Lessons learned from managing electronic sow feeders and collecting weights of gestating sows housed on a large commercial farm

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Summary

An observational study was conducted on a commercial 5600-sow farm using electronic sow feeders (ESF) to collect daily feed intake and scales to obtain sow body weights. The challenges that emerged during this study and proposed solutions may be useful for future research projects in commercial farms with ESF feeding systems. A total feed delivery per day was reported for females, regardless of how many times they may have entered the feeding station. It would be valuable to obtain records for individual feeding events to determine how many times females entered the feeding stations and if it was a feeding or non-feeding event. In this system, there was wide variation in daily sow weights because they entered the feeding station several times a day. Discrepancies in individual body weight were found to be attributed to the speed a sow moved across the scale, long scale length, and interference with the scale antenna. Possible solutions include adding panels before and after the scale, reducing scale length, and careful placement of the antenna. Nevertheless, combining the feeding of gestating sows via ESF with daily weight collection has the potential to generate valuable data sets.

Keywords: swine, body weight, data collection, electronic sow feeders, sow

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Resumen – Lecciones aprendidas al manejar comederos electrónicos en hembras y al recolectar pesos de hembras gestantes alojadas en una granja comercial grande

Se condujo un estudio observacional en una granja comercial de 5600 hembras utilizando comederos electrónicos (ESF por sus siglas en inglés) para hembras para registrar el consumo diario de e alimento y básculas para obtener los pesos corporales de las hembras. Los retos que surgieron durante este estudio y las soluciones propuestas pueden ser útiles para futuros proyectos de investigación en granjas comerciales con sistemas de alimentación ESF. Se reportó el total de la administración diaria de alimento para las hembras, independientemente de cuántas veces entraran a la estación de alimentación. Sería valioso obtener los registros por evento individual de alimentación para determinar cuántas veces las hembras entran a las estaciones de alimentación y si fue un evento de alimentación o no. En este sistema, hubo una amplia variación en los pesos diarios de las hembras porque entraron a la estación de alimentación varias veces al día. Se encontró que las discrepancias en el peso corporal individual se atribuían a la velocidad a la que la hembra se movía en la báscula, lo largo de la báscula, y la interferencia con la antena de la báscula. Las posibles soluciones incluyeron añadir divisiones antes y después de la báscula, reducir la longitud de la báscula, y la colocación adecuada de la antena. Aún así, la combinación de la alimentación de las hembras vía ESF con la recolección del peso diario tiene el potencial para generar una base de información valiosa.

Résumé – Leçons apprises dans la gestion des distributeurs électroniques d'aliment pour truie et la collecte du poids des truies gestantes logées dans une grande ferme commerciale

Une étude observationnelle a été menée dans une ferme commerciale de 5600 truies en utilisant des distributeurs électroniques d'aliment (DEA) pour obtenir l'information sur la consommation quotidienne d'aliment et des balances pour obtenir le poids des truies. Les défis qui sont apparus durant cette étude et les solutions proposées pourraient être utiles pour des projets de recherche futurs dans des fermes commerciales avec des systèmes d'alimentation DEA. La quantité totale d'aliment distribuée par jour était reportée pour les femelles, indépendamment du nombre de fois qu'elles seraient entrées dans la station d'alimentation. Il serait utile d'obtenir les données pour chaque occasion individuelle afin de déterminer combien de fois les femelles sont entrées dans les stations d'alimentation et s'il y avait ou non consommation d'aliment. Dans ce système, il y avait une grande variation dans le poids quotidien des truies car elles entraient dans

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la station d'alimentation plusieurs fois par jour. Des anomalies dans les poids individuels ont été trouvées et ont été attribuées à la vitesse à laquelle les truies passaient sur la balance, la longue longueur de la balance, et de l'interférence avec l'antenne de la balance. Les solutions possibles incluent l'addition de panneaux avant et après la balance, réduire la longueur de la balance, le placement approprié de l'antenne. Néanmoins, la combinaison de l'alimentation des truies gestantes via les DEA et de la collecte quotidienne du poids des animaux a le potentiel de générer des données valables.

