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Low-input sustainable sow housing for Iowa

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Low-input sustainable sow housing for Iowa

Abstract
This project developed a low-cost, innovative sow housing and feeding system that is currently under consideration for a patent. A quasi ad libitum (free feeding of a controlled diet) electronic feeding system for gestating sows was housed in a 9.1 X 18.3 meter steel-hooped structure covered with an aluminized plastic tarp. A feeder served as a partition between high-energy and low-energy diet feeding areas. After weighing, hogs were directed to the appropriate diet by means of a tag number read by a computer. Such farm size-neutral housing can help producers raise lean market pigs. Other advantages include improved sow welfare, better worker environment, and less odor than confinement.

Keywords
Agricultural and Biosystems Engineering, Animal Science, Hoops and alternative livestock systems

Disciplines
Agriculture | Animal Sciences | Bioresource and Agricultural Engineering

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Abstract: This project developed a low-cost, innovative sow housing and feeding system that is currently under consideration for a patent. A quasi ad libitum (free feeding of a controlled diet) electronic feeding system for gestating sows was housed in a 9.1 X 18.3 meter steel-hooped structure covered with an aluminized plastic tarp. A feeder served as a partition between high-energy and low-energy diet feeding areas. After weighing, hogs were directed to the appropriate diet by means of a tag number read by a computer. Such farm size-neutral housing can help producers raise lean market pigs. Other advantages include improved sow welfare, better worker environment, and less odor than confinement.

Background
Iowa's large swine industry is made up of many medium- and small-scale producers. For example, in 1992, of 31,790 swine producers in Iowa, 28,464, or 90%, produced less than 1,000 head annually. Many of these producers have farrow-to-finish swine operations.

The Iowa swine breeding herd currently numbers about two million. On small and medium-size farms, gestation swine housing can be a limiting factor in remaining competitive with larger producers in a rapidly changing industry. Additionally, many Iowa swine buildings built during the 1970s and remodeled during the 1980s will soon need replacement.

Meanwhile, the trend is expected to continue toward leaner pigs as the industry's standard. Producers who are unable to meet the packing industry norms will find it difficult to access the market. A major step for producers to achieve lean market pigs is to acquire and maintain lean breeding stock. These breeding animals require improved winter environments to maintain reproductive performance.

This project sought to develop a low-input, innovative sow housing system that would also be less reliant on fossil fuels, more animal- and operator-friendly, generally more farm-size neutral, and potentially more acceptable to the public than current confinement sow gestation systems.

The objectives of this project were to (1) develop and demonstrate a low-cost gestating sow facility under Iowa conditions, with special emphasis on group housing with bedding and sow feeding; (2) compare the system's performance with a conventional sow confinement system; and (3) demonstrate this technology to Iowa swine producers, information providers, and swine industry leadership.

Approach and methods
All sows for this study came from ISU swine farms in Ames and possessed demonstrated leanness. The system was built at the ISU Rhodes Research Farm. The project also demonstrated several housing and management innovations developed primarily outside the United States, including a hooped structure with polyethylene fabric stretched over a tubular framework; loose housing of sows with bedding and a minimal amount of concrete flooring; alternative bedding sources, for example, newspaper and cornstalks; and the use of electronic identification tags to manage the sows in loose housing.

A major challenge in designing the housing system was sow feeding. In order to feed each sow in the group her daily feed allocation, individual feeding stalls would have been needed. These would have taken a large amount of space. Therefore, a totally new
feeding system was developed that provided individual management of the sows yet was automated and took up a relatively small area.

**Building layout:** A quasi *ad libitum* (free feeding of a controlled diet) electronic feeding system for gestating sows was developed. The system was constructed in a 9.1 X 18.3 meter steel-hooped structure covered with an aluminized plastic tarp. The building is divided into a concrete area and a bedded area with a dirt floor (see Fig. 1). A feeder serves as a partition between high-energy diet and low-energy diet feeding areas. The pelleted diets are formulated using oat milling byproduct as the major ingredient. Seven feeding spaces are on each side of the feeder. An alley leads the sow to the appropriate pen or out the bypass exit.

