ORIGINAL RESEARCH

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A model to predict the numbers of pigs weaned per week

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Summary

A spreadsheet was developed to predict the numbers of pigs weaned per week 19 weeks after the sows were served. The prediction was based on 3-week rolling averages of sows served and 12-week rolling averages of litter size, preweaning mortality, and farrowing rate. The spreadsheet can be used to manage the future flow of pigs on a given farm. A model of the component parts of pigs weaned per week was used to determine the relative impact of each production parameter. The farrowing rate, litter size, and preweaning mortality had little impact on the variation of pigs weaned per week. The numbers of sows served explained 62% of the variation in pigs weaned per week. We recommend that producers keep the numbers of sows served within a farm-specific minimum and maximum to produce a steady flow of pigs through the system. This will require an adequate gilt pool for weeks when there are too few sows in estrus, and will require that producers allow sows to remain open for another estrus cycle if the maximum number of sows has been served for the week.

Key words: swine, pigs weaned, sows served, model

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The even flow of pigs through a pig production system is very important for a number of reasons. It is essential that producers make optimum use of existing facilities, thereby decreasing the fixed costs of production.[1–5] On the other hand, if there are excess numbers of pigs being produced with insufficient barn capacity, the pigs become crowded. Overcrowding can decrease feed intake and average daily gain and can often increase prevalence of disease, all factors that lead to decreased flow through the barn.[1,5–10] A steady flow of pigs produced has become even more important in integrated SEW production systems in which the nursery operator expects a given number of pigs per week to fill the nursery. Profits for the sow producers depend on producing a steady supply of pigs each week.

The purposes of the present study were:

- to develop a spreadsheet that would predict the number of pigs weaned per week based on the current number of services and previous production performance, and
- to determine the factors responsible for the fluctuation in pigs weaned per week.

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This article is available on the AASP Web site at:

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Prediction spreadsheet

A copy of our spreadsheet can be downloaded from the AASP web site; follow the links to this article at http://www.aasp.org/shap/issues/v5n6/. Our spreadsheet assumed that several component factors, if combined together, can predict the number of pigs weaned per week in a herd. Factors that we assumed contribute to the number of pigs weaned per week included:

- the number of sows served in a week, 19.5 weeks (137 days) prior to weaning;
- the farrowing rate per week;
- the number of pigs born alive per litter, 3 weeks prior to weaning; and
- preweaning mortality.

Historical PigCHAMP® production records taken from the Performance Monitor reports from five swine herds were used to develop the spreadsheet. The convenience sample of farms selected was chosen based on the first author's knowledge of the management and disease status of the herds. Data from 1993 and 1994 were exported from PigCHAMP® and imported into Quattro-Pro™ (Corel Quattro Pro™ 6.0). Estimates of the numbers of pigs weaned per week were calculated based on the values of the four contributing factors from various time intervals.

The time intervals used for preweaning mortality, pigs born alive, and farrowing rate included:

- 52 weeks prior to the week of interest to represent seasonal changes in productivity, and
- 12-week rolling averages to represent within-herd trends in productivity.

The time intervals for the number of sows served included:

- 137 days prior to weaning,
- 3-week rolling averages, including 137 days prior to weaning plus the week before and after; and
- 5-week rolling averages including 137 days prior to weaning plus the 2 weeks before and after.

Pearson's correlation coefficients were calculated for the predicted and actual number of pigs weaned per week to determine which would be the best predictor.

Assumptions

The assumptions of the spreadsheet were as follows:

