on the incidence of transport losses, physical indicators of stress and carcass trim loss. The results suggest that transporting pigs in pot-belly trailers rather than in straight decks results in an increased incidence of pigs exhibiting indicators of stress on arrival at the slaughter plant. However, losses during transport for the two trailer types were similar. The greater distance pigs were moved at the farm prior to loading the higher the incidence of indicators of stress and non-ambulatory pigs at the farm after loading. #04-131

### **Transport lairage affects on well-being of 18kg pigs using a multi-disciplinary approach**

Susan Eicher • Agricultural Research Service, USDA • spruiett@purdue.edu

Fifty pound pigs were transported across seasons, January, April, August and October. Measures of behavior and of the immune system on the truck, during the lairage and after the transport showed some effects of increased transport stress in the continuously transported pigs. Overall, in this setting of a controlled lairage environment without mixing of the pens, lairage lessened changes after transport. #04-134

### **Core body temperature, stress hormone level and pork quality differences of market weight pigs relative to seasonal environment, on-farm handling intensity, transport stocking density and time in lairage\***

Eric Berg • University of Missouri • bergep@missouri.edu

The present series of studies were conducted to evaluate three seasonal environments, two on-farm handling intensities, two transport stocking densities, and two lairage lengths, on digestive tract temperature and blood plasma cortisol levels. The results of this study indicate that during times of heat stress, pigs should be kept in lairage less than 3 hours to improve animal welfare. Further study is necessary to determine if lairage longer than 3 hours marginalizes the effects of the seasonal heat stress environment on pigs. #04-022

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## Production Practices

### **Effect of weaning age and commingling after the nursery phase on humoral and behavioral indicators of well-being and on growth performance**

Charles Maxwell • University of Arkansas • cmaxwell@uark.edu

This study evaluated the effects of weaning age and commingling after the nursery phase in wean-to-finish facilities on growth performance, immunological measurements and behavioral observations. Weaning pigs at an early age results in a less immunologically-developed pigs compared to pigs weaned later, but this may contribute to the benefits of early-weaning with respect to an overall improvement in gain and days to a common weight. However, management strategies should be further explored to optimize these benefits without the detrimental effects on health observed during the nursery period in this study. #02-063

### **Factors affecting the behavior of early-weaned piglets\***

Tina Widowski • University of Guelph • twidosk@uoguelph.ca

This project involved two experiments aimed at examining the relationships among feeding, drinking, nursing and post-weaning behavior in early-weaned piglets. Early-weaned piglets often develop belly-nosing and sucking or chewing on the navels or ears of other pigs. The main finding of this project was that style of drinker can have a significant effect on the behavior of the newly weaned piglet. During the first 48 hours post-weaning, piglets with bowls spent less time at the drinker, more time at the feeder and ate more than piglets with nipple drinkers. They also performed significantly less belly-nosing over the nursery period suggesting that the motor patterns involved with drinking water from bowl drinkers somehow satisfied their sucking or nosing motivation. #02-169

### **Impact of early weaning and photoperiod manipulation on sow and piglet welfare\***

Janeen Salak-Johnson • University of Illinois • Johnso17@uiuc.edu

These experiments were designed to determine the effect of photoperiod manipulation pre- and post-gestation on sow and piglet performance and immune response and photoperiod manipulation on early-weaning success in piglets. It appears that the photoperiod treatment a sow is subjected to may influence early responses of her piglets. More, importantly, photoperiod may potentially provide a management tool that could be used to counteract the negative consequences of weaning stress and other stressors. Further research is needed to determine the precise effects of photoperiod on gestational sows and their piglets. #03-111

### **Ammonia levels and the effect on nursery pig welfare**

Frank Mitloehner • University of California-Davis • fmmitloehner@ucdavis.edu

The objective was to determine acute or chronic effects of moderate and high concentrations of atmospheric ammonia (NH<sub>3</sub>) on welfare of newly weaned pigs. In summary, exposure to 35 and 50 ppm atmospheric ammonia affects systemic responses and increased cytological and biochemical markers of injury and inflammation. Atmospheric ammonia also increased cortisol concentrations and tended to decrease feeding behavior resulting in a trend for lower dry matter intake. #03-159

