Calculating breeding herd feed usage and cost in commercial production systems

Lori L. Thomas, MS; Robert D. Goodband, PhD; Steve S. Dritz, DVM, PhD; Mike D. Tokach, PhD; Jason C. Woodworth, PhD; Joel M. DeRouchey, PhD

Summary

The objective of this paper is to describe a production tool for swine producers, veterinarians, and nutritionists to benchmark feed usage and feed cost within gestation, lactation, and gilt development phases of a production system. The model was developed using Microsoft Excel (version 16.0.11328.20438) and includes key variables within the breeding herd affecting feed usage. Data from a commercial production system was used to determine model accuracy as well as demonstrate its use. The results from this production tool provide estimates for feed usage and feed cost within each subpopulation of animals in the breeding herd.

Key words: swine, breeding herd feed usage, breeding herd feed cost

Received: July 31, 2019
Accepted: January 14, 2020

Resumen - Cálculo del uso y costo del alimento del hato reproductor en sistemas de producción comercial

El objetivo de este documento es describir una herramienta de producción para productores porcinos, veterinarios y nutriólogos para comparar el uso de alimento y el costo del alimento en las fases de gestación, lactancia y primerizas en desarrollo en un sistema de producción. El modelo fue desarrollado usando Microsoft Excel (versión 16.0.11328.20438) e incluye variables clave dentro del hato de cría que afectan el uso de alimento. Se utilizó la información de un sistema de producción comercial para determinar la precisión del modelo y demostrar su uso. Los resultados de esta herramienta de producción proporcionan estimaciones para el uso y el costo del alimento dentro de cada subpoblación de animales en el hato de reproducción.

Résumé - Calcul de l'utilisation et du coût des aliments d'un élevage de reproducteurs dans un système commercial de production

L'objectif de cette publication est de décrire un outil de production pour les producteurs porcins, les vétérinaires et les nutritionnistes afin d'avoir un point de référence pour l'utilisation et le coût des aliments lors des périodes de gestation, lactation et développement des cochettes dans un système de production. Le modèle fut développé en utilisant Microsoft Excel (version 16.0.11328.20438) et inclut des variables clés à l'intérieur du troupeau de reproducteurs qui affectent l'utilisation des aliments. Les données en provenance d'un système commercial de production furent utilisées afin de déterminer la précision du modèle aussi bien que de démontrer son utilisation. Les résultats issus de cet outil de production fournissent des estimés pour l'utilisation et le coût des aliments à l'intérieur de chacune des sous-populations d'animaux dans le troupeau de reproducteurs.

Feed cost in the swine industry has historically encompassed 65% to 75% of variable costs of production, and as a result, swine producers continually seek ways to reduce feed cost. Although the breeding herd represents a numerically small fraction of the total swine herd, they consume approximately 20% of the total feed produced and can have a large impact on the profitability of a production system.[1] In contrast to other phases of production where body weight is used to derive cost and revenue, breeding herd revenue and production costs are commonly calculated per weaned pig.[2] Historically, the emphasis in reducing feed cost per weaned pig has been focused around the factors that increase the number of pigs weaned. Previous literature has developed detailed productivity trees displaying the relationships between factors influencing pigs weaned per female per year and models have been developed to quantify changes.[3-5] However, little emphasis has been placed on examining factors affecting feed usage and cost in gilt development, gestation, and lactation.

Feed cost per weaned pig is affected by feed cost (ingredient cost as influenced by diet composition), feed usage, and the number of pigs weaned. Each variable is influenced by numerous factors, many of which are interrelated within the breeding herd. It is typical for producers to calculate feed cost per weaned pig based on gestation and lactation feed usage and generally do not include feed costs in the gilt development unit (GDU). When farms continue to have replacement rates exceeding 50%, capturing gilt development feed usage and cost is imperative to minimizing feed cost per weaned pig. Therefore, the purpose of this paper is to describe a model that serves as a production tool to internally evaluate factors affecting

LLT, RDG, MDT, JCW, JMD: Department of Animal Sciences and Industry, College of Agriculture, Kansas State University, Manhattan, Kansas.

SSD: Department of Diagnostic Medicine and Pathobiology, College of Veterinary Medicine, Kansas State University, Manhattan, Kansas.

Corresponding author: Dr Robert D. Goodband, Department of Animal Science and Industry, Kansas State University, 253 Weber Hall, Manhattan, KS 66506; Tel: 785-532-1228; Fax: 785-532-7059; Email: goodband@ksu.edu.

This article is available online at http://www.aasv.org/shap.html.

Thomas LL, Goodband RD, Dritz SS, Tokach MD, Woodworth JC, DeRouchey JM. Calculating breeding herd feed usage and cost in commercial production systems. *J Swine Health Prod.* 2020;28(3):135-145.

feed usage per weaned pig, and subsequently feed cost per weaned pig. Specifically, this model partitions feed usage within the breeding herd among the different female populations allowing for the isolation of feed cost per weaned pig within each population and benchmark or diagnose differences among breeding herds. The model also calculates feed usage and feed cost per inventoried sow as another way to report breeding herd feed cost, offering a second means of comparison. Our specific aim was to develop a learning tool to stimulate the complexities of breeding herd feed cost, aside from the factors affecting the number of pigs weaned, through a commercial production system.

Materials and methods

Model description

The model was designed with the intent of being used within commercial swine production systems as a form of benchmarking among different breeding herds within and across production systems, as well as individual farms over time. This approach allows the producer to enter production data from one or several breeding herds into the model and compare feed usage and cost on a weaned pig and inventoried sow basis for each subpopulation within the breeding herd. For most producers, feed usage and feed cost for each subpopulation within the breeding herd has not been reported in this fashion, but instead as one value for gestation and one value for lactation. The use of this model allows for not only within system farm comparisons, but also quantifies feed usage within each subpopulation and includes GDU.

The mathematical model is reflective of current US swine production practices and is easily expandable to different production systems, assuming continuous mating within the breeding herd. For simplification and demonstration purposes, the time interval used in the model is reported on a weekly and annual basis.

Data from a commercial production system with multiple individual sow farms was collected to provide model inputs and validate calculations. The model was developed using the Open Source Optimization Solver for Excel[6] in Microsoft Excel (version 16.0.11328.20438). The model can be found at: `https://www.asi.k-state.edu/research-and-extension/swine/calculators.html`.

