Study and field evaluation of an artificial intelligence system's ability to predict the good moment to breed sows: PigWatch® from Ro-Main

J. Labrecque[1], B. Eng.; J. Rivest[1], PhD; C. Klopfenstein[2], PhD, DVM
[1]Conception Ro-Main inc., St-Lambert-de-Lauzon, Quebec, Canada;
[2]Centre de développement du porc du Québec inc. (CDPQ), Quebec City, Quebec, Canada

Introduction

In order to have optimal reproductive performances, sow insemination has to happen within a relatively short time in the sow's estrus period. Studies have shown that the ideal time is approximately in the twenty-four hours before ovulation.[1-4] For the producer this ideal time is entirely theoretical because of the high level of difficulty to monitor the ovulation. What we do know is that ovulation occurs consistently around the two thirds through the estrus[5] and that the estrus period is characterized by distinctive symptoms such as responsiveness to boar exposure. The estrous usually lasts between 40 and 60 hours but it can be as short as 24 hours, or even extend up to 96 hours.[6] In short, it is nearly impossible for managers of farrowing operations to inseminate sows at the right moment in their estrus period.

To ensure fertilization of each sow, researchers often recommend doing two inseminations per estrus. Producers adapt these recommendations and develop various procedures that often require two and sometimes three or four inseminations per estrus period.[7] Generally, a first insemination is performed at the first behavioral symptoms associated with estrus, followed by another insemination every following 24-hour period up to estrus cessation. This method gives good results, provided that good estrus detection has taken place. For this reason, it requires the presence of skilled employees as well as the use of multiple doses of semen.

Ro-Main's PigWatch® system is an artificial intelligence innovation which goal is to predict the best time to inseminate weaned sows, based on real-time analysis of sow behavior in their stall. Product development has been achieved mainly through measurement of sow behavior before and during estrus, the development of electronic modules, and the design of artificial intelligence algorithms to analyze behavioral data and predict the best time for insemination. PigWatch® 2016 thus aims to inseminate each sow only once and at the best moment relative to ovulation.

The following sections present the results of a joint study made by the Centre de développement du porc du Québec inc. (CDPQ) and Conception Ro-Main inc. that aimed to assess the reliability of the PigWatch® (2016 Beta) system's insemination planning recommendations. Recent field results from commercial farms equipped with the PigWatch® 2016 system will also be presented and discussed.

Description of PigWatch® 2016

PigWatch® 2016 is a computerized AI management system designed to predict the best time to inseminate recently weaned sows. The PigWatch® 2016 system consists of motion sensors installed on top of every weaned sow's stall, plus a data analysis module and a computer software to interface with the producer. Figure 1 shows the architecture of the PigWatch® 2016 system and Figure 2 shows an actual PigWatch device in the farm.

The motion sensors allow constant and non-intrusive monitoring of sow behavior by assessing its real-time level of activity. The monitoring unit including the sensors is installed directly above each sow. A display system consists of LED's that indicate the sow's heat status, if it has already been inseminated, and whether to do the AI at that precise moment or not. The data analysis module is a computer that analyses the real-time behavioral data of each sow. It contains the artificial intelligence algorithm that is at the heart of the system and that performs complex calculations to determine the best time to do the insemination. The PigWatch® 2016 software provides a user interface that shows the information as graphs detailing the progression of each sow during estrus and as reports with the list of sows to be inseminated. Figure 3 shows an example of a PigWatch® 2016 behavioral graph in which the best moment to breed is indicated as a vertical line at 7:00 on November 11th.

The PigWatch® 2016 algorithm was optimized to predict the ideal time for insemination of sows, while taking into account the presence of farm workers in the barn. The aim of the system is to predict a single best time to inseminate each sow. Even so, very few operations employ farm workers around the clock during insemination periods. For this reason, at the end of each day, just before the farm staff leave the premises, PigWatch® 2016 tries to predict which sows should be inseminated in anticipation of having their optimal insemination time during the night. The next morning, the system evaluates the need to repeat the insemination if it judges that optimal insemination time did not occur overnight, as expected. Consequently, some sows will have two PigWatch® AI requests and be inseminated twice.

