Results & Perspectives about Automated Water Intake Recording, Infrared Thermography & Vision Systems

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The “Centre de Développement du porc du Québec” (CDPQ) is a non-profit organization with different objectives, including the development and testing of novel technologies and new methods for sustainable swine production. Some of the projects related to these objectives are carried out at the Deschambault swine testing station, a wean-to-finish facility, with a capacity of 360 pigs. Since 1994, a total of 37 trials have been performed at the station in an all-in-all-out swine production system whereas the current trial is in a continuous flow management system.

The results presented here are mainly from a project led by the Canadian Centre for Swine Improvement and funded by Swine Innovation Porc, as part of the "Swine Cluster 2: Generating Results Through Innovation" research program. This project was specifically designed to develop and test new technologies that could benefit the swine industry. Within this initiative, the CDPQ has recorded and analyzed individual water intake data during the grow-finish phase. They also worked with infrared cameras to capture individual and grouped pig images corresponding to

heat emissions at the skin surface. The CDPQ also tested different vision systems to evaluate weight and conformation, and different tracking systems to assess pig's behaviour.

Water Intake Recording

The individual water intake recording system was designed and generated by the CDPQ in 2013. A custom bowl was installed in each of the 28 pens for the grow-finish phase (30 to 130 kg). Each bowl contains a nipple activated by the pigs, a 3L bowl closed on 3 sides to reduce water waste, a water level meter for the bowl and a water meter (Figure 1). This system allows the recording of water intake from each pig's visit. A radio frequency identification system (RFID) is used for the identification of the pigs. The custom bowl makes it possible to record, for each visit, the time of day, the duration, the water intake from the nipple and from the bowl for each animal. In addition to the individual watering system described above, each pen is equipped with an IVOG® individual feeding system (Insentec, NL) that records feed intake for each visit per pig.

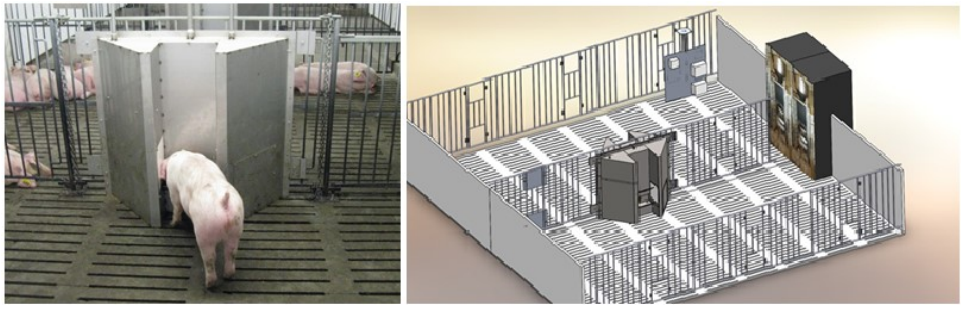

Figure 1. Individual water intake recording system

The data was recorded over two trials. The first trial included 345 pigs and was carried out during the winter, from November 2014 to February 2015, the second trial included 278 pigs and was completed during the summer, from July to October 2015. Overall, the results from 47 pens were analyzed, each pen containing 14 pigs on average.

First of all, it has been demonstrated that temperature has a significant effect on water consumption. In the winter trial, the average temperature was around 20°C, whereas for the summer trial, the average temperature was 25°C. Research has shown that when the temperature in the barn is higher than 22°C, pigs consume significantly more water, either for drinking or to be wasted. For pigs 30 to 100 kg, the water intake during winter and summer goes up from 4 to 8 liters and from 6 to 12 liters respectively, which is an increase of 50% at the end of this period. Therefore, high temperatures will interfere with the prediction of water consumption.

Also, as it is possible to determine normal water intake per pen during winter, one of the objectives of the research was to establish whether water intake variation could be associated with animal health. We then wanted to compare water intake and feed intake as accurate early indicators of the health of the animal. To achieve this, all the health treatments from each pig were used and compared with water intake and feed intake at the pen level. Then, water intake and feed intake were considered for each. Three alert levels, based on the relative decrease (%) of daily water and feed consumption compared to the previous day, were defined. These

alerts were determined at three confidence levels of 90, 95 and 99% on healthy and comfortable days. In total, there were 1,192 and 1,243 healthy and comfortable pen days, respectively, for which water and feed consumption data were available. The three alert levels were applied for the three days preceding a treatment in a pen on comfortable days. Alert confidence levels were statistically compared between healthy days and days preceding one or more treatments in a pen.

There are several decreases in water consumption that precede a large number of treatments for pigs (Figure 2). In the results obtained, we noticed that on days 67, 131 and 139 there is a high number of treatments applied to the pigs, and on the previous days we notice a drop in water and feed consumption, which could be related to treatments and diseases. They are a few days when treatments administered are not associated with a significant drop in water and feed intake (for example days 82 and 93). On day 124, there are treatments associated with a decrease in feed consumption, but not with water consumption. However, we have noted that during treatments, we generally detect a decrease in water consumption much faster than the decline in feed consumption, especially at day 131.