Determining feed usage

The breeding herd is composed of 3 primary areas: 1) gestation, 2) lactation, and 3) gilt development (Figure 1). Each of these areas are occupied by females in different stages of their reproductive cycle, and because of this, exhibit differences in feed usage. The model herein is designed to isolate each subpopulation of females and determine feed usage specific to each one.

To do this, the model requires a series of inputs based on annual production records and current farm practices. The model estimates feed usage for subpopulations within gestation, lactation, and GDU in one of two ways (Figure 2).

The first method is to estimate and enter individual average daily feed intake (ADFI) for each subpopulation of animals within gestation, lactation, and GDU (Figure 2). For example, within gestation, the user will enter estimated ADFI values for mated females, females to be serviced within the wean-to-estrus interval, cull sows, and boars. The second and recommended option for estimating feed usage for each subpopulation is with actual feed delivery reports for gestation, entry-to-first-service interval, lactation, and GDU feed (Figure 2). The model allows for gilts within the entry-to-first-service interval to be fed the same gestation diet as the remaining gestation herd population or a separate diet. If fed a separate diet, the model will estimate feed usage for gilts within the entry-to-first-service interval based on actual feed delivery. However, if gilts are consuming gestation feed, the model requires the user to enter estimated ADFI for gilts within the entry-to-first-service interval. In addition, the model will require the user to enter estimated ADFI values for females in the wean-to-estrus interval, boars, and cull sows within gestation, as well as pre-farrow females in lactation (only if pre-farrow females are limit fed). These estimated ADFI values are needed to partition feed appropriately to the respective subpopulation. Without providing any estimated ADFI values, the model would produce ADFI identical for each subpopulation within the barn, which we know is not correct. If ADFI for the required subpopulations are unknown, default values can be used and are discussed in detail within each subpopulation.

Gestation

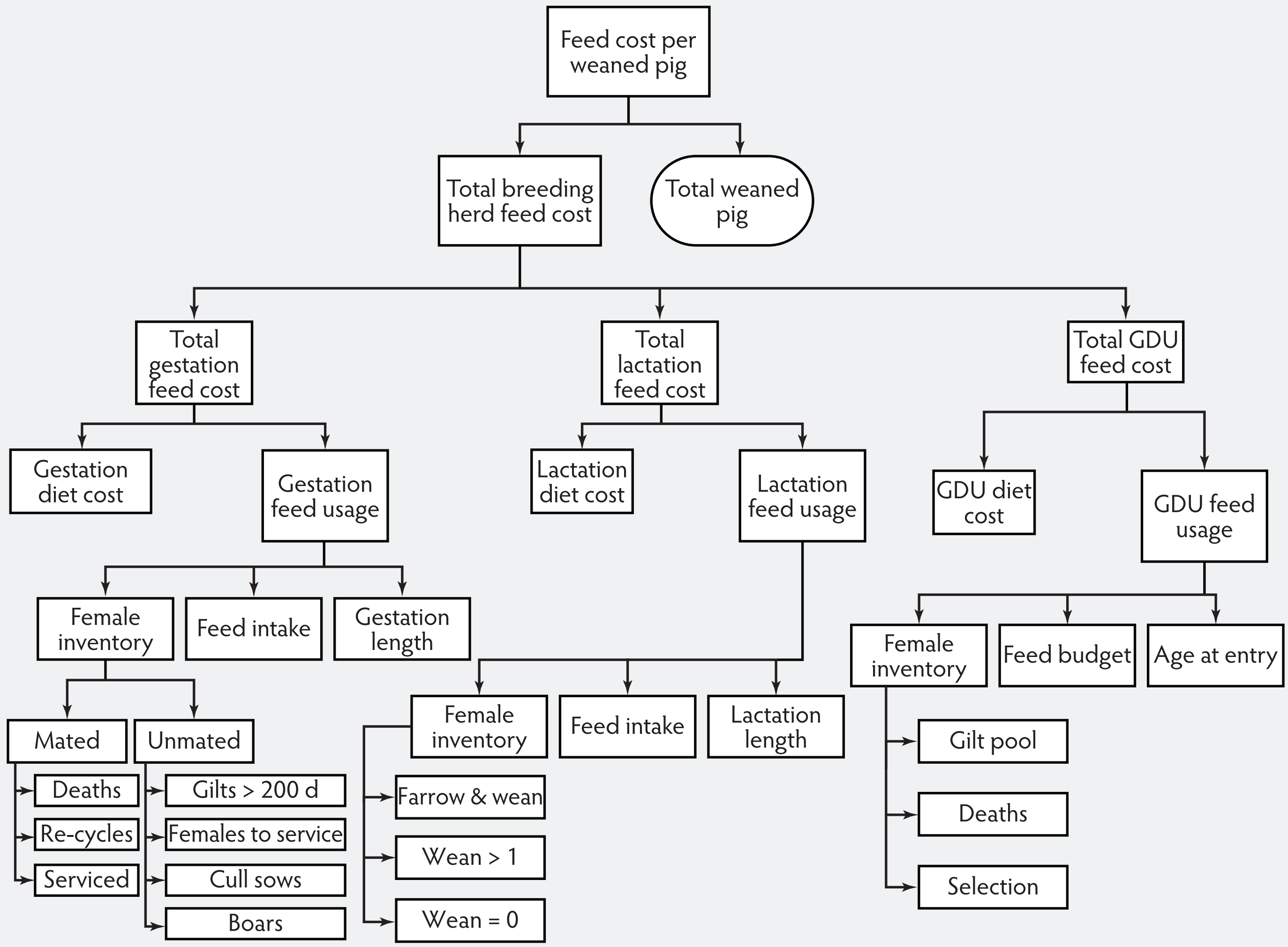
In the model, gestation feed usage is determined separately for each subpopulation of females within the gestation barn (Table 1). Female populations in gestation are divided into 1) mated females, 2) unmated females, and 3) boars used for heat-detection or semen collection. Subpopulations of mated females in gestation include females who were serviced and died during gestation (mortality), females who were serviced and re-cycled during gestation (re-cycles), and females who were serviced and will farrow (gestating sows).

The mean day of death is required to estimate feed usage for the mortality subpopulation. If the mean day of death is unknown, the default value assumes gestating females died on day 58 (midpoint) of gestation. Because females spend more time in gestation compared to lactation, and deaths occurring in lactation occur in early lactation, the model assumes mortality occurs only within the mated female gestation population. Female re-cycles are a function of female services, farrowing rate, and female deaths. Like mortality, the mean day of re-cycle detection is required to estimate feed usage, and if the mean day is unknown a default value assumes re-cycles were found on day 58 of gestation. Gestating sows are a function of female services and farrowing rate. The model assumes continuous mating within the gestation population. For example, as females are serviced and enter the gestation mated population, pregnant females in the gestation mated population enter the farrowing house.