Figure 1: PigWatch® 2016 system architecture

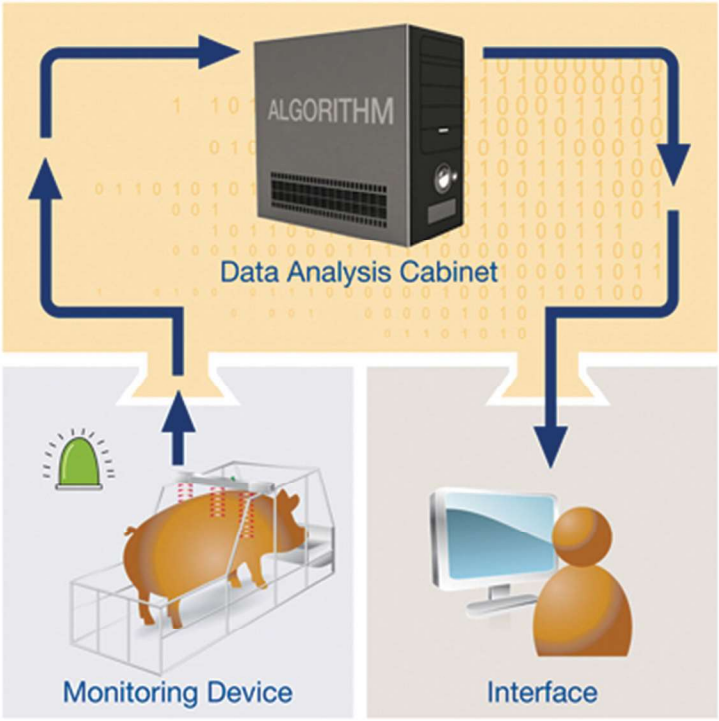


Figure 2: PigWatch® device above sow stall

Study

Materials and methods

This study was conducted from September 2014 to March 2015. The project was carried out in a commercial breeding-gestation-farrowing facility, with a holding capacity of 1,600 sows (Genetiporc, Landrace × Large White), at Ferme A.G & R. Labrecque inc. in St-Bernard-de-Beauce, Quebec. This facility operates in four-week batches and weans piglets over three days (Wednesday, Thursday and Friday).

For each batch involved in the project, 39 of the 90 sows weaned on Wednesday morning were randomly selected and routed into the gestation room assigned to the project. Of the 39 selected sows in every batch, between 20 and 30 were chosen so that the necessary human interventions in the room were limited to one hour in the morning and one hour in the afternoon. Since the PigWatch® system monitors the natural behavior of the sow, it is advisable to avoid disturbing the sows as much as possible so that PigWatch® can analyze noise-free data.

Blood samples were taken from all eligible sows selected for the project (20 to 30 sows per batch) with the aim of establishing time of ovulation for each sow by analysis of the serum hormones, progesterone and estradiol.

The authors hypothesized a priori that the PigWatch® system issues a request for insemination before ovulation and that these requests are based on the analysis of sow behavior. Therefore, by sampling blood at the PigWatch® insemination request, it would be possible to confirm the decrease in serum estradiol and detect the increase in serum progesterone, the indicator retained to identify time of ovulation. To obtain sufficient data to estimate the time of ovulation from the serum levels of both estradiol and progesterone but to limit the disturbance to the sows, a minimum of five blood samples per sow were taken over a 48-hour period, at a rate of two blood samples per day.

Sows were fed twice daily on a fixed schedule (5:30 am and 2:00 pm) and farm workers minimized their daily activities in the room to reduce interference with the sows as prescribed by the PigWatch® protocol. Blood sample collection began immediately after feed distribution in the morning and in the afternoon.

All inseminations were post-cervical AI with 2 billion sperm cells per dose.