**Feeding system layout:** A staging wheel with anti-reverse backstops and a wheel locking system prevents more than one sow from gaining access to the scale per processing cycle. To force a sow to go completely through the staging wheel and onto the scale, a one-way gate is situated before the staging wheel. Sows are completely on the scale when they are fully through the staging wheel. The gates leading into each feeding pen and the scale exit gate are controlled by computer-operated linear actuators, which provide movement by a motor-driven screw that causes a tube to extend or retract. A one-way gate inside the entrance to each feeding pen and in front of the staging wheel keeps sows from exiting the way they entered. Two one-way gates are used to prevent sows from entering the feeding pen through the exit gates. The computer and associated electronic equipment are located in an enclosed room on stilts.

**System logic:** A hungry sow will go through the staging wheel, gaining access to the scale. As she spins the staging wheel, a normally open limit switch is tripped, signaling the computer. (A limit switch is an electrical switch that completes an electrical circuit when closed but breaks the circuit when opened. A normally open switch is used to detect a sow entering the staging wheel; normally closed switches are used to detect a sow leaving a feeding area.) The computer extends a linear actuator, which acts as a lock to prevent another sow from getting to the scale. Next, the computer begins scanning for the sow's responder tag number. The sow must be completely on the scale for the tag on her right ear to be read by the computer. Then the scale communicates her weight to the computer. With the sow identified and her current weight recorded, the average daily gain is calculated using the last three daily weights. If it is greater than desired, she will be directed to a pen with a low-energy diet (low-ration). If it is less, she will be directed to a pen with a high-energy diet (high-ration).

When the computer has determined which pen the sow needs to be in, it sets the path for the sow to follow. First the feeding pen gate is opened, then the scale exit gate. While waiting for the sow to leave the scale, the computer monitors the weight on the scale. Once the scale reads zero, signifying that the sow has left, the computer closes the scale exit gate. After the scale exit gate is closed, the pen entrance gate will be closed after a set time to allow the sow time to reach the correct pen. Once she does, the computer updates all data files, increases the count of sows in that pen, and then unlocks the staging wheel so another sow can go through the system. The computer also monitors the exit gates on the feeding...
pens, which have normally closed limit switches. When a sow exits the feeding pen, the switch is opened and the computer is signaled to decrease the sow count in that pen by one sow. If a sow needs to be directed to a pen that is already full, the computer will open the scale exit gate without opening a pen gate. The sow exits out the bypass gate to return to the bedding area.

Electronic design: An IBM-type microcomputer using a Quick BASIC program serves as the central processing unit for the feeding system operation. The tag reader operates by emitting a radio signal through an antenna to excite the responder in the ear tag. The responder returns a signal to the antenna, identifying the sow. A livestock scale is used that can communicate with the computer through a serial port. A data acquisition board aids in data collection and system control. Limit actuators capable of forward and backward motion operate gates to direct the sows and lock the wheel so only one sow is allowed on the scale. All the electronics and software to operate this system were developed by the ISU Department of Agricultural and Biosystems Engineering.

Findings

Timing constraints and behavior: The amount of time required for sows to make a complete cycle through the feeding system varied widely. Specific stages include (see photo)

1. start through wheel and fully load scale
2. fully on scale and tag is read
3. exit the scale once scale gate is opened
4. off the scale and into the high-ration pen
5. off the scale and into the low-ration pen
6. time spent in the high-ration pen
7. time spent in the low-ration pen
8. total time in system if sent to high ration
9. total time in system if sent to low ration

The average total time for a sow to make a complete cycle through the system was graphed for five sows. Those that did not get to their appropriate pens before the pen gate closed exited and returned to be processed again a short time later. The second time through the system, the sow went to the pen with the open gate almost immediately. Steps 1 and 2 required the most time; sows were often slow going through the staging wheel because they enjoyed playing with the wheel and chewing on the plywood. Times also varied in step 3, probably because of variability in sow behavior and a desire for feed. More time is needed to reach the low-ration pen because it is further from the scale than the high-ration pen. Average total feeding time per sow was about 30 minutes. Sometimes sows lay down in the feeding pen and did not immediately exit when finished eating.