The second division in the gestating category is the unmated female population. This further subdivides to gilt entry-to-first-service interval and nonproductive sows. The unmated gilts within the entry-to-first-service interval captures the cost associated with these females as they enter the breeding herd. The model assumes the population of unmated gilts within the entry-to-first-service interval are eligible for breeding (> 200 days of age). From this population, gilts are subdivided into: gilts serviced and entering the mated population (serviced gilts), gilts who skip a heat and are serviced 21 days later before entering the mated population (skipped gilts), and gilts culled and removed from the breeding herd (culled gilts).

The unmated nonproductive sow population includes all remaining sows consuming gestation feed. The 2 unmated nonproductive sow populations include sows yet to be serviced (weaned females and re-cycles to be serviced) and sows to be culled (culled sows).

Figure 1: Representation of the feed cost per weaned pig separated into gestation, lactation, and GDU subpopulations. Within each area of the breeding herd, feed cost is composed of diet cost and feed usage. Feed usage is further divided among female populations, feed allowance, and days on feed. GDU = gilt development unit.



The model requires an input for ADFI for nonproductive sows to be serviced and nonproductive cull sows. If ADFI values are unknown, default values of 3.6 and 5.2 kg are used.[7-10] The model assumes unmated nonproductive sows to be serviced are within the wean-to-estrus interval and include sows weaned from the farrowing house as well as re-cycles to be serviced. Total nonproductive cull sow inventory is a function of annual culling rate. Lastly, in addition to entering nonproductive cull sow intake, the mean number of cull sow days on the farm is needed to estimate feed usage for this population.

Lactation

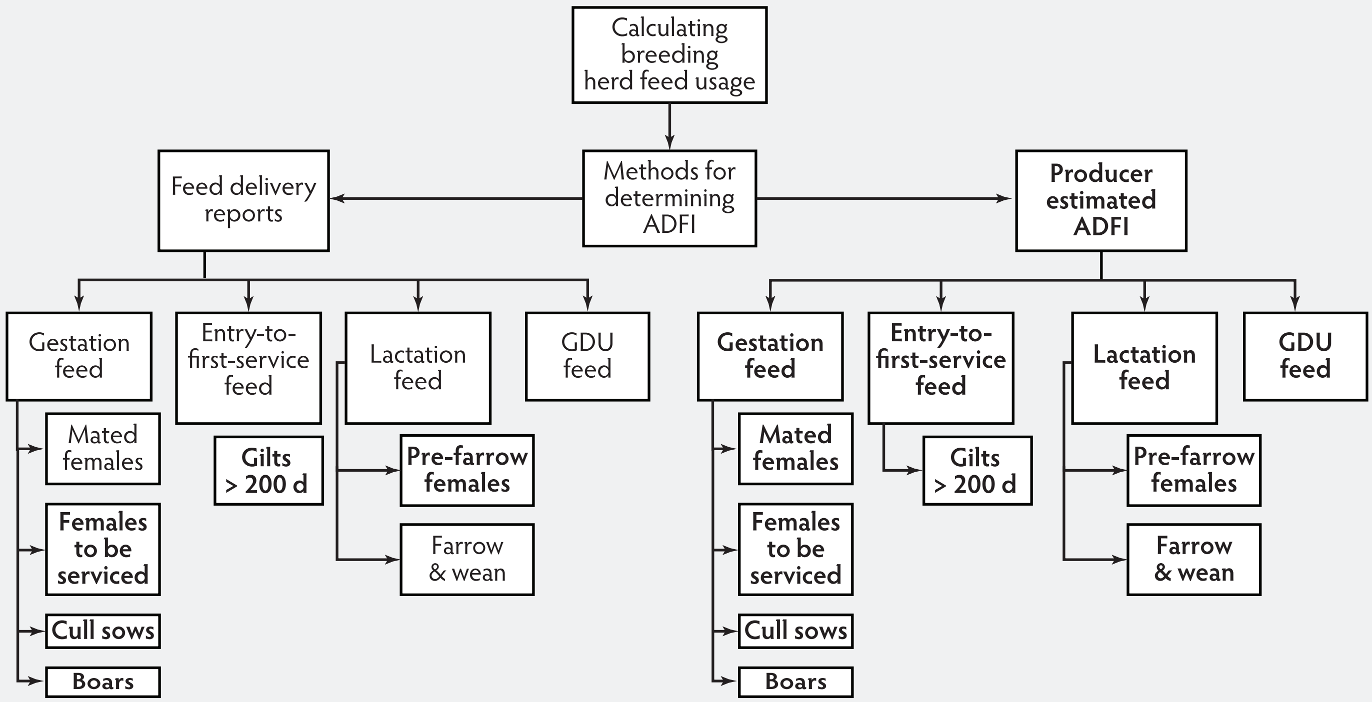
Lactation feed usage is determined separately for each subpopulation of females within the farrowing house. Female populations in lactation include pregnant females who have not yet farrowed (pre-farrow sows), females that farrow and wean a litter (normal lactating sows), females that farrow and wean > 1 litter (nurse sows), and females that farrow but do not wean a litter of pigs, ie, females that farrow and pigs are transferred onto another sow (weaned without a litter sows).

Pregnant females loaded into the farrowing house that have not yet farrowed is estimated based on female services and farrowing rate. The same calculation is used to estimate the number of normal lactating females while also accounting for nurse sows and those farrowed but did not wean a litter of pigs (weaned without a litter sows). The model allows for pregnant females loaded into the farrowing house that have not yet farrowed to be fed ad libitum, in which ADFI will be determined using the model, or the user can input estimated ADFI if they are not on full-feed. The model also has an option for lactation feed being fed to unmated nonproductive sows to be serviced (wean-to-service interval).