In many US production systems, a standard practice is to house sows in individual stalls during gestation. Gestation stalls allow numerous benefits, including individual animal care and feed allowance based on body weight and condition. However, in 2001 the European Union announced a ban of gestation stalls by 2013 because of welfare concerns regarding space allowance and social behavior.[1] The United States has followed with nine states enacting bans on the use of gestation stalls. Furthermore, pressure from pork retailers, the restaurant industry, and welfare activists has resulted in many production systems considering conversion to group housing for gestating sows. As many production systems are transitioning from individual gestation stalls to different styles of group housing, there are new opportunities for data collection in gestation facilities.[2]

Electronic sow feeding (ESF) systems are computerized feeding stations that serve as a non-competitive feeding system for group-housed sows.[3] Electronic sow feeders typically have a single enclosed feeding station that can feed up to 60 group-housed sows per station each day. The stations are equipped with computers that track and dispense a specified amount of feed for each sow. Each sow has an ear tag that contains a radio frequency identification (RFID) transponder for individual identification. This type of system is appealing to producers, as it allows them to manage and monitor individual feed intake and provide opportunities to adjust feeding program strategies to better satisfy changes in gestation nutrient requirements. Feeding sows individually prevents excessive feed consumption, a common concern in group-housed sows which can detrimentally increase body weight (BW). Electronic sow feeders are also appealing from a research standpoint because some systems allow for recorded individual feed intake and more than one feed line can supply each station to provide different diets to be fed.[4] It is also possible to use a scale in conjunction with the ESF to measure body weight every time the sow exits the feeding station.

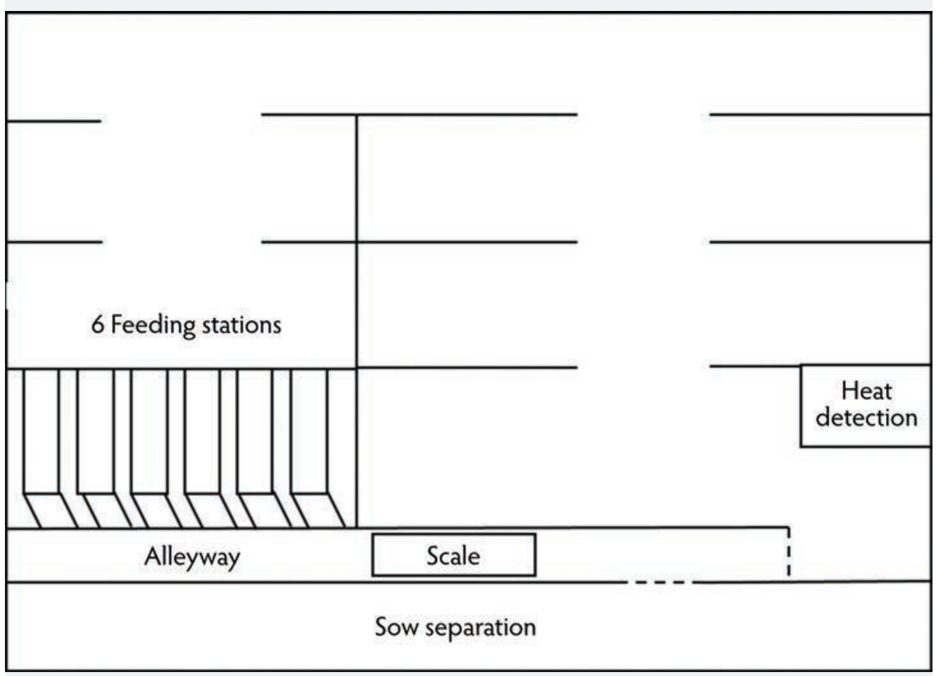
In the peer-reviewed scientific literature, there is virtually no data reported for ESF use in large scale commercial conditions (> 5000 sows) similar to that seen in US swine production. Therefore, we conducted an observational study on a large-scale sow farm to determine gestation weight gain and feed efficiency by collecting daily ESF intake and sow body weight data. The objective of this paper is to discuss the challenges that emerged when collecting this data and propose some solutions that may be useful for future research conducted in similar gestation feeding systems.