### **Floor space requirements for grow-finish pigs in large groups\***

Harold Gonyou • Prairie Swine Centre • gonyou@sask.usask.ca

The effects of group size and floor space allowance on productivity, health and welfare were tested on 1728 grow-finish barrows. Group sizes were 18 (small) and 108 (large) pigs per pen, and space allowances were 0.52 m<sup>2</sup>/pig (crowded) and 0.78 m<sup>2</sup>/pig (uncrowded), creating four experimental treatments: small crowded, small uncrowded, large crowded, and large uncrowded. Although some behavioral variables, such as lying postures, would suggest that pigs in large groups were able to use space more efficiently, overall production performance and health variables would indicate that pigs in large and small groups were similarly affected by the crowding imposed in this study. In fact, the broken line analysis of average daily gain suggests that large groups were affected by space restriction earlier in the study than were small groups. Little support was found for reducing space allowances for pigs in large groups. #04-089

**Production  
Practices**  
*continued*

**Effect of stocking density on the welfare and performance of grow-finish pigs**

John Deen • University of Minnesota • Deenx003@umn.edu

This study evaluated the behavior, injury levels, stress hormone concentrations, disease and mortality and production parameters of grow-finish pigs in combinations of four stocking densities and groups of similar and varying body weight compositions. In fully slatted floor, space allotted considering the final market weight of barrows, corresponding to 'k' values of 0.037 (0.88 m<sup>2</sup>/pig) and 0.034 (0.81 m<sup>2</sup>/pig) appear to be acceptable when compared to a 'k' value of 0.27 in production and welfare terms. A 'k' value of 0.031 (0.74 m<sup>2</sup>/pig) was intermediate to higher (0.037 and 0.34) and lower (0.027) 'k' values. #04-093

**Economics of pig space: analysis of production systems and marketing impacts**

James Kliebenstein • Iowa State University • jklieben@iastate.edu

This study evaluates the economic impact of changing pig space allotments in a production system. A simulation model was developed to use in evaluating economic impacts of increasing pig space allotments above those currently in use. Results indicated that restricting pig space has significant negative financial consequences for existing commercial confinement swine production systems. Also, marketing weight and timing mitigation strategies can be short-term solutions when compared to restricting flows into the finishing phase of production, but are clearly inferior to the longer range solution of adding finishing barns to existing production systems to accommodate the pigs. #04-177

**The impact of routine piglet processing on well-being**

Donald Lay • Agricultural Research Service, USDA • layd@purdue.edu

The aim of this experiment was to evaluate stress responses evoked by two alternative methods for performing the following processing procedures: teeth resection (clip vs. grind); tail-docking (cold vs. hot-clip); identification (ear notch vs. tag); iron administration (inject vs. oral); castration (cords cut vs. torn) and to compare a combination of the 'most' and 'least' aversive methods. The data indicate that both the 'most' and 'least' processing approaches reported in this study result in robust stress responses. In addition, the time required to perform procedures contributes significantly to the stress experienced by the pigs. #04-043

**On-Farm  
Euthanasia**

**Developing criteria for timely euthanasia decision-making\***

Morgan Morrow • North Carolina State University • morgan\_morrow@ncsu.edu

The objective of this project was to provide the economic and welfare information necessary to help producers decide whether they should euthanize a casualty nursery pig or keep it. Results showed that as more pigs are euthanized the value of casualty pigs decreases 11-fold (\$18.44 to \$1.61) and adverse welfare improves 7-fold (score 80 to 11). Farms vary in the prevalence of casualty conditions and managers need to focus on the conditions on their farms and adjust their protocol accordingly. #02-175

## Miscellaneous

### Characterization of sow longevity and the developmental factors that influence it

Ronald Bates • Michigan State University • batesr@msu.edu

The objectives for this project were to 1) assess four different measures of longevity and determine what relationship developmental performance characteristics may have with these differing definitions, and 2) estimate the genetic variation for herd life and determine if non-genetic factors influence the heritability estimate. The makeup of the litter a female is born into and how she performs through development can impact her subsequent longevity. In addition, the number of pigs within her first litter also significantly influences her survival risk. **#02-174**

### Strategies to optimize sow longevity

Sandra Rodriguez-Zas • University of Illinois • rodrgzzs@uiuc.edu

Sow longevity and production records of 148,568 sows in 32 Central Illinois commercial herds were analyzed to characterize sow performance and profitability. The largest difference in longevity between the major genetic lines was approximately one parity. The optimal replacement age was six parities under the default or average biological and economical conditions, higher than three to four parities, the average age at removal in U.S. breeding herds. Our study demonstrated that genetic lines and minimization of voluntary culling in early parities can provide producers with more opportunities to maximize profitability through effective voluntary culling. **#03-110**