Gilt development unit

The model is designed to capture gilt development feed usage, and the associated feed cost, starting at entry into the breeding herd. For producers purchasing or producing weaned replacement gilts, nursery feed usage and the associated feed cost, mortality, and selection rates should be included with GDU inputs. The user enters the annual mean days gilts are in the GDU before entering the breeding herd population (mean days in GDU). For example, if replacement gilts are purchased at weaning, the mean days entered would include days from purchase

Figure 2: Two different methods for determining feed usage. Regardless of method, the model requires (bold text) estimated ADFI values for females to be serviced, cull sows, gilts > 200 days of age (only if consuming gestation feed), and boars consuming gestation feed and pre-farrow females consuming lactation feed (only if pre-farrow sows are limit fed). ADFI = average daily feed intake; GDU = gilt development unit.



to entry into the breeding herd population (nursery + GDU). If females are purchased at selection (> 200 days of age) and thereafter directly enter the breeding herd, the resulting days in the GDU would be zero. Thus, the model allows for flexibility among productions systems to tailor GDU inputs specific to their system.

Female populations within the GDU include replacement gilts eligible to enter the gilt pool (replacement gilt pool), gilt mortality (GDU mortality), and non-select gilts (GDU non-selects).

Replacement gilt inventory is a function of replacement rate and total female inventory (> 200 days of age) accounting for gilt death loss and selection rate in the GDU. Gilt mortality is a function of GDU mortality rate. If the mean day of death within the GDU is unknown, a default value equivalent to half the days in GDU is used to determine how much feed was consumed before death. Non-select gilts are a function of GDU selection rate and if the mean days of feed consumed before non-select females are removed from the herd is unknown, a default value equivalent to half the days in the GDU is used.

Practical application

The utility of the model was determined using data from a large commercial production system with multiple sow farms. Data was compiled from production records and farm managers based on current farm practices. The model calculates feed usage and feed cost per weaned pig and per inventoried sow for each subpopulation within gestation, lactation, and GDU. In addition, the model also calculates a system weighted mean (weighted by breeding herd female inventory) that can be used to help with benchmarking and identify farms that are greater than 1 SD from the mean.

Annual breeding herd productivity records were obtained (Porcitec; Agritec Software) from 4 breeding herds within a large production system to evaluate the model (Table 2). All 4 farms house gestating females in conventional gestation stalls and are fed via feed drops. Females across all 4 farms were fed in gestation stalls during the wean-to-estrus period and provided feed ad libitum. Cull sows were housed in pens or gestation stalls and provided feed ad libitum before being sold. Upon moving into the farrowing house (day 113 of gestation) females were limit fed until farrowing. Thereafter, the feeders in lactation allowed for ad libitum feed intake during lactation. Replacement gilts entered an off-site nursery at weaning, spent 50 days in the nursery, and were then transported to the GDU. Gilts entered the unmated breeding herd population at approximately 200 days of age. Gilts were provided feed ad libitum in the nursery and GDU.

Model calculated mated female (gestation) ADFI for farms 1, 2, 3, and 4 were 2.2, 2.1, 2.3, and 2.4 kg, respectively (Table 3). The producer estimated mated female ADFI at 2.0 kg which was 0.2 kg less feed per day than consumed. The mated female population consumes the greatest quantity of feed among female subpopulations within gestation. Thus, discrepancies between model calculations and producer estimates can have a large financial impact and it is important to understand why differences exist. Factors possibly contributing to the increase in ADFI for mated females could be feed wastage, thin females requiring more feed, or inaccurate feed drops.

Model calculated lactation ADFI for farms 1, 2, 3, and 4 were 5.6, 6.6, 6.4, and 6.2 kg, respectively, compared to the producer's

Table 1: Equations used in the estimation of female inventories per week for each breeding herd population*

Population	Equation
Gestation	
Mated females	
Mortality†	= (total female inventory × avg mortality rate, %) (365.25/7)
Re-cycles	= (avg services per wk × (1 – avg farrowing rate, %)) – mortality per wk
Gestating sows	= avg services per wk × farrowing rate, %
Unmated females	
Entry-to-first-service interval‡	
Serviced gilts	= (gilts available per wk × gilts bred, %)
Skipped gilts§	= (gilts available per wk - gilts serviced per wk) × gilts skipped, %
Culled gilts¶	= (gilts available per wk - gilts serviced per wk) × (1 – gilts skipped, %)
Nonproductive sows	
Weaned females to be serviced**	= (females that farrow and wean per wk + nurse sows weaned per wk) × weaned females bred, %
Weaned without a litter to be bred††	= weaned zero females per wk × weaned zero females bred, %
Re-cycles to be serviced	= re-cycles per wk × re-cycles bred, %
Culled sows	= (total female inventory × avg culling rate, %) (365.25/7)
Lactation	
Pre-farrow sows	= avg services per wk × farrowing rate, %
Normal lactating sows	= (avg services per wk × farrowing rate, %) × (1 – nurse sow, % + weaned zero females, %)
Nurse sow	= (avg services per wk × farrowing rate, %)
Weaned without a litter sows††	= (avg services per wk × farrowing rate, %) × nurse sow, % × weaned zero females, %
GDU	
Replacement gilt pool	= **[(**{(total female inventory × replacement rate, %) + [(total female inventory × replacement rate, %) × avg GDU mortality rate, %] + [(total female inventory × replacement rate, %) × (1 – avg GDU selection rate, %)]} / 365.25**)** × 7**]** – (GDU mortality – GDU selection)
GDU mortality	= {[(total female inventory × replacement rate, %) × avg GDU mortality rate, %] / 365.25} × 7
GDU non-selects‡‡	= {[(total female inventory × replacement rate, %) × (1 – avg GDU selection rate, %)] / 365.25} × 7

* The model was designed assuming farrowings are uniformly distributed through the week (continuous mating).
† The model assumes mortality occurs within the gestation population to mated females only.
‡ Gilts available per week are defined as gilts > 200 days of age, within the entry-to-first-service interval, and eligible to bred.
§ Gilts skipped are defined as gilts who skip a heat and are serviced 21 days later.
¶ The model assumes if the eligible gilt is not bred or skipped, she is culled.
** Weaned females to be serviced includes females that farrow and wean a litter and females that farrow and wean > 1 litter (nurse sow).
†† Females who weaned without a litter are defined as females who farrow and pigs are transferred to another sow.
‡‡ GDU non-selects is defined as gilts not selected to enter the replacement gilt pool and are removed from the breeding herd.
GDU = gilt development unit.

