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Sub-clinical respiratory infection identified on farms by monitoring weight changes of pigs with the Weight-Detect instrument

T. Banhazi[1,2*], M. Dunn[1], A. Banhazi[1], J. Reixach[3], A. Ramon-Perez[4], P. Llonch[4] and J. Maselyne[5]

[1]InnoTech Vision ApS., Niels Pedersens Alle 2, 8830 Tiele, Denmark
[2]Wroclaw University of Environmental and Life Sciences, ul. Chełmońskiego 38C, PL51-630 Wroclaw, Poland
[3]Selección Batallé S.A., Av. dels Segadors, s/n 17421 Riudarenes, Girona, Spain
[4]Autonomous University of Barcelona (UAB), Plaça Cívica, Campus de la UAB, ES08193 Bellaterra, Sardañola del Vallés, Catalonia, Spain
[5]ILVO, Burgemeester van Gansberghelaan 92/1, BE 9820 Merelbeke, Belgium
[*]Correspondence: thomas.banhazi@plfag.com

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Abstract. The essential task of growth rate monitoring of pigs is usually undertaken on farms using electronic scales, but new technologies are now available to continuously monitor the weight of pigs. One of these systems (Weight-Detect, WD, PLF Agritech, Brisbane, Australia) has been introduced on a commercial pig farm in Spain as part of the EU funded aWISH project to (1) assess the applicability of the technology and (2) use this information to assess the general welfare status of pigs. The WD unit was installed in early 2024 and manual weight recordings were undertaken periodically using an electronic scale to validate the WD system. In terms of absolute values, the manual measurements indicated that the WD system was able to predict the average pen weight of the pigs with 1.7% (2.0 kg) precision. More importantly, this case study demonstrated that the WD unit was able to detect weight reduction in pigs six days before the clinical signs of a respiratory disease infection were noticed. According to the WD measurements the study pigs achieved an average daily gain (ADG) of 882 g d^{-1} between the 20/03/24 and 16/04/2024. However, between the 17/4/2024 and 30/04/2024 their ADG dropped dramatically to 286 g d^{-1}. The animals were diagnosed with respiratory disease on the 22/04/24, six days after the dramatic reduction in ADG was recorded by the WD system. This period of ADG stagnation has caused an approximate 14-day delay in reaching the desired slaughter weight, (approx. 130 kg), potentially creating significant financial losses for the producer. After the 1/05/24 pigs recovered and achieved an ADG of 645 g d^{-1} until their last recorded weighing day on the 20/5/24. These results highlight the WD system's ability to alert livestock managers about impending health problems before clinical signs appear, so appropriate mitigation measures can be implemented to reduce the negative impacts on welfare and production performance.

Key words: ICT tools, image analysis, profitability, smart technologies, weight detection.

INTRODUCTION

Regular monitoring of pig growth rates is a common practice in the farming industry to ensure operational efficiency (Emmans & Kyriazakis, 1997; Banhazi, 2013). Key indicators such as Average Daily Gains (ADGs), which measure the weight increase over specific time periods, are essential for assessing growth efficiency. Thus, regular monitoring of both average pen weights (APWs) and ADGs is a crucial responsibility for farm managers (Hicks et al., 1998; Losinger, 1998; Honeyman & Kent, 2001). Traditionally, this has involved periodic and manual weight checks using electronic scales (Van der Stuyft et al., 1991; Banhazi et al., 2022c). On most farms, pigs undergo spot-check weighing just a few times during their growth phase to evaluate their performance (Korthals, 2001; Kollis et al., 2007; Banhazi et al., 2022c). However, more frequent measurements of APWs and ADGs are recommended for identifying inefficiency periods sooner (Banhazi et al., 2012). Studies indicate that occasional spot-checks can overlook short-term inefficiencies on commercial farms, which can significantly degrade overall growth efficiency if not promptly rectified (O'Connell et al., 2004; Banhazi & Black, 2009; Willis et al., 2016; Black & Banhazi, 2022).