Farm description and feeder design

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this study. The study was conducted at a 5600-sow farm in central Nebraska. The gestation barn contained 16 pens, housing 260 females (Camborough, PIC, Hendersonville, TN) per pen. Gilts (parity 1) and sows (parity ≥ 2) were penned separately to allow for additional attention to gilts who were still adjusting to the ESF system. Pens provided 2.0 m^2 per sow and 1.95 m^2 per gilt. Each pen contained 28 nipple waterers to provide ad libitum access to water and was equipped with 6 ESF stations (Nedap Velos, Gronelo, Netherlands) allowing up to 45 females per station (Figures 1 and 2). Each feeding station was 2.0 m long × 0.56 m wide. Feed was dispensed at a rate of 150 g/min with the addition of 100 mL of water. Each feeding station was calibrated weekly. The calibration process consisted of collecting feed from 5 consecutive screw dispenser rotations (approximately 90 g of feed dispensed per rotation, for a total collection of approximately 450 g) from each feeding station. The samples were weighed to determine how much feed was dispensed per rotation which was subsequently entered into the Nedap Velos system to complete the calibration. For the study, 3 pens were equipped with a scale (2.13 m long × 0.51 m wide; New Standard US Inc, Sioux Falls, South Dakota) located in the alleyway where sows walked when they exited the feeding stations (Figures 1 and 3).

Females were group-housed from days 4 to 112 of gestation in dynamic groups, meaning recently bred sows (approximately day 4 of gestation) were entering the pen as sows due to farrow were exiting (approximately day 112 of gestation). This occurred over a 3- to 4-week period, thereafter the pen remained

Figure 1: Group housing design where research data was collected.



static (no movement of newly bred sows into the pen) until the first of the sows reached day 112 of gestation and the process repeated.

The study was conducted over a 149-day period, from late May to mid-October. A total of 861 females were enrolled in the study, of which 712 were moved into the farrowing house for subsequent lactation. Selection criteria for female enrollment was based on current farm flow. Females exhibiting lameness or any obvious signs of illness were not enrolled in the study. Of the initial 861 females, 40 (4.6%) were removed from the data set due to mortality or culling decisions made by the farm management. Ninety-seven females (11.3%) were excluded from the data set because they were removed from their pen for greater than 3 consecutive days due to illness or lameness. The remaining 12 females (1.4%) were removed due to lost RFID tags.

Figure 2: One individual pen showing electronic sow feeding stations.

Data collection

Feed intake

It is important to note that in this and all other ESF systems, it is assumed that the feed dispensed is consumed by the sow before leaving the feeding station and therefore, every time a sow enters the feeding station the feeder bowl is assumed to be empty. Thus, feed intake data within the ESF system is recorded as disappearance. Females were assigned to a feed allowance based on parity and body condition score. Body condition was evaluated visually every other week by the same individual, scoring females from 1 (very skinny) to 5 (excessively fat). Females could consume the set amount of feed in one visit or over several visits to the feeding station. However, the system only generated 1 total intake value per day of gestation. Hence, if a sow consumed her entire feed allowance in two separate feedings, only one intake value was reported and represented the sum of both feeding events. It would be valuable to obtain records of individual feeding events to determine how many times females entered the feeding stations and if the visit was a non-feeding or feeding event.

Feed intake data had to be manually extracted daily through the Nedap Velos software because long term data storage was not available during the time of the study. Feed intake data provided RFID, farm name, day of gestation, total feed offered, pen location, date, feed line (the system had two feed lines but only one was used during this study), and parity. Due to the lack of long term electronic storage, feed intake data was downloaded daily at approximately 1 PM to ensure all females had eaten their daily feed allotment prior to the system reset at 2 PM. Feed intake data was lost on 13 days (8.7%) due to download malfunction. Therefore, it would be advantageous to improve system software and allow for feed intake data to be downloaded automatically and stored to an off-site database to maintain a record of observations.

Within the first week of data collection, we observed missing values (no value reported) or zero values reported as a feed intake value. Initially, it was unclear if there was a difference between these two values. Through daily observations, we determined there was a 5-second delay between when the sow's RFID was read and when the feeding station dispensed feed. If the sow left the station within those 5 seconds, feed was not dispensed and was recorded as an intake value of zero. Out of 712 sows, 322 had at least 1 zero for an intake value (45.2%). However, on average, sows had zeroes reported as an intake value on 1.9 days out of the 106 total days (1.8%). A sow who did not enter the feeding station on a specific day had a missing intake value for that day. Of the 712 sows, 190 had at least 1 missing intake value (26.7%) and on average, did not enter the feeding station for 1 day during the study (0.9%).