Table 2: Selected model inputs from 4 sow farms to demonstrate model use*

Input variable	Farm 1	Farm 2	Farm 3	Farm 4
Female inventory†	1583	4109	2772	1480
Boar inventory	3	10	17	4
Avg services (sows & gilts)/wk	80	213	142	77
Re-cycles serviced, %	43	63	99	70
Avg days found open, d‡	40	58	37	42
Wean-to-estrus interval, d	5.9	6.8	7.7	6.9
Avg farrow rate, %	87.6	80.1	79.0	85.8
Avg culling rate, %	46.4	48.0	35.3	40.5
Avg cull sow days, d§	24	27	24	22
Avg mortality rate, %	9.9	12.8	16.0	10.6
Entry-to-first-service interval, d	23.4	15.3	46.7	21.7
Entry-to-removal interval, d	41	51	71	11
Avg lactation length, d	20.1	21.6	24.6	18.9
Avg nurse sows weaned, %¶	3.5	5.0	8.5	3.8
Avg sows weaned zero, %**	0.3	7.4	3.6	4.3
Avg number of pigs weaned/wk	818	1929	1156	789
Avg replacement rate, %	58.6	62.3	49.4	45.7
Unmated females to be serviced ADFI, kg††	3.4	3.4	3.4	3.4
Unmated cull sows ADFI, kg††	3.0	3.0	3.0	3.0
Boar ADFI, kg††	2.0	2.0	2.0	2.0
Unmated gilts entry-to-first-service interval ADFI, kg††	3.0	3.0	3.0	3.0
Pre-farrow ADFI, kg††	2.7	2.7	2.7	2.7

* Averages are reported on an annual basis unless otherwise specified.
† Total female inventory includes gilts > 200 days of age and sows.
‡ Average days from first service to found open.
§ Average days cull sows remain on the farm after classified as a cull sow.
¶ Females that farrow and wean > 1 piglet.
** Females that farrow but wean zero piglets.
†† Producer estimated ADFI based on farm observations.
ADFI = average daily feed intake.

Table 3: Model calculated ADFI for each sow farm*

Input variable	Farm 1	Farm 2	Farm 3	Farm 4
Calculated mated female ADFI, kg	2.2	2.1	2.3	2.4
Calculated lactation ADFI, kg†	5.6	6.6	6.4	6.2
Calculated GDU ADFI, kg‡	2.0	2.0	3.3	1.8

* Model calculated ADFI was derived from feed delivery inputs for females in gestation and lactation (using the optimization tool to separate deliveries to gestation, entry-to-first-service interval, and lactation), and feed budget inputs for GDU.
† Females are provided with ad libitum feed at farrowing.
‡ Gilts are produced internally and enter the breeding herd population at 200 d of age.
ADFI = average daily feed intake; GDU = gilt development unit.

estimate for lactation feed intake at 5.9 kg (Table 3). Lactating females consumed 0.3 kg more per day than the producer estimated. Within this production system, pre-farrow females in a lactation stall were provided 2.7 kg of feed per day until farrowing, after which females were provided with ad libitum feed. Speculation for differences in model calculated and producer estimated lactating female ADFI could be that pre-farrow females received more than the allotted 2.7 kg per day. Other possibilities include poor feeder management (wastage) or differences in parity structure.

Model calculated ADFI for GDU (from weaning to 200 days) using feed delivery for farms 1, 2, 3, and 4 were 2.0, 2.0, 3.3, and 1.8 kg, respectively (Table 3). Feed delivery records included nursery and GDU. Within this system, nursery and GDU sites commonly supplied gilts for multiple sow herds. Therefore, nursery and GDU feed deliveries were partitioned appropriately to accurately reflect gilt flow among the breeding herds.

Model calculated feed usage and feed cost per weaned pig are presented in Figures 3 and 4 and per inventoried sow in Figures 5 and 6. Gestation, lactation, and GDU diet costs differ among the breeding herds due to different feed mills manufacturing the feed. Gestation, lactation, and GDU feed usage and feed cost per weaned pig for all 4 farms were 54.3 kg and $10.71. Similarly, gestation, lactation, and GDU feed usage and feed cost per inventoried sow for all 4 farms were 1336 kg and $263.76.

The use of this model within this production system highlights differences in feed usage and feed cost between the 4 farms. Weaned pig feed usage and feed cost were greatest on farm 3 and lowest on farm 4 (Figures 3 and 4). These differences were influenced by the number of pigs weaned as well as differences in feed usage in gestation, lactation, and GDU, with farm 3 feed usage being the greatest in almost all subpopulations. When evaluating differences in feed usage and feed cost per inventoried sow, farm 3 was the greatest, however the magnitude of differences in feed usage and feed cost within each subpopulation were smaller. This showcases the reduction in the number of pigs weaned on farm 3 compared to remaining farms.

The model calculated notable differences in feed usage, and in turn feed cost, in gestating females, re-cycles, serviced gilts, weaned females to be serviced, and cull sow subpopulations within gestation. Gestation diet cost was $0.18/kg for farms 1 and 2 and $0.17/kg for farms 3 and 4. Based on delivery data, estimated ADFI for gestating females on farm 4 was 0.2 kg greater than the remaining 3 farms, contributing to the $12.77 increase in feed cost per inventoried sow (Table 4). Gestating females on farm 2 had the lowest feed cost per inventoried sow; however, feed usage per inventoried sow for re-cycles was the greatest at 50.3 kg, compared to the mean of the other 3 farms at 27.1 kg. This can be partially explained by a lower farrowing rate and greater days from first service to found open for farm 2 compared to the mean of the other farms. This contributed to increased feed cost of $0.18/weaned pig and $4.37/inventoried sow for farm 2 compared to the mean of farms 1, 3, and 4 (Table 4). Similarly, farm 2 fed cull sows for an additional 4 days compared to other farms and had a higher culling rate, contributing to an increased feed cost of $0.09/weaned pig and $2.08/inventoried sow (Table 4). Lastly, serviced gilts from farm 3 had the greatest feed usage per weaned pig and per inventoried sow (Table 4). This can be partially explained by an increase in the entry-to-first-service interval for gilts on farm 3 by 27 days, contributing to an increase in feed cost of $0.30/weaned pig and $5.54/inventoried sow. Thus, within gestation, the model indicated there were numerous subpopulations of females with differences in feed usage and cost. Using the model allows for the user to further diagnose and understand where opportunities exist to reduce breeding herd feed usage and, subsequently, feed cost.

Differences in feed usage and feed cost were observed in lactation subpopulations as well. Lactation diet cost was $0.23/kg for farms 1, 2, and 3 and $0.22/kg for farm 4. In farm 3, feed cost increased by $0.80/weaned pig and $7.29/inventoried sow or normal lactating sows and $0.20/weaned pig and $3.79/inventoried sow for nurse sow subpopulations compared to the mean of the other farms (Table 4). These differences are attributed to numerous factors, including increased ADFI in lactation, increased lactation length, and increased percentage of nurse sows in farm 3.