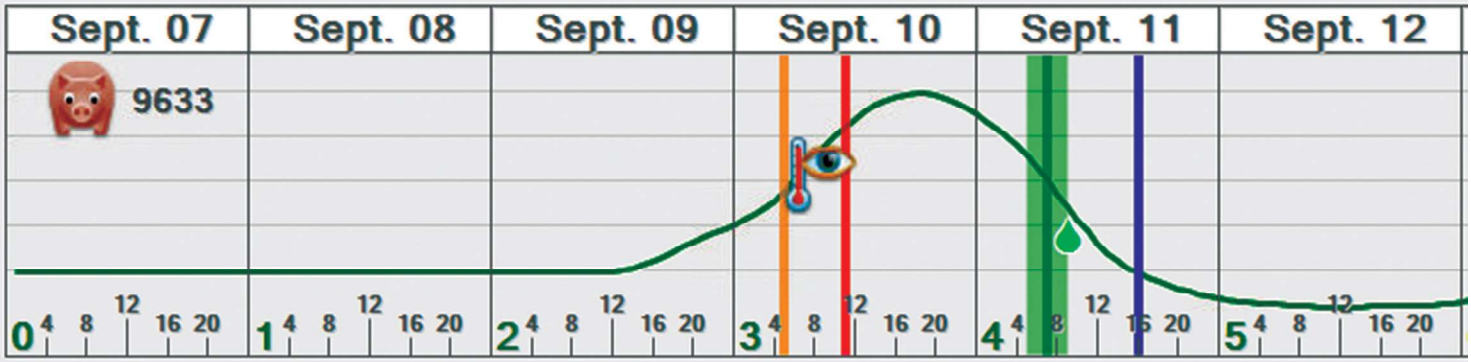
The total number of piglets born and sow fertility at 35 days served as indicators of reproductive performance. Sow fertility was assessed by transabdominal ultrasonography (diagnostic imaging) between 35 and 40 days post-insemination.

Results and discussion

122 sows were selected for analysis (20 sows in Batch 1, 22 in Batch 2, 27 in Batch 3, 23 in Batch 4, and 30 sows in Batch 5) and the time of ovulation was estimated from a statistical analysis of the temporal variation of the serum estradiol and progesterone levels. This time was chosen as the mid-point of the most likely period of ovulation as determined by the analysis.

The 122 sows were inseminated on average 1.16 times following requests from PigWatch®, and they had a 95.1% fertility rate and 15.29 piglets born per litter.

Figure 3: Example of a PigWatch® 2016 behavior graph



The sows were inseminated an average of 10.1 hours before ovulation; with a standard deviation of 10.8 hours (between 41 hours before and 11 hours after ovulation). Median is 10.65 hours before ovulation and 95% of insemination requests are between 31.5 hours before ovulation and 8 hours after. Figure 4 shows the distribution of the sows per the time interval between their PigWatch® insemination request and their ovulation time as estimated by the above-mentioned method. Time zero refers to the time of ovulation and negative time intervals mean that the PigWatch® insemination request was before the estimated ovulation time. Table 1 shows the results for mean total born piglets and gestation rates by group of eight hours.

Statistical analysis did not enable identification of any linear ($P = 0.7378$), quadratic ($P = 0.3379$), or cubic ($P = 0.1757$) relationship between gestation rate and the interval between the PigWatch® request and ovulation.

Statistical analysis identified a significant quadratic relationship ($P < 0.05$) between the number of total born and the time interval between the PigWatch® request and ovulation. This relationship indicates that the maximum number of total born is obtained when the PigWatch® request occurs 12.7 hours before ovulation.