- Fluctuations in productivity: We assumed that there are within-herd trends in farrowing rate, litter size, and preweaning mortality. For example, a herd that is currently experiencing a high litter size probably has had a high litter size over the previous few weeks and is likely to have a high litter size for the next few weeks. Likewise, a herd that currently has a low litter size likely had a low litter size last week and will have a low litter size next week. We initially used a prediction equation based on the most current data available: what occurred during the last 8 weeks. We also used the farrowing rate from 52 weeks prior to the week of interest to account for seasonal variation. However, we know that farrowing rate, litter size, and preweaning mortality are influenced by
  – the parity distribution in a herd,
  – disease, and
  – management changes that occur in time sequences.
  We included these trends in our analysis by predicting the number of sows farrowed and the number of pigs weaned using 12-week rolling averages. These rolling averages resulted in the predictors that most accurately reflected what occurred.
- Gestation and lactation lengths change from sow to sow: We cannot assume that all sows bred over a 7-day interval will farrow exactly 115–122 days later. Similarly, we cannot assume that, for a herd with an average lactation length of 21 days, all sows bred over a 7-day interval will wean their litters 136–143 days later. This is because sows are bred on each day of the week and gestation length varies from 110–120 days. Weaning age also varies according to the day of the week that the sow farrows and whether or not the producer weans once or twice a week. We found the best prediction of the numbers of sows available to farrow and wean were based on 3-week rolling averages that included the week before and the week after the specified breeding week. The spreadsheet does take into consideration the average weaning age of the herd to predict the numbers of pigs weaned per week.
- Weekly farrowing groups: The final assumption is that the herds are farrowing at weekly intervals. If a herd batch farrowed less frequently, the rolling averages and the predictions would have to be altered accordingly.

Predictions

The spreadsheet produces a prediction that is calculated as:

> the 3-week rolling average of the number of sows bred × the 12-week rolling average of farrowing rate × the 12-week rolling average number of pigs born alive per sow × the survival rate of the piglets.

The survival rate is calculated as:

> 100 – the 12-week rolling average of preweaning mortality rate.

As soon as the number of sows bred is entered into the spreadsheet, the number of pigs to be weaned in 137 days is predicted. As more current information is available, the prediction changes using the new rolling averages.

Validation of the predictions

Using historical data from PigCHAMP®, the actual number of pigs weaned per week was determined to examine how close the predictions were to the true figures. The prediction based on the production parameters from the previous year was moderately correlated (0.74, $P < .001$) with the actual numbers of pigs weaned whereas the prediction based on rolling 12-week averages was highly correlated (0.96, $P < .0001$). These results indicate that seasonal changes that occurred from year to year were not as important as temporal trends that occurred on the farms.

The spreadsheet was used in five herds to predict the number of pigs weaned per week. For each month, the spreadsheet produces a graph that illustrates the predicted numbers of pigs weaned for that month of sow breedings (Figures 1–3). Figure 1 shows the expected numbers of pigs weaned from the numbers of sows that were bred in February for one producer. Beginning the week of July 22, we know the actual number of pigs that were weaned each week. For this farm, the February predictions are consistently higher than the actual average number of pigs weaned. This results when the productivity in the preceding 12-week period was better than the productivity in the month of interest. In March, the predicted number of pigs weaned per week closely approximates the actual numbers of pigs weaned (Figure 2). In April, the predictions are lower than the actual number of pigs weaned because the productivity was increasing (Figure 3). Because the predictions are based on 12-week rolling averages, herds that have very inconsistent production will also have poorer predictions. These monthly graphs can be used to predict trends in the expected numbers of pigs weaned from the recorded numbers of breedings in a given month. If the productivity is expected to exceed the space in the grower/finisher barn, the best management tool may be to sell feeder pigs or arrange for additional housing in either an outdoor situation or in a contract finishing barn.

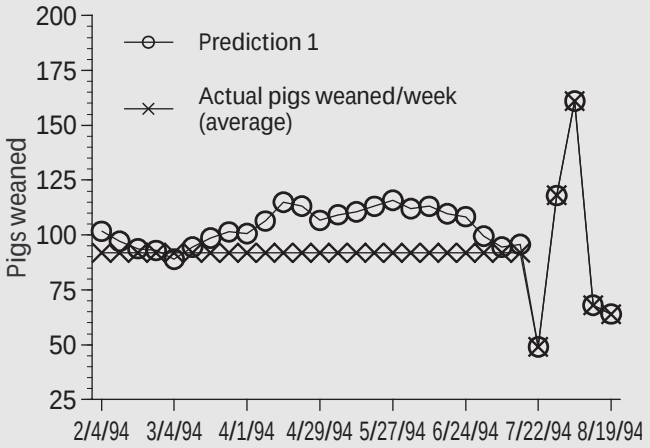
Variation

Methods

To determine which factors explained most of the variation or fluctuation in the number of pigs weaned per week, we selected 50 herds for analysis. The herds represented a convenience sample, produced by contacting veterinarians and asking for the names of producers with PigCHAMP® records.[11] From the records received, we selected herds that had data for the last 3 months of 1993, and all of 1994.