Emerging Precision Livestock Farming (PLF) technologies present solutions for automated, continuous weight monitoring of pigs in pens, aiming to identify and mitigate inefficiency periods (Brandl & Jorgensen, 1996; Schofield et al., 1999; Wang et al., 2006; Parsons et al., 2007; Banhazi et al., 2011). These advanced PLF tools enable livestock managers to automatically gather weight data, analyse it, and make informed management decisions based on the findings (Banhazi et al., 2022b), while transforming commercial livestock production facilities into virtual research labs (Banhazi & Black, 2009). PLF AgriTech Pty Ltd. has also developed a sophisticated weight prediction technology (Weight-Detect, WD, PLF AgriTech, Brisbane, QLD) and this innovation has the potential to drastically cut production costs on pig farms (Black & Banhazi, 2013; Black et al., 2016). However, the full range of benefits from these technologies remains unclear, particularly in terms of their application for health and welfare monitoring. To explore these possibilities, a WD system has been installed on a commercial pig farm in Spain as part of the EU-funded aWISH project (HEurope grant 101060818). The project's objectives included assessing the technology's feasibility and utility for monitoring pig health and welfare. Ultimately, this study aimed to quantify the advantages of utilizing weight monitoring tools specifically and PLF technologies generally on commercial farms.

MATERIALS AND METHODS

Equipment installation on the study farm

The pen monitored was located in traditional grower-finisher building in the northern part of Spain with automatically controlled natural ventilation system installed. All experimental pigs were fed pelleted diet and were kept on fully slatted floors. After the study pen was selected, the WD equipment was installed in early 2024 at approximately 2.0 m height. Fig. 1 shows the installation location of the WD system in the study pen. Corresponding manual weighing procedures were undertaken on the farms in the same pen at varying intervals based on normal on-farm management procedures using an electronic scale (WA08, Meier-Brakenberg, Extertal, Germany). Nine pigs were housed in the study pen and the APWs were predicted daily. ADG values were calculated for a specific period by subdividing the weight gain (difference between starting and finishing weights) by the number of days of a given period. Standard farm reports were emailed to the farm manager weekly by PLF Agritech staff.

Figure 1. The WD camera installed above the resting area in the pen on a commercial farm in Spain.

Description of WD instrument

The functionality of the WD instruments has been described previously, so only a brief description will be given here (Banhazi et al., 2011, 2022b). The WD instruments utilize an off-the-shelf 3D camera (Basler ToF Camera, Ahrensburg, Germany) with a 30-fps frame rate and a maximum and minimum depth of 6 m and 0.5 m, respectively. The processing component of the WD (Fitlet 2, Compulab, Yokneam Illit) system operates via two processes: one acquires depth images (after detecting 'pig shapes'), while the other handles the processing of these images in real-time. Weight prediction is achieved by analysing and extracting features and measurements from the captured images, generating corresponding weight estimates (Banhazi & Dunn, 2016; Banhazi et al., 2022b).

Figure 2. The data processing and communication unit of the WD system before deployment.

This prediction process is conducted in real-time using the Automated Data Analysis and Management System (ADAMS), a secure database operated by PLF Agritech Pty. Ltd. (PLFAg) and maintained in the Amazon cloud. ADAMS facilitates automatic analysis of collected data and the generation of periodic reports, which is then emailed to users. The system has been patented in Australia, USA and in Europe (Banhazi & Dunn, 2016). Fig. 2 shows the data processing component of the WD system.

Data management and analysis

Automated reports were emailed to the producer in a PDF format reporting on APW and ADG information related to the study pen. In the reports and in this study, descriptive statistics have been used to generate the average, maximum, minimum values and other important parameters. The predicted and measured APWs were also compared using descriptive statistical methods in this study. As this study was an observational study (and not a classic treatment vs. control experiment), no additional statistical analysis was undertaken.

RESULTS AND DISCUSSION

The descriptive statistics associated with the dataset is displayed in Table 1. The average errors of all measurements were 2.0 kg or 1.7%. Fig. 3. illustrates the difference between APW data captured by the WD instrument and the data captured by manually operated weight scale during different growth periods between 20/03/24 and 20/05/24 on the Spanish farm. The APW data predicted by the WD instrument and corresponding manually collected data (gold standard) are shown in Fig. 4.

Table 1. Descriptive statistics of weight measurements obtained throughout the study

Measurement days (date)	27/03/2024	15/04/2024	30/04/2024	16/5/24
Max weight in pen (kg)	106.0	126.0	140.0	157.8
Min. weight in pen (kg)	75.0	98.2	104.0	112.2
Range (kg)	31.0	27.8	36.0	45.6
Measured APW (kg)	93.3	110.7	118.7	130.7
Predicted APW (kg)	94.3	111.3	115.9	127.2
difference (kg)	1.0	0.6	2.8	3.5
difference (%)	1.1	0.5	2.4	2.7