The importance of understanding the difference between the two values was to be certain the values generated were accurate. Previous research has indicated that errors can occur during the collection of feed intake data from ESF and the importance of feeder management to minimize these errors.[5] Initially, it was believed that it was impossible to walk through the feeding station without feed being dispensed. Therefore, differences in values reported were thought to be attributed to a system error. After this investigation, it was determined that sows could walk through the ESF system and be recorded without feed being dispensed.

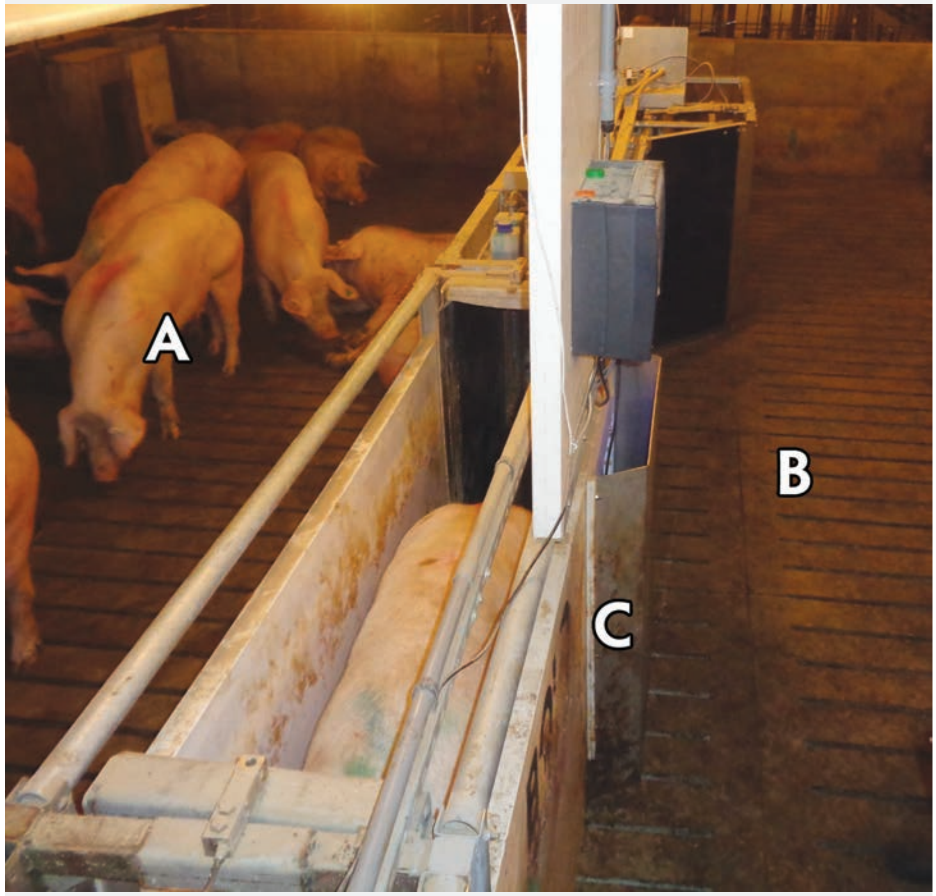
Body weight

As the sow entered the scale, an RFID sensor, like that used in the ESF station, recorded the date, time, sow identification, and body weight to the nearest kilogram. Weights were stored on secure digital memory cards that were removed from the scale head and loaded onto a computer on a weekly basis. The barn environment is not conducive to handling memory cards and caution should be taken to minimize human error (eg, losing or dropping into the pit) when removing and replacing them. Scales were calibrated weekly during the time of feeder calibration. Two individuals were required for scale calibration. One individual would obtain their weight using a portable digital scale and this weight was then entered into the scale system as the calibration weight. Then the scale system would be zeroed and the individual who was weighed would step onto the scale while the other individual observed the scale head. Weights were obtained standing at the beginning, middle and end of the scale to check for accuracy. Occasionally, manure would have to be removed from under the scale to improve readings. This emphasizes the importance of doing regular scale calibration.