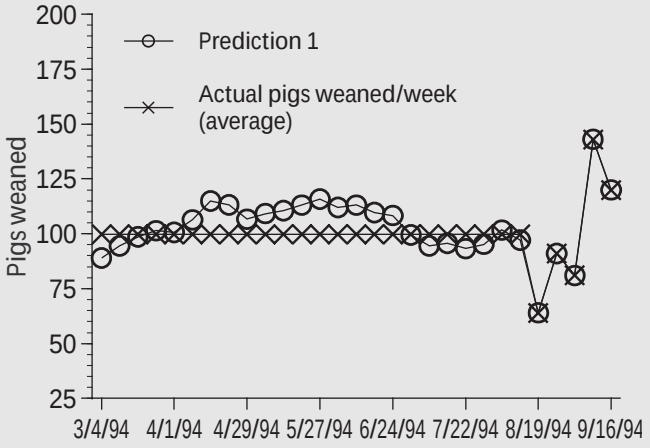
We screened 56 herds before we found 50 herds with useful data. Five herds had corrupt data that couldn't be read by our computers. The remaining 51 selected herds were then screened for data that were incompatible with normal biological ranges. One more herd was then excluded because 6.6% of its data was outside the given ranges (123 of 1873 observations). The number of excluded observations in the other herds ranged from 0–19 (19 of 4573), with the majority of herds

Figure 1



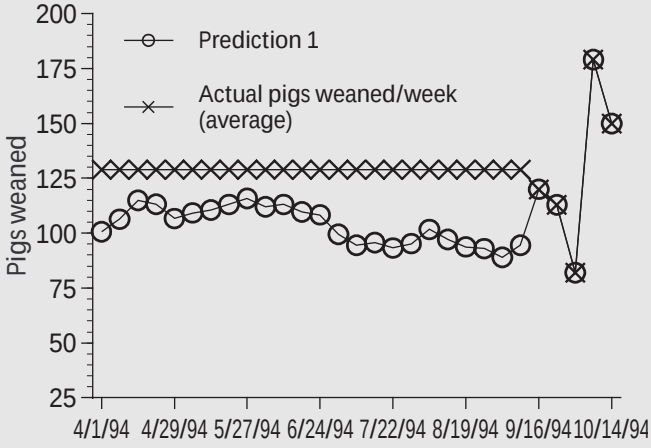
Predicted and actual numbers of pigs weaned based on February's breedings

Figure 2



Predicted and actual numbers of pigs weaned based on March's breedings

Figure 3



Predicted and actual numbers of pigs weaned based on April's breedings

losing one observation in the process.

Those data were then exported from PigCHAMP® as an ASCII file, and imported into PC/SAS.[12] Variables exported for each observation included:

- farm of origin,
- sow identification number,
- the date of each service,
- the parity and service number,
- the farrow date,
- the number of pigs born alive,
- the number of pigs weaned,
- the number of pigs that died, and
- the date of weaning.

We calculated expected wean dates for each sow service, using the formula:

expected wean date =
service date + 115 days gestation +
herd average lactation length

The average lactation length was determined using a 1-year Performance Monitor report in PigCHAMP®, and assigned on a per-herd basis. We further categorized the observations by the weeks of actual weaning and expected weaning, with week 1 beginning on January 6, 1994 and week 51 ending on December 28, 1994. Observations outside this date range were deleted. Data were then screened for anomalies in the numbers of pigs born alive, numbers of pigs weaned, numbers of services, and the parity and was omitted when these parameters were biologically incompatible with normal ranges. Observations were deleted if the time between service and weaning was < 100 days, or > 120 days plus three times the average lactation length for a given herd.