Field evaluations

At the time of writing this paper, two 1600-sow units in Canada (Canada 1 and Canada 2) and one 200-sow unit in Belgium (Belgium) are equipped with PigWatch® 2016. The first 1600-sow unit in Canada is a 4-week batch farrowing operation installed with PigWatch® 2016 since July 2016. All the sows of this farm are not currently managed by PigWatch® 2016 because of the way the rooms are separated in the farm. The second 1600-sow unit in Canada is also a 4-week batch farrowing operation installed with PigWatch® 2016 since October 2016. The farm in Belgium is a 5-week batch farrowing operation using the complete PigWatch® 2016 method since September 2016. Table 2 shows the results of these farms with PigWatch® 2016 so far. The number of sows on PigWatch® is usually smaller at the beginning and increases over time as part of the PigWatch® integration and training process.

Canada 1 had a decrease in fertility between its first and second batch with PigWatch® 2016. Mycotoxins were identified as a potential source for many problems in the farm during that period including an abnormal number of abortions, low fertility in gilts, etc. The fertility results increased gradually after the problem occurred but the problem was still not completely controlled in November 2016.

The farm in Belgium had an average fertility rate of 86.9% in the five batches before the installation of PigWatch® 2016 (N = 259). The first fertility results with PigWatch® are encouragingly higher at 89.7%. These results were obtained with 1.6 inseminations per sow, which is higher than what is normally expected from PigWatch® 2016. This high number of inseminations can be explained by the system's difficulty to analyze the data that reflect disturbances to the sows. In fact, the PigWatch® 2016 integration technician identified a source of stress that affected several sows, thus affecting the quality of the data. That source of stress will be eliminated for the subsequent batches. This example shows the importance of strictly following the PigWatch® 2016 protocol to optimize the results.

A total of 1065 sows have been inseminated with PigWatch® 2016 in commercial farms so far with an average of 1.26 insemination per sow and the average fertility rate is 91.3%. Although no statistical analysis can be performed on these numbers because of the absence of controls, these results demonstrate that using PigWatch® in commercial setting can give good reproduction performance with fewer insemination doses per sow.

Conclusion

The results of the above-mentioned study show that the PigWatch® system makes insemination requests in a period around ovulation that is consistent with known information and is conducive to obtaining good reproduction performances. Although limited at time of writing this paper, the available commercial data tend to confirm that PigWatch® 2016 can

Figure 4: Distribution of the sows per the time interval between their PigWatch® insemination request and their ovulation time, where 0 is the estimated time of ovulation