Sows had to walk across the scale as they moved from the feeding station back into the pen. Through observation, we found that when workers were in the pen, sow activity through the feeding stations was high. This increase in activity caused sows to move too quickly across the scale for an accurate weight. A proposed solution was to provide panels at the beginning and end of the scale to slow the rate of passage across the scale. This was considered during the study but was not implemented due to concern that this may cause the females to move too slowly and congregate in the alleyway between the ESF and the scale, causing an unhealthy environment for the animals. Specifically, the concern pertained to the gilts who were still adjusting to the ESF environment. We also observed multiple sows on the scale at one time. The sow in front had her front legs off the scale while the sow behind only had her front legs on the scale. Although not a possible option during our study, reducing the scale length may be a possible solution for future research.

We also observed that as a sow moved across the scale, the antenna read the RFID and continued to record weights until the next responder tag was detected. Some females would stand on the back of the scale but not far enough forward for the antenna to read the RFID. Thus, these weights were recorded and attributed to the previous sow. To resolve this, the antenna was moved toward the middle of the scale. After making this adjustment, the female's RFID was recognized as she stepped onto the scale. This was another situation where a shorter scale may have been beneficial.

Figure 3: One sow has left the feeding station and is walking over the scale as she exits the system. The sows seen to the left (A) are sows in the pen and the area to the right (B) is the sow holding area. The transponder reader (C) can be seen on the right side of the sow near the front of the scale.



Another problem observed was that the antenna on the scale could read through the panels of the scale and if a sow was laying in the pen against the outside of the scale, her RFID could be read. However, once a sow was on the scale, her RFID was read and recorded properly. In addition, if a sow in the pen was laying against the panel adjacent to the scale, this pressure against the plastic panels of the scale impacted the accuracy of the recorded weights. The effect was greatest when multiple animals were laying in this area. To prevent these interferences from occurring, sternum bars were added to the pen adjacent to the scale to prevent sows from laying in this area.

After a couple of weeks of data collection, it became apparent that there was wide variability in the data and some of the values were biologically impossible. Therefore, each sow was weighed separately at least twice during the study where a qualified individual observed the sow standing on the scale and could verify an accurate body weight. These weights were collected on all females near the beginning and end of gestation. Each female was stopped on the scale using sort boards to obtain a specific weight. With approximately 260 females in dynamic pens, there was a range in the day of gestation in which the individual weights were captured. On average, the first weight was obtained on day 26 of gestation (± 10 days) and the second weight was obtained on day 87 of gestation (± 10 days).

Data management

In addition to feed intake and body weight data collection, backfat measurements were obtained following breeding and at day 112 of gestation. Sow reproductive performance was recorded using the PigCHAMP Knowledge Software (Ames, Iowa). The following reproductive traits were obtained:

total number of piglets born, total number of piglets born alive, number of stillbirths, number of mummified fetuses, number of weaned piglets, parity, and gestation length. Due to the size, each data file (daily feed intake, daily BW, backfat measurement, and reproductive performance) was managed individually then merged or combined using statistical software (SAS Version 9.4, SAS Institute Inc, Cary, North Carolina).

Backfat measurement and reproductive performance data files did not require additional manipulation prior to analysis. Each file contained the relevant information identified by the individual sow. Body weight and feed intake data files required additional steps before analysis. Based on visual analysis of scatter plots of individual sows and use of reference weights, it was clear that there was a line over time (Figure 4) that contained the normal individual variability in body weight. We determined that on average, the sows walked across the scale approximately three times per day. The scale recorded a weight every 250 ms, thus generating numerous body weights for an individual sow starting the moment her foot stepped on the scale. On average, the scales recorded two acceptable weights per sow per day. The other recorded weights were clearly too heavy and attributed to two sows being on the scale at the same time or too light due to the sow being only partially on the scale. Therefore, it was necessary to eliminate these outlier weights from the BW data set using the reference weights that were collected.