We were interested in the impact four factors had on the total number of pigs weaned in a given week:

- the number of sows mated,
- the farrowing rate,
- the number of pigs born alive, and
- the preweaning mortality rate.

For each farm, values for each factor were assigned on a per week basis, where:

number of sows mated =
number of services per expected wean week

farrowing rate =
number of farrowings per expected wean week ÷
number of services per expected wean week

number of pigs born alive =
number of pigs born alive per actual wean week

preweaning mortality rate =
number of pigs that died per actual wean week ÷
number of pigs born alive per actual wean week

The data from the 50 herds were used to model the relationship

between these factors and the number of pigs weaned per week. The number of pigs weaned per week was regressed on the number of sows served, the farrowing rate, the weekly average pigs born alive, and preweaning mortality using multiple linear regression using PC/SAS.[12] The partial R^2 value for each variable in the model was determined using PROC REG in PC/SAS with the forward stepwise option. This value represents the percent of variation in the pigs weaned per week explained by each component factor after controlling for the other factors that are in the model.

Results

The 50 herds contained 64,060 observations. The mean herd size for this data set was 421.5 sows and the median was 507 sows. The average lactation length was 21.8 ±2.5 (SD) days, the average number of pigs born alive was 10.5 ±2.9, the median parity was 2.5 and the average parity was 2.5 ±2.3, and the average number of services per parity was 1.1 ±0.4. The calculated farrowing rate for all 64,060 observations was 70.7% (Table 1). The mean number of services per week, per herd was 20.5 ±14.2 (SD). The weekly average farrowing rate was 71.7% ±16.4. The average number of pigs born per litter was 10.4 ±1.3. Mean preweaning mortality was 10.5% ±7.0. The mean number of pigs weaned was 144.7 ±97.4.

All of the component variables were significantly associated with the number of pigs weaned per week ($P < .05$) and together accounted for 65.2% of the variation in the number of pigs weaned per week. However, the number of sows served per week explained 62.3% of this variation. Farrowing rate, litter size, and preweaning mortality each accounted for less than 3% of the variation in the number of pigs weaned per week (Table 2). The component variables did not explain 100% of the variation in pigs weaned per week because the model was based on the herd's average gestation and lactation lengths. Based on these averages, we predicted the week in which each sow would be weaned. In practice, producers wean sows according to the availability of space in the farrowing and nursery barns, and the size and condition of the sows and the piglets. The importance of this model was not to explain 100% of the variation in pigs weaned per week but to identify the most important variable to control.

Table 1

Values for component factors of the total number of pigs weaned per week per farm in 50 North American farms, 1994

Variable	Number of observations*	Mean	Standard deviation	95% confidence interval	Maximum value	Third quartile	Median	First quartile	Minimum value
Total pigs weaned	2355	144.71	97.41	140.71 148.71	720	188	124	78	0
Number of sows served per week	2470	20.45	14.16	19.93 21.07	105	26	17	11	1
Farrowing rate	2470	71.68	16.37	70.35 72.00	100	82.14	73.33	63.16	0
Litter size	2355	10.44	1.27	10.38 10.45	16	11.14	10.50	9.78	0
Mean preweaning mortality	2351	10.46	7.01	10.16 10.74	100	13.12	9.33	6.32	–13.33†

* Not all farms had observations for every week

† On a per-week basis, preweaning mortality can be negative if pigs are cross-fostered and then indentified with the foster sow