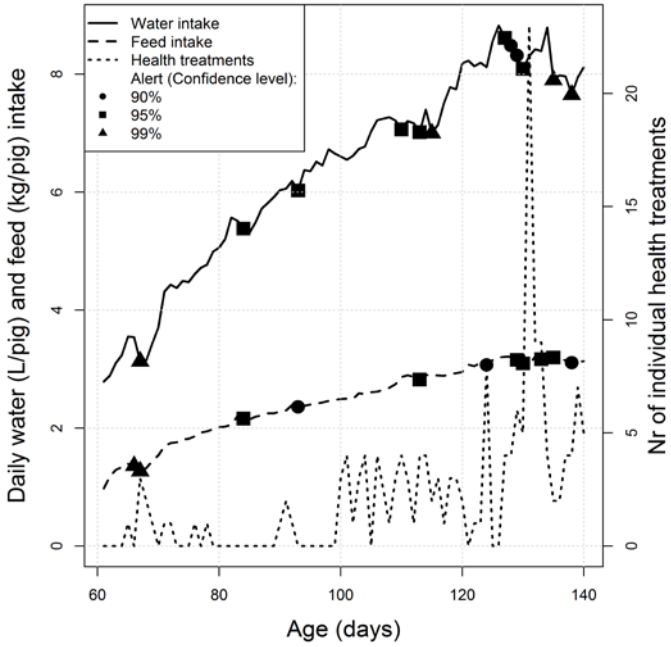

Figure 2. Water intake, feed intake and number of health treatments during the grow-finish phase

There are 7 days of treatments associated with a decrease in water/feed intake and 6 declines in consumption which are not followed by any treatment. It is possible for some of these 6 declines that no disease signs were detected by the farm worker, or there was a presence of false positives. False positives are less damaging, since if you are treating for prevention, or the producer is watching over some pens more than what is usual, when there is no disease, it's a lot less damaging than not treating an undetected sick animal.

Among the similarities between water and feed consumption, frequency of the three alerts one day before treatment are all significantly higher than the frequencies on healthy days ($P < 0.001$). Alert frequencies are from 3.5 (for level =

90%) to approximately 10 (for level = 99%) times higher one day before treatment compared to healthy days. This demonstrates a detection potential at least one day before treatment. In addition, for a confidence level of 90%, the results show a detection potential of up to two days before treatment for water and feed consumption ($P \leq 0.007$); alert levels are more than twice as frequent as on healthy days.

Therefore, as these results show, it's safe to say that swine producers could use water consumption to improve and facilitate their farming methods. Also, by installing a water meter in each pen they could easily detect abnormal consumption declines, be more sensitive to the onset of disease symptoms, perform early diagnostic tests for the identification of diseases, and be able to provide early and effective treatments.

Infrared Thermography

Infrared thermography measures heat emitted by the animals. This is a quick and non-invasive technology providing measurements that could be automated. This technology can have many applications in the swine industry, including the detection of sick animals. The infrared technology also has the potential to be a lower cost method to identify and rank animals with improved feed efficiency that could be used in a genetic selection program. A camera was installed on a rail above 3 pens in the nursery of the Deschambault test station and was set up to capture a picture every 5 minutes rotating around each individual pen (Figure 3). The piglets monitored are part of a natural disease challenge model (PigGen

Canada, 2017) and the images were captured for a period of 20 days during 13 trials. In collaboration with researchers from Alberta Agriculture and Forestry and the AAFC Lacombe Research Centre, various variables were computed from the infrared images including the highest temperature from the group of pigs of each pen. These temperatures were then compared to feed and water intake collected on the pen.

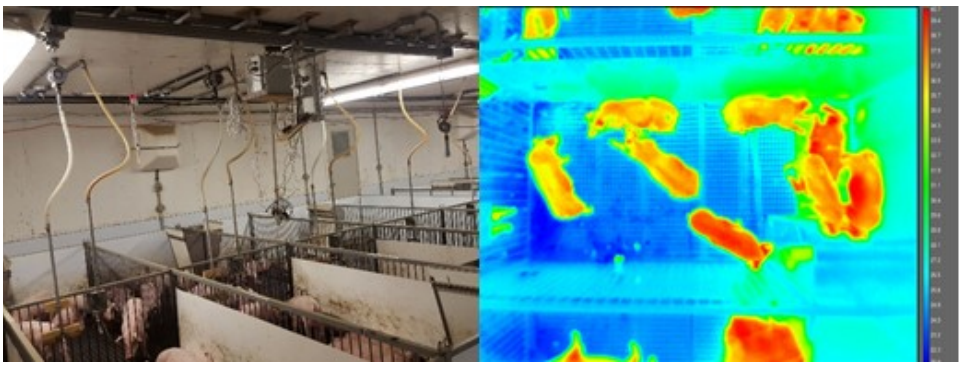

Figure 3. Infrared camera

The results from this project are still being analyzed at the time of writing this article. Some preliminary results have shown an increase in heat emissions and a decline in water and feed intake prior to the detection of symptoms and the application of health treatments.