For this process, the reference weights were utilized and the following steps were applied. First, average daily gain (ADG) was calculated from the two reference weights for each sow as follows:

$$\text{ADG} = \frac{(\text{Weight2} - \text{Weight1})}{(\text{Date2} - \text{Date1})}$$

Using ADG, a predicted weight (PW) was calculated based on the initial known weight and day of gestation:

$$\text{PW} = (\text{Weight1} + [\text{ADG} \times \text{d}]),$$

where d is calculated as the difference in days between when the measured weight and reference weight were recorded. Finally, the ratio of predicted weight to the measured weight was determined as follows:

$$\text{Ratio} = \text{Predicted weight/Actual weight.}$$

If the measured weight was 5% above or below the predicted weight, the weight was deleted. Body weights greater or less than 5% of the predicted weight were considered outliers and will be discussed later in this review.

Following these steps, the number of observations in the weight data set was decreased dramatically. Figures 4 and 5 show body weights for an individual sow before and after applying the above steps. It is important to note that we assumed ADG in gestation is fixed with only two known BWs (early and late gestation). This assumption was evaluated by determining the difference between the observed weights obtained by the scale and the predicted weight generated from the 2 manual weights. Agreement was measured using a paired *t* test to evaluate the difference between measured weights from the scale and predicted weights. The predicted weight was 0.05 kg less than the measured weight with a 95% confidence interval (0.014 to 0.077 kg). The expected difference for perfect agreement is 0 and although there was significant evidence for differences in BW (the confidence interval did not include 0), the difference was small relative to the BW of an individual sow. This assumption could be further validated by obtaining additional reference weights throughout gestation and creating a curvilinear ADG prediction throughout gestation. Thus, we may have eliminated more data points in one phase of gestation than another. It should also be noted that the estimate of fixed ADG was only used for developing the data cleaning routine (removing outliers from the data set). Subsequent analysis was performed on the actual body weights observed in the ESF scale.

Because a single BW was needed each day for subsequent analysis, sows with no BW values for a day or sows with multiple BW values on a day had to be addressed. It was possible for sows to have multiple accurate body weights per day. We were able to generate an average BW per day for each sow if multiple accurate BWs were available using the PROC MEANS statement in SAS. There were 99.6% of sows with at least one missing BW, leaving only 3 sows with no missing BWs throughout the course of gestation. Sows on average had missing BW values on 26 days of gestation, meaning that BW had to be estimated 24.5% of the time. There was no evidence that missing body weights differed across different weeks of gestation. Missing body weights were generated from the closest surrounding measured weight and the ADG from the 2 manual weights. If the most recent observed weight was prior to the missing weight, the ADG for each missing day was added to the most recent observed weight. If the most recent observed weight was after the missing weight, the ADG was subtracted from the observed weight.

For feed intake, females that did not walk through the feeding station and thereby did not consume any feed had blank feed intake values that were replaced with zeroes. As previously mentioned, errors occurred during the download of feed intake a total of 13 days over the course of the trial (149 days). The specific dates of errors were known and because it is not logical to assume feed intake

Figure 4: An example of an individual sow's body weight throughout the course of gestation. Each black dot indicates a weight obtained throughout the study (1862 total weights). The red dots are the two reference weights when the sow was individually weighed.