The staging wheel caused the greatest problem in the feeding system. Initially, the computer was unable to consistently capture all limit switch events on the staging wheel when tripped by a sow entering the system. A memory chip that latches onto the limit switch closing alleviated this problem. The sows chewing on the wood part of the staging wheel caused it to rotate. Occasionally a sow would cause the wheel to trip the limit switch and not go through the scale, and the computer locked up trying to process a sow when there was not one in the system. Because the wheel was free to spin forward and backward within limits, sows sometimes got on the scale without tripping the limit switch.

Additional tripping mechanisms were added to the wheel to prevent sows from getting on the scale without the computer registering it. A
one-way gate was also placed in front of the scale to hinder sows from playing with the staging wheel without progressing through the wheel. Six anti-reverse backstops were added to the wheel to curb sows from spinning the wheel backwards and backing off once they were on the scale. To avoid computer lock-up, a timer was incorporated into the tag-reading portion of the program to check the scale after five minutes. If a sow was on the scale, the exit gate opened, the sow was directed out the bypass exit, and the system was reset so another sow could be processed. If no sow was on the scale, the system simply reset itself.

Incorrect sow weight also caused problems. Errors in the program code that caused the wrong weight to be displayed by the computer were corrected. Problems with sows only half on the scale when their weight was recorded were also resolved by reversing the tag reading and weight reading routines. In addition, sows bouncing the pen exit gates open and opening the limit switches repeatedly while exiting the feeding areas caused inaccurate pen counts to be displayed by the computer. This problem was partially resolved by changing the position of the tripping mechanisms on the pen exit gates.

Work can now focus on adjusting times between gate closings, reducing "dead time" so sows are processed more quickly. Other improvements in the electronic control and layout will also be addressed in future work. A larger antenna may facilitate quicker sow tag reading; monitoring of feeding pen exit gates can be refined as well. A spring-loaded mechanism on the pen entrance gates would eliminate the possibility of sow injury from a moving gate. Conclusions on the success of the project will not be drawn until these refinements are made.

**Implications**

Sow housing is an integral component of how the swine industry is structured. If alternative sow housing is size-neutral, then Iowa's smaller producers should be able to use it to improve their ability to produce lean market pigs. Because this system houses sows under a roof, the problem of outdoor feedlot runoff and erosion is eliminated. If this system were adopted, other potential advantages would include improved sow welfare, better worker environment, less odor than confinement, less reliance on fossil fuels and electricity, utilization of waste paper as bedding, improved production flexibility, alternative building use, and improved competitiveness for small and medium producers, which will help keep swine populations diffuse, resulting in more ready access to land for manure application and utilization.

However, this loose group housing requires improved feeding methods to enable each sow to receive appropriate feed. This new feeding system was based on those designed for feeding dairy cattle individually. Because such sow systems incorporate relatively new technology, they are not yet in use. However, as additional refinements are made in the system described here, it may offer an alternative for sow housing that may help to stabilize the structure of the swine industry in Iowa.

Several field days were held in fall 1995 to demonstrate this project to educators, scientists, and the media. Because development of the new feeding system was a protracted process, data to be used in comparing this system with others are not yet available. In the meantime, however, the system is under consideration for a patent. Once the system data are available and the patent process is complete, an operations manual will be prepared. Demonstrations will keep observers sufficiently isolated from the herd to prevent disease transmission.

The Iowa Pork Producers cooperated by assisting with publicity. In addition, various private firms provided equipment and materials: Hawkeye Steel (bulk feed bins), Allflex (responder tags, scanner, and scale), Ritchie Manufacturing (hog waterer), and Am Can Inc. (the hooped structure).