The use of infrared thermography in commercial farms could be an indicator to producers of sick animals and the prevalence of some diseases in their barns. This was also demonstrated by Dr. Cook (2014) who treated piglets with a vaccine in order to observe pig behaviour and frequency of clustering when their body temperature increased. As this technology is non-invasive, it doesn't stress the

animals and it is aligned with improving animal welfare. However, the device used for this research is expensive (over $10,000). Therefore, there is a need to use less expensive cameras with minimum precision and to develop real-time data analysis applications.

Vision Systems

Three different devices using 2D or 3D vision systems to evaluate weight and conformation have been tested at the Deschambault test station. This technology is evolving rapidly and it could easily, one day, replace the human-eye or the weighing scale to weigh pigs prior to slaughter, or to provide new phenotypes related to the conformation of the pigs (e.g. primal cuts yield). The first equipment tested was the Optisort from Hölscher Leuschner (Emsbüren, Germany): a hog sorter with a camera located above the pigs on top of a crate. The test was done in 2013 with a 2D camera and the system has since been updated and is now equipped with a 3D camera. The second equipment was a system developed by the CDPQ using 3 Kinect cameras from Microsoft used to collect 3D pictures of pigs kept in a pen during one minute. The third device tested was the PigWei, a 2D camera that can be held in one hand to take videos of the pig. It was developed in Spain by Ymaging (Barcelona, Spain) (Figure 4).

Figure 4. Vision systems (from left to right: Optisort, Kinect and PigWei)

On a group of 72 pigs, the Optisort has shown a standard deviation of 2.85 kg for the difference between the weight at the weighting scale and the Optisort for an average weight of 95.6 kg. For the Kinect system, on a group of 42 pigs, the standard deviation was 1.9 kg for the difference between the half carcass weight at the plant and the Kinects for an average half carcass weight of 52.6 kg. As for the PigWei, at this time, the CDPQ hasn't gotten the final results.

A main benefit of the vision system technology to evaluate weight is animal welfare, as there is no animal handling (for the Pigwei and Kinect system), which could result in less stress and injuries. As information technology moves forward incredibly fast, the idea that a system working for Canadian swine in the short-term is realistic and could also facilitate the work of producers for the evaluation of live weight prior to slaughter. Also, this technology can provide more information than just weight, which could add value to using it.

Animal behaviour was assessed using a vision system commonly referred to as an Animal Tracking System instead of visual analysis from video recordings (which is time-consuming). Three different tracking systems to assess pig's behaviour have been evaluated at the Deschambault station. The first one was the Noldus system. The Noldus system works with an EthoVision XT software developed by Noldus Information Technology. It can be used in every set-up as long as the animals can be seen from above (a 90º view of the pen is required). For the trial, the system was put in a pen in the nursery section of the station. Each piglet was colour-marked with a different tape (Figure 5). Then, a 50-second video captured in the nursery was sent to Noldus Information Technology. They read the video using EthoVision XT to see if the quality was suitable and also if the individual tracking of the nine piglets was possible. This system has recorded the distance covered (cm) and the average velocity (cm/s) of the pigs.

Figure 5. Ceiling camera view for a tracking system installed in the nursery

The Quuppa system and TrendNet cameras were installed at the Deschambault station in October 2017. The Quuppa system uses the same principle as radio frequency identification (RFID) tags, but on a different radio frequency. For the installation, the CDPQ used 2 Quuppa locators which have 7 unique antennas in each device. The pigs were given ear tags, and a radio signal is transmitted by those tags to the Quuppa locators. The Quuppa locators calculate the angle of arrival, and are then able to determine an accurate position of the tag in three dimensions. This allows the determination of pig behaviour and the spots in the pen where they prefer to stay throughout the day.

The Quuppa system can cover a large perimeter meaning it could be used in large spaces on a commercial farm, if you have enough Quuppa locators. The basic Quuppa system comes with 5 locators. The ear tag system is durable and the tags survive even the pigs' destructive side. However, the Quuppa system is still expensive for commercials farms, but could be useful in the research field to evaluate pigs' behaviour and help improve animal welfare. It could also be another technology used as an early predictor of health problems given the behaviour of the pigs will be affected by diseases. Each pig is identified with a unique tag, so it is not necessary to manipulate pigs once the tags are set and activated. The results obtained from this study are still being analyzed.

The third tracking device tested at the station was 2 TrendNet cameras with a software program allowing for evaluation of the pig's behaviour without having a person analyzing those images, which takes a long time. Two cameras were

positioned over a pen, with 2 other infrared cameras, allowing for images of the pigs to be taken all day, even when the lights are off. The images are still being analyzed, and results are yet to come. This system will allow the evaluation of the pig's behaviour at the group level, not at the individual level.

We are probably only seeing the tip of the iceberg of new technologies proposed to Canadian swine producers to answer their needs. It is important to evaluate new products and to participate in development in order to inform producers about their potential applications. All these technologies are continuously improving and for many of them, it is only a matter of time before their adoption.

References

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PigGen Canada (2017) Innovating and investing in disease prevention: The development of a natural disease challenge model, https://piggencanada.org/2017/01/06/ innovating-and-investing-in-disease-prevention-the-development-of-a-natural-disease-challenge-model/ (11/16/2017)