In terms of absolute values, the four (4) manual measurements indicated that the WD system was able to predict the APWs of the pigs with 1.1% (1.0 kg), 0.5% (0.6 kg), 2.4% (2.8 kg) and 2.7% (3.5 kg) precision respectively, despite the fact that range (spread) of the weight measurements within the groups were 31.0 kg, 27.8 kg, 36.0 kg and 45.6 kg, respectively. The pigs were uneven in this study pen which made weight prediction challenging as explained previously (Banhazi et al., 2022b). Despite the unfavourable experimental conditions, the WD unit performed with less than 3% error margin. However, it is recognised that generating realistic expectations about the expected precision of WD units is paramount (Artmann, 1999; Kopler et al., 2023) when communicating with end users. Many companies tend to overstate the precision and capabilities of such image-analysis based weighing systems, which can lead the development of unrealistic expectation in end-users. It is important to clearly communicate the reasons for any imprecision to users. Factors such as the timing of urine and faecal release, as well as feed and water intake, can cause fluctuations in body weight, making certain differences in weight acceptable and indeed expected (Liu et al., 2023). This study also demonstrated a clear correlation between increased error margin of weight prediction and increased spread of pigs' weights within the pen (Fig. 3). As the weight difference in the study pen increased (as a natural consequence of aging of pigs), the error margin associated with weight prediction also increased. This relationship was equally strong ($R^2 = 0.84$) when considering the percentage of error (%) or the relationship between the range (of pig weights in the pen) and absolute predictive error (in kgs) of the WD system was quite strong ($R^2 = 0.89$).

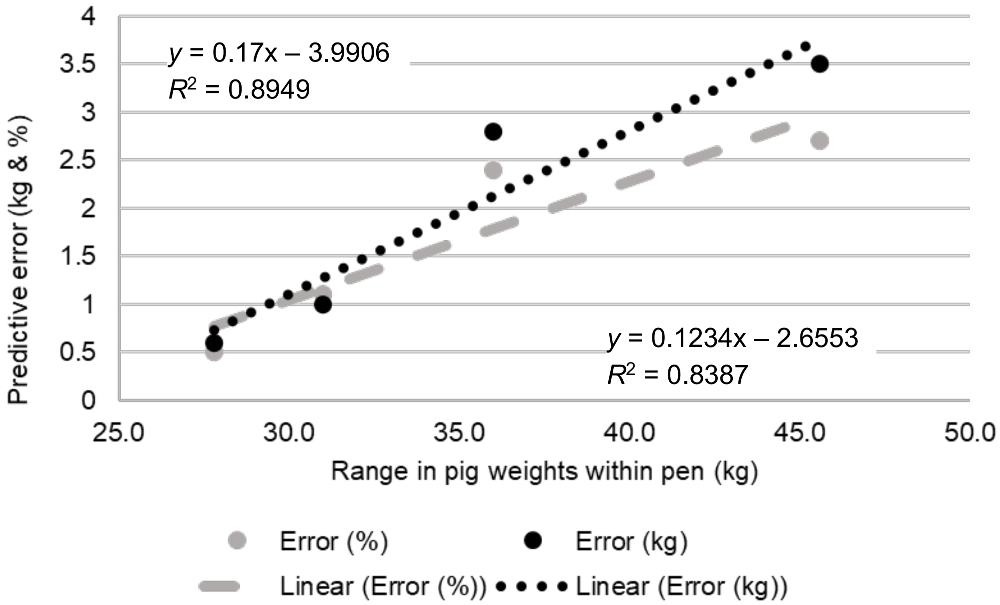

Figure 3. Correlation between increased spread of pig weights (kg) in the pen and increased error margin (as expressed in kg and as percentage).

Various factors, including animal behaviour, camera positioning, and farm management practices, can heavily influence the accuracy of weight monitoring systems. Animal behaviour is particularly important since accurate predictions depend on the even sampling of animals within the pen. When the system captures more images of smaller or larger pigs disproportionately, it can distort the predicted APWs (Lind et al., 2005; Tscharke & Banhazi, 2013a; Tscharke & Banhazi, 2013b). Thus, proper camera placement is crucial to ensure that the visual sampling of pigs is representative and even. Earlier studies often assumed that even sampling would naturally occur within pig pens (Schofield, 1990). However, it has since become clear that that this is not necessarily the case and strategic camera placement is vital for precise weight estimations (Banhazi et al., 2022b).

More importantly, this case study demonstrated that the WD unit was able to detect weight reduction in pigs six days before the clinical signs of a respiratory disease infection were noticed (Fig. 4). According to the WD measurements the study pigs achieved an ADG of 882 g d^{-1} between the 20/03/24 and 16/04/2024 (Table 2). However, between the 17/4/2024 and 30/04/2024 their ADG plummeted to just 286 g d^{-1}. This translated into a 596 g d^{-1} ADG decrease compared to the previous period. The animals were diagnosed with respiratory disease on the 22/04/24, six days after the dramatic reduction in ADG was recorded by the WD system (Fig. 4).