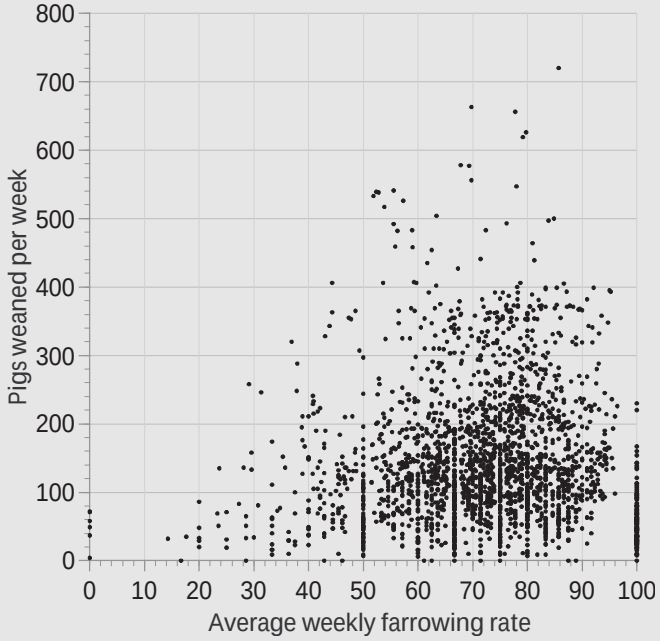
Table 2

Variation explained by each of the component factors of the number of pigs weaned per farm per week

Source	Parameter estimate	Probability	Coefficient of determination
Intercept	–98.40	0.0001	
Number of sows served	5.55	0.0001	0.62
Farrowing rate	0.97	0.0001	0.02
Litter size	6.59	0.0001	0.006
Preweaning mortality	–1.09	0.0001	0.006

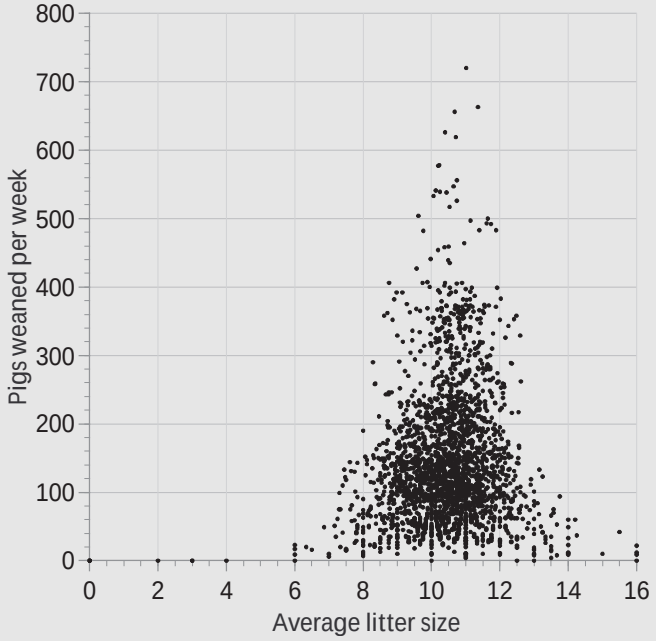
Total number of pigs weaned per farm per week =
–98.40 + 5.55 (frequency of services) + 0.97 (farrowing rate) + 6.59 (litter size) – 1.09 (mean preweaning mortality)
The coefficient of determination (partial r^2) represents the percent of variation in the pigs weaned per week explained by each component factor after controlling for other factors in the model.

Figure 4



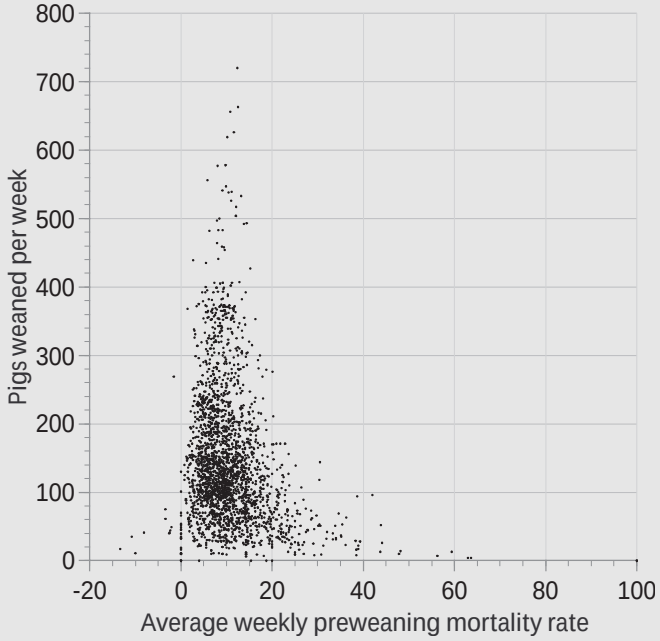
Relationship between the average farrowing rate and the number of pigs weaned per week