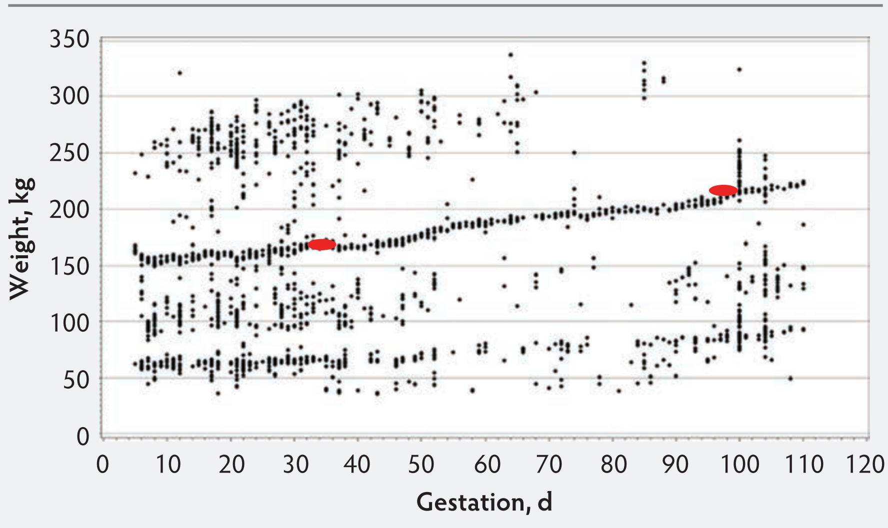
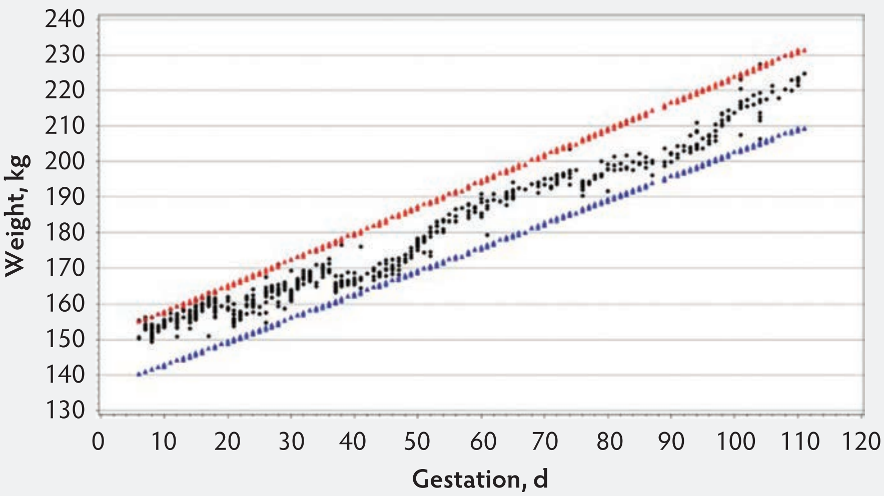


Figure 5: Individual sow body weight throughout the course of gestation after outlier data were removed. The black dots indicate weights obtained throughout the study (671 accurate weights). The red and blue lines were calculated based on the reference weights manually collected and used to determine average daily gain that could then be used to predict sow BW. Weights obtained 5% above (red line) or below (blue line) the predicted weight were deleted and deemed inaccurate.



values of zero for these days, the daily allotment of feed for the sow was assumed to be the amount of feed consumed on that day.

After removing outlier weights from the data set and reporting a feed intake and BW value for each day of gestation, these data sets were then merged with backfat and reproductive performance data. Two additional errors were identified following the merger that are believed to be specific to this farm. First, discrepancies were found in the parity reported between feed intake and reproductive performance data. Recall, feed intake and reproductive performance data files each report parity for a given sow. It is unknown if this is a recording error in the feeding system or farm recording system. To resolve this problem, parity was used from the reproductive performance data only. Second, when comparing gestation lengths from the reproductive performance data and the gestation lengths that were manually determined based on when the females left the pen and the date females farrowed, we found that the days of gestation were off by one day (day 4 of gestation in reproductive performance data is day 5 of gestation in the feed intake data). This error was attributed to the feeding system reset time of 2 PM versus the reproductive data being reset at midnight.

Implications

- As the swine industry transitions from individual gestation stalls to group housing, ESF combined with scales offer unique data collection possibilities for improved sow management as well as research opportunities.
- Feed intake and weight change data can be used to develop models for nutrient requirements and partitioning of nutrients among maternal and fetal growth. There are unlimited possibilities for research of the effects of gestation feeding and sow lifetime reproductive performance.
- Daily intake and BW collection of gestating sows can be successful, but it is imperative that the data collection process is well understood and managed appropriately. Observing the females in the feeding system is helpful in providing insight to any discrepancies that may be occurring in the data set, which is critical in assuring accurate data.
- Nevertheless, daily feed intake and BW collection of pregnant sows throughout the course of gestation can be successful and with these recommendations for conducting further research in commercial settings, we will obtain valuable information regarding the females of today's production systems.

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Conflict of interest

None reported.

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