In addition to gestation and lactation, the model also highlighted differences in feed usage and feed cost per weaned pig and per inventoried sow for GDU subpopulations. Within this system, diet cost was $0.21/kg for farms 1, 2, and 3 and $0.20/kg for farm 4. Feed cost for replacement gilts was $1.45/weaned pig and $23.99/inventoried sow more in farm 3 compared to the mean of the other farms (Table 4). Similarly, non-select gilt feed cost was $0.25/weaned pig and $4.20/inventoried sow more in farm 3 compared to farms 1, 2, and 4 (Table 4). These differences in feed cost can be explained by increased gilt ADFI in farm 3 compared to farms 1, 2, and 4 (Table 3), as well as difference in pigs weaned and female inventory.

Conclusions

The purpose of this paper was to describe a production tool that can be used as a resource by swine producers to understand differences in feed usage and feed cost within the breeding herd. The model developed was successful at partitioning feed usage and feed cost among subpopulations within gestation, lactation, and GDU within multiple farms from a commercial swine production system.

When demonstrating model use, feed usage and subsequent feed cost per weaned pig and per inventoried sow was determined, illustrating the variability that can exist within systems and how to rationalize and make sense of these differences. Due to the complexity of the response variable, the model cannot quantify financial impacts of individual variables; however, the model remains useful for benchmarking and highlighting differences among the different farms.

Implications

- Feed use and cost was determined for each subpopulation of females in the herd.
- The model shows the complexity of feed usage within the sow farm and GDU.
- In addition to number of weaned pigs, other factors also can reduce feed cost.

Acknowledgments

This manuscript represents contribution No. 20-032-J from the Kansas Agricultural Experiment Station.

Conflict of interest

None reported.

Disclaimer

Scientific manuscripts published in the *Journal of Swine Health and Production* are peer reviewed. However, information on medications, feed, and management techniques may

Figure 3: Model calculated annual feed usage per weaned pig for each breeding herd segment for each of the 4 farms.

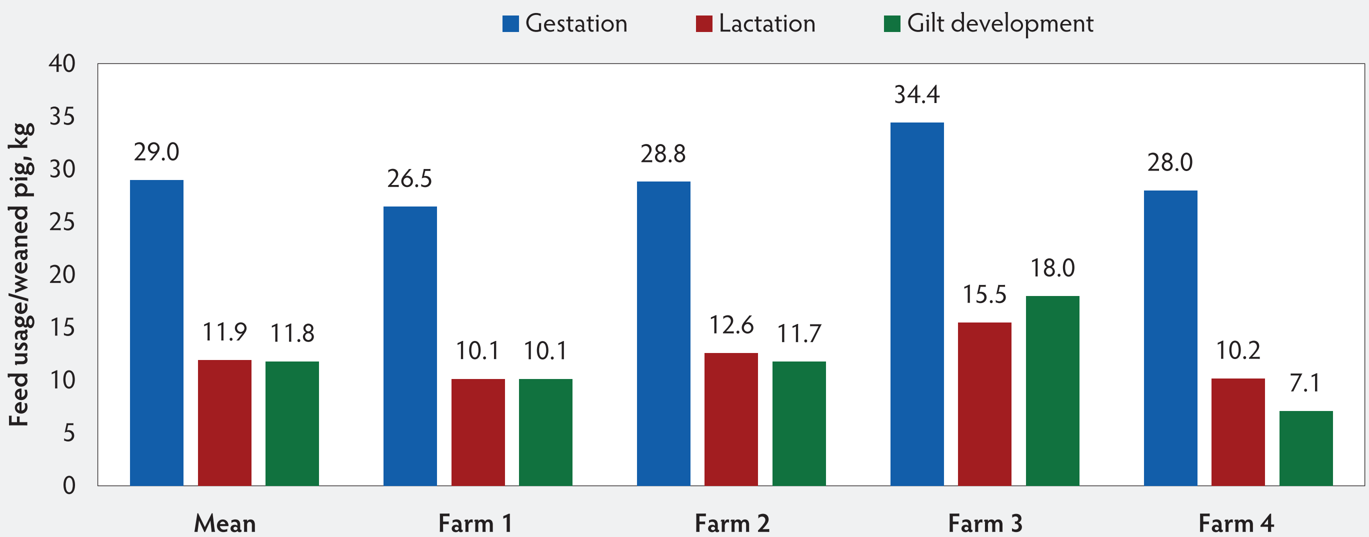
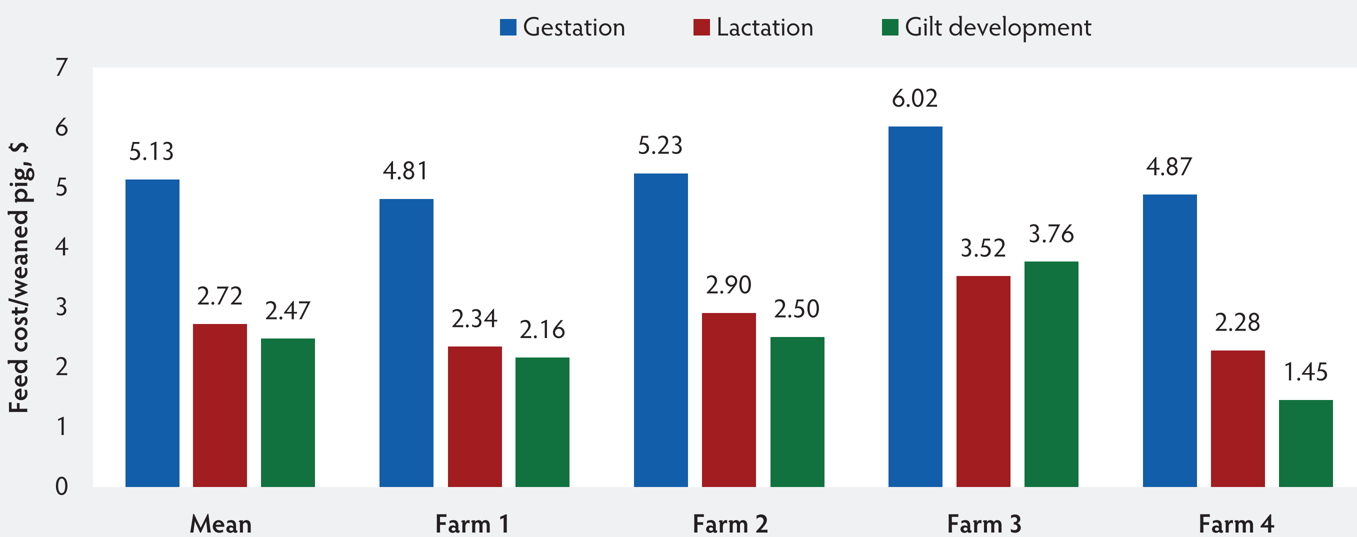


Figure 4: Model calculated annual feed cost per weaned pig for each breeding herd segment for each of the 4 farms.



be specific to the research or commercial situation presented in the manuscript. It is the responsibility of the reader to use information responsibly and in accordance with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

References

*1. Ball RO, Moehn S. Feeding pregnant sows for optimum productivity: past, present, and future perspectives. *Proc APSA.* Melbourne, Australia. 2013:151-169.