Figure 5



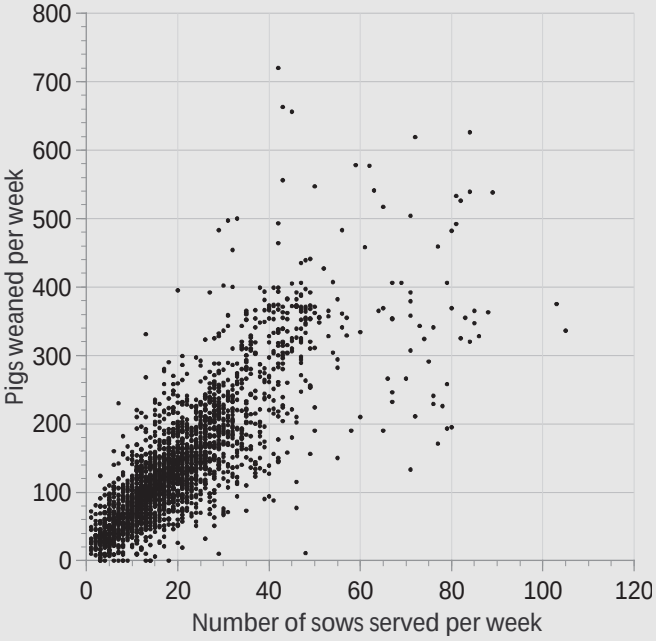
Relationship between the average number of pigs born alive and the number of pigs weaned per week

Figure 6



Relationship between the average number of pigs born alive and the number of pigs weaned per week

Figure 7



Relationship between the number of sows served per week and the number of pigs weaned per week

Figures 4 through 7 plot the relationship between each component part of the pigs-weaned-per-week parameter and the actual number of pigs weaned per week. These component parts include:

- the number of sows served,
- the farrowing rate,
- the liveborn litter size, and
- the preweaning mortality.

These figures can be used on an individual-herd basis to determine

which one parameter explains most of the variation in the numbers of pigs weaned per week. The numbers of pigs weaned per week decreased as the weekly farrowing rate decreased, and increased as the average numbers of pigs born alive increased (Figures 4 and 5). There was not a close association between the average numbers of pigs born alive and an increase in the survivability of pigs (Figure 6). The variable with the closest relationship to the number of pigs weaned per week was the number of sows served per week (Figure 7).

Discussion

A change in the number of sows served should have a far greater impact than any equivalent change in farrowing rate, litter size, or preweaning mortality. If a producer has reached capacity in terms of the number of pigs being farrowed or weaned, then s/he will want to make this level of production as constant over time as possible. With inconsistent production, there will be times when pigs are overcrowded or, conversely, when space is underutilized. Research shows that the producer is in a less profitable position if either of these occurs. Brent,[1] Luce,[2] and Waddell[3] found that consistent understocking can quickly result in significant revenue losses or, as Waddell termed them, "profitability leaks." This is particularly the case when building costs increase; optimal use of space then becomes more of a critical factor in determining financial success.[5]

Low levels of variation throughout the production process can be most easily achieved by focusing on the number of sows served. Consistency in terms of the number of sows served will pay off in terms of even pig flow, and optimal profitability on a continual basis. We recommend that producers determine a maximum number of females to serve per week and to not exceed that number. Similarly, producers need to establish a consistent gilt pool to ensure that the numbers of services per week never go below a predetermined minimum number.

Implications

- The number of pigs weaned per week can be predicted based on 12-week rolling averages of the average number of pigs born alive, the preweaning survivability of piglets, the farrowing rate, and a 3-week rolling average of the number of sows served per week.
- It is possible to predict the number of pigs weaned per week as soon as the numbers of sows served during a 3-week period is known.
- The number of sows served per week explained 62% of the variation in pigs weaned per week.
- Producers must control the numbers of sows served per week to control the flow of pigs from the farrowing room to the rest of the system.

Acknowledgements

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