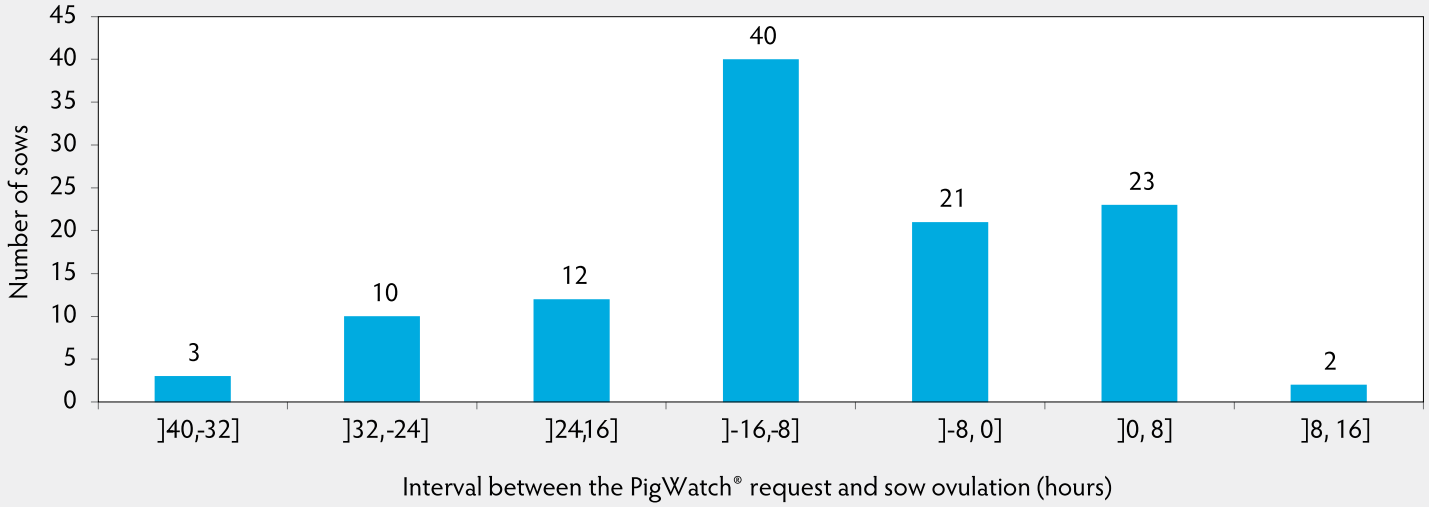


Table 1: Results for mean number of total born piglets and gestation rate by group of eight hours

Groups	Number of sows	Total born piglets	Fertility rate
]-40, -32]	2	10.50	100.0%
]-32, -24]	13	15.10	84.6%
]-24, -16]	12	15.18	100.0%
]-16, -8]	45	16.09	95.0%
]-8, 0]	22	16.24	100.0%
]0, 8]	24	13.74	95.8%
]8, 16]	3	15.50	66.7%

Table 2: Recent reproduction results of the farms equipped with PigWatch® 2016

Farm	Date	N	Dose/sow	Fertility rate	Total born piglets
Canada 1	07-2016	149	1.29	95.97%	15.37
Canada 1	08-2016	192	1.26	89.06%	N/A
Canada 1	09-2016	191	1.26	90.05%	N/A
Canada 1	10-2016	174	1.21	91.38%	N/A
Canada 1	11-2016	179	1,18	N/A	N/A
Canada 2	10-2016	141	1.26	N/A	N/A
Belgium	09-2016	39	1.62	89.7%	N/A

indeed yield good reproduction performances by targeting the good moment to breed sows. These findings indicate that it is possible to determine a good time to inseminate sows from the analysis of sow behavior with an artificial intelligence algorithm, as is done by the PigWatch®
2016 system.

Inseminating sows once at the right moment has the potential to improve the fertility rate and the number of total born piglets, while cutting nearly in half the number of insemination doses. Using less sperm cells per fertilization optimizes the use of the best boars and has the potential to increase the genetic improvement rate.

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References

1. Soede, N.M., Wetzel, C.C., Zondag, W., de Koning, M.A. and B. Kemp. 1995. Effects of time of insemination relative to ovulation, as determined by ultrasonography, on fertilization rate and accessory sperm count in sows. Journal of Reproduction and Fertility, 104(1): 99-106.

2. Nissen, A.K., Soede, N.M., Hyttel, P., Schmidt, M. and L. D'Hoore. 1997. The influence of time of insemination relative to time of ovulation on farrowing frequency and litter size in sows, as investigated by ultrasonography. Theriogenology, 47: 1571-1582.

3. Almeida, F.R.C.L., Novak, S. and G.R. Foxcroft. 2000. The time of ovulation in relation to estrus duration in gilts. Theriogenology, 53(7): 1389–1396.

4. Hughes, P.E. and G. Pope. 2001. Estimating the optimum timing of insemination in pigs. Manipulating pig production VIII: 166-172.

5. Terqui, M., Guillouet, P., Maurel , M.C. and F. Martinat-Botté. 2000. Relationship between peri-estrus progesterone levels and time of ovulation by echography in pigs and influence of the interval between ovulation and artificial insemination (AI) on litter size. Reproduction, Nutrition, Development, 40: 393-404.

6. Soede, N.M. and B. Kemp. 1997. Expression of estrus and timing of ovulation in pigs. Journal of Reproduction and Fertility. Supplement, 52: 91-103.

7. Poilvet, D. 2003. Reproduction des porcs - Inséminez vos truies au bon moment. Available at: http://porc.reussir.fr/actualites/reproduction-des-porcs-inseminez-vos-truies-au-bon-moment:22836.html. Accessed 14 November 2016.