2. Main RG, Dritz SS, Tokach MD, Goodband RD, Nelssen JL. Effects of weaning age on growing-pig costs and revenue in a multi-site production system. *J Swine Health Prod.* 2005;13(4):189-197.

3. Koketsu Y, Tani S, Lida R. Factors for improving reproductive performance of sows and herd productivity in commercial breeding herds. *Porcine Health Manag.* 2017;3(1). doi:10.1186/s40813-016-0049-7

4. Dewey CE, Wilson S, Griffin J. A model to predict the numbers of pigs weaned per week. *Swine Health Prod.* 1997;5(6):219-224.

5. Dial GD, Marsh WE, Polson DD, Vaillancourt JP. Reproductive failure: Differential diagnosis. In: Leman AD, Straw BE, Mengeling WL, D'Allaire S, Taylor DJ, eds. *Diseases of Swine.* 7th ed. Ames, Iowa: Wolfe Publishing; 1992:88-137.

*6. Mason AJ. OpenSolver – an open source add-in to solve linear and integer programmes in Excel. OpenSolver. **http://opensolver.org/**. Published January 12, 2018. Accessed January 14, 2019.

7. Fitzgerald RF, Stalder KJ, Johnson CD, Layman LL, Karriker LA. An economic analysis of feeding cull sows. *Prof Anim Sci.* 2008;24:355-362.

8. Whitney MH, Baidoo SK, Levis DG, Wilson ME. Breeding boar nutrient recommendations and feeding management. In: Meisinger DJ, ed. *National Swine Nutrition Guide*. Des Moines, IA: US Pork Center of Excellence; 2010:136-144.

*9. Ketchem R. Improving wean-to-first service interval. National Hog Farmer. **https://www.nationalhogfarmer.com/genetics-reproduction/0622-improving-wean-to-first-service-interval**. Published June 22, 2009. Accessed January 4, 2019.

10. Baidoo SK, Aherne FX, Kirkwood RN, Foxcroft GR. Effects of feed intake during lactation and after weaning on sow reproductive performance. *Can J Anim Sci.* 1992;72:911-917.

* Non-referred references.

Figure 5: Model calculated annual feed usage per inventoried sow for each breeding herd segment for each of the 4 farms.

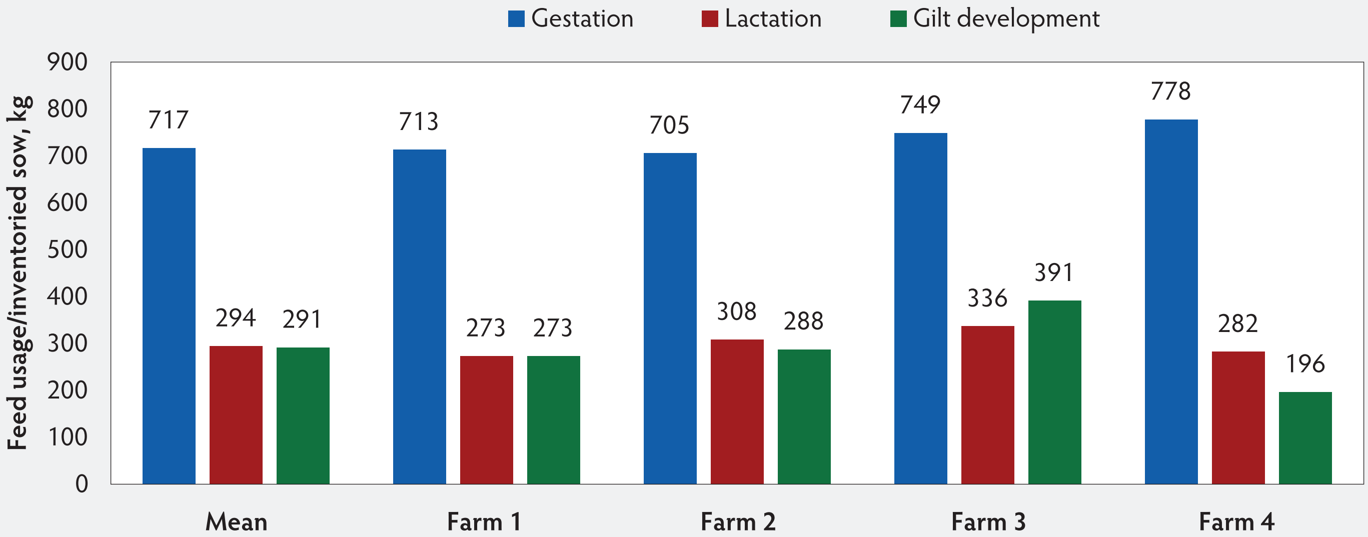


Figure 6: Model calculated annual feed cost per inventoried sow for each breeding herd segment for each of the 4 farms.

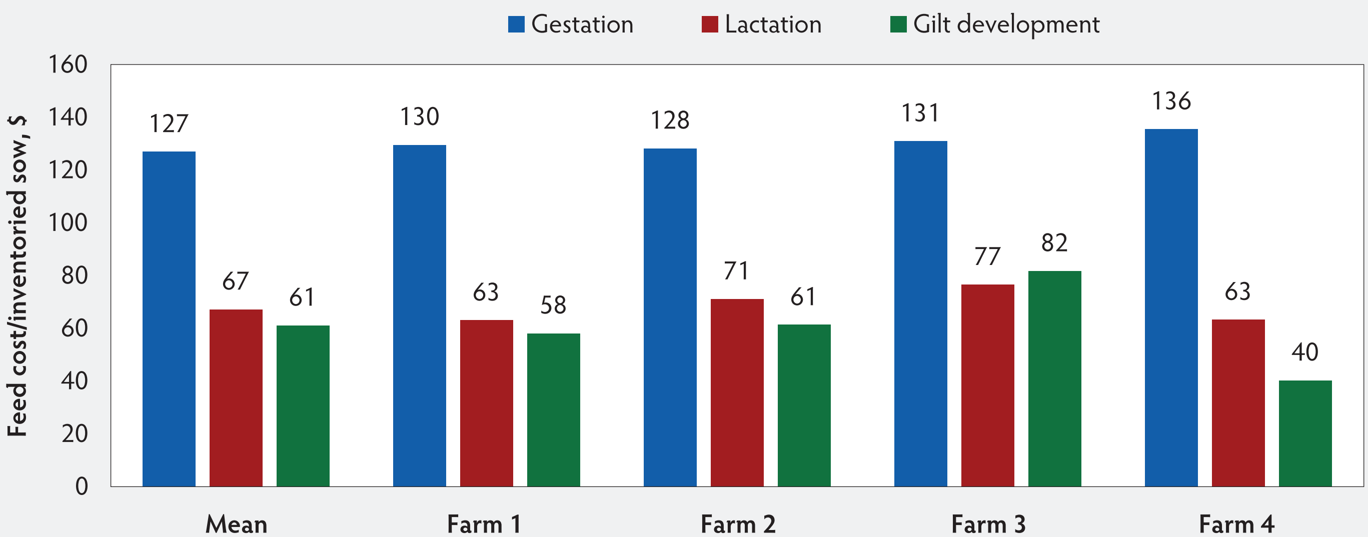


Table 4: Feed usage and cost per weaned pig and per inventoried sow by subpopulation on 4 sow farms*†

Parameter	Farm 1	Farm 2	Farm 3	Farm 4
Gestation				
Gestating sows				
Days on feed, d	114	113	113	114
Annual inventory	3649	8885	5834	3444
Annual intake, metric ton	894	2136	1510	9366
Annual feed cost, $	162,484	388,153	264,194	163,185
Feed usage/weaned pig, kg	21.0	21.2	25.0	22.8
Feed cost/weaned pig, $	3.81	3.86	4.38	3.97
Feed usage/inventoried sow, kg	565	520	545	633
Feed cost/inventoried sow, $	102.64	94.46	95.32	110.25
Re-cycles				
Days on feed, d	40	58	37	42
Annual inventory	360	1,681	1,107	413
Annual intake, metric ton	31	207	93	42
Annual feed cost, $	5654	37,602	16,195	7275
Feed usage/weaned pig, kg	0.7	2.1	1.5	1.0
Feed cost/weaned pig, $	0.13	0.37	0.27	0.18
Feed usage/inventoried sow, kg	20	50	33	28
Feed cost/inventoried sow, $	3.57	9.15	5.84	4.91
Serviced gilts, > 200 days				
Days on feed, d	23	15	47	22
Annual inventory	835	2304	1232	609
Annual intake, metric ton	59	106	173	40
Annual feed cost, $	10,652	19,221	30,204	6905
Feed usage/weaned pig, kg	1.4	1.1	2.9	1.0
Feed cost/weaned pig, $	0.25	0.19	0.50	0.17
Feed usage/inventoried sow, kg	37	26	62	27
Feed cost/inventoried sow, $	6.73	4.68	10.90	4.67
Females culled				
Days on feed, d	24	27	24	22
Annual inventory	735	1972	978	599
Annual intake, metric ton	53	161	70	39
Annual feed cost, $	9609	29,261	12,183	6880
Feed usage/weaned pig, kg	1.2	1.6	1.2	1.0
Feed cost/weaned pig, $	0.23	0.29	0.20	0.17
Feed usage/inventoried sow, kg	33	39	25	27
Feed cost/inventoried sow, $	6.07	7.12	4.40	4.65
Annual feed cost, $	90,921	256,119	182,896	83,397
Feed usage/weaned pig, kg	9.2	11.0	13.3	9.0

Table 4: Continued

Parameter	Farm 1	Farm 2	Farm 3	Farm 4
Lactation				
Normal lactating sows				
Days on feed, d	20	22	25	19
Annual inventory	3511	7878	5125	3165
Annual intake, metric ton	394	1110	804	372
Annual feed cost, $	90,921	256,119	182,896	83,397
Feed usage/weaned pig, kg	9.2	11.0	13.3	9.0
Feed cost/weaned pig, $	2.13	2.54	3.03	2.03
Feed usage/inventoried sow, kg	249	270	290	251
Feed cost/inventoried sow, $	57.4	62.3	66.0	56.3
Nurse sows				
Days on feed, d	26	27	28	26
Annual inventory	127	443	498	130
Annual intake, metric ton	18.1	77.5	87.3	20.6
Annual feed cost, $	4172	17,889	19,852	4615
Feed usage/weaned pig, kg	0.4	0.8	1.5	0.5
Feed cost/weaned pig, $	0.10	0.18	0.33	0.11
Feed usage/inventoried sow, kg	11	19	31	14
Feed cost/inventoried sow, $	2.64	4.35	7.16	3.12
GDU				
Replacement gilt pool				
Days on feed, d	199	199	199	199
Annual inventory	928	2560	1369	676
Annual intake, metric ton	363	994	912	245
Annual feed cost, $	77,383	211,800	190,563	50,136
Feed usage/weaned pig, kg	8.5	9.9	15.1	5.9
Feed cost/weaned pig, $	1.81	2.10	3.16	1.22
Feed usage/inventoried sow, kg	229	242	329	165
Feed cost/inventoried sow, $	48.88	51.54	68.76	33.87
GDU non-selects				
Days on feed, d	99.5	99.5	99.5	99.5
Annual inventory	325	896	479	237
Annual intake, metric ton	64	174	160	43
Annual feed cost, $	13,542	37,065	33,349	8774
Feed usage/weaned pig, kg	1.5	1.7	2.6	1.0
Feed cost/weaned pig, $	0.32	0.37	0.55	0.21
Feed usage/inventoried sow, kg	40	42	58	29
Feed cost/inventoried sow, $	8.55	9.02	12.03	5.93

* Diet cost for gestation, lactation, and GDU were the same across farms.
† Inventory, intake, and feed costs are reported on an annual basis unless otherwise specified.
GDU = gilt development unit.