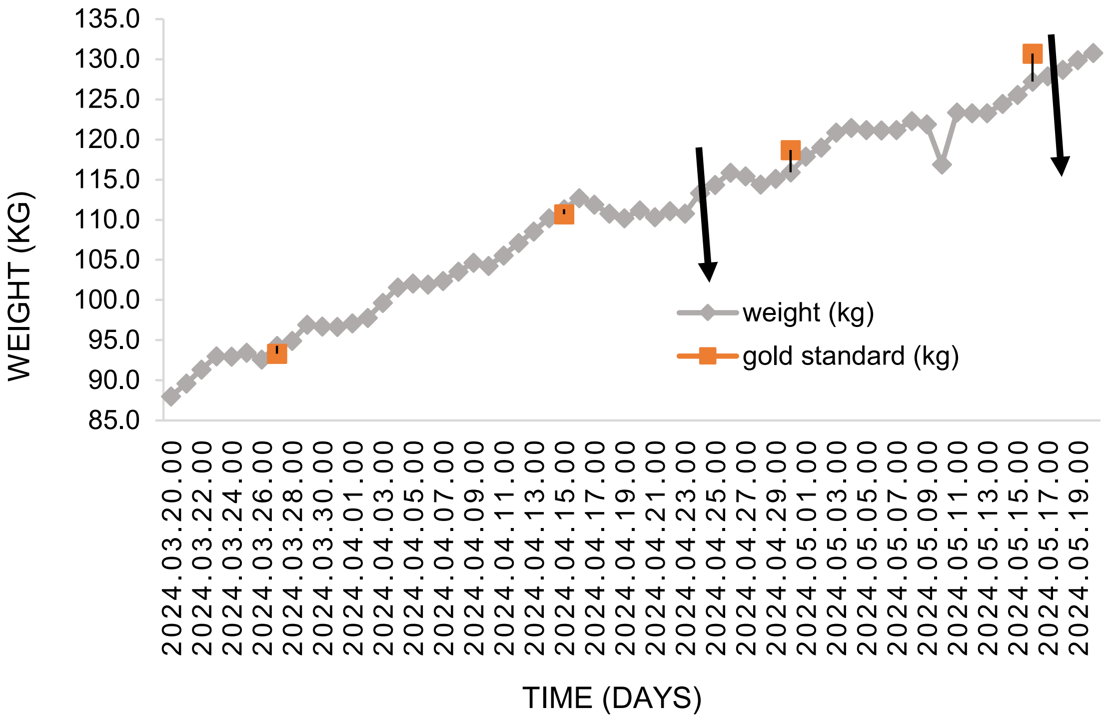

Figure 4. The growth curve observed by the WD system in the study pen. (The arrows indicate the beginning and end of the weight reduction period associated with the respiratory infection. The red dots indicate the manual (gold standard) measurements.).

The typical clinical signs of respiratory infections include reduced feed intake, reluctance to move, coughing, laboured breeding and general respiratory distress. This period of ADG stagnation (when pigs gained only 4.0 kg during that time and actually lost weight between days) led to an approximate 14-day delay in reaching the target slaughter weight, (approx. 130 kg) potentially creating significant financial losses for the producer (Fig. 5). After the 1/05/24 pigs recovered and increased their ADG to 645 g d^{-1} (359 g d^{-1} ADG increase compared to the previous period) until their final weighing day on the 20/5/24. The pigs were subsequently slaughtered on the 21/5/24 achieving an overall ADG of 690 g d^{-1} throughout their growth period (Table 2).

Table 2. ADG measurements obtained throughout the study

Measurement period (dates)	Weight gained (kg)	ADG (g d^{-1})	ADG change (g d^{-1})	Comments
20/03/24–16/04/24	24.7	882		Very good initial ADG
17/04/24–30/04/24	4.0	286	596 decrease	ADG stagnation due to respiratory infection
1/05/24–20/5/24	12.9	645	359 increase	ADG increase due to treatment/recovery
20/03/24–20/5/24	42.8	690		Overall performance of the batch

The primary advantage of weight monitoring systems is their ability to map the growth curve, enabling producers to pinpoint periods of inefficiency and tackle recurring health, nutritional and management problems (Fig. 4). When producers leverage this data to address issues around suboptimal ADGs, the return on investment can be substantial. In this study, the specific economic benefit of the weight estimation was highlighted by the WD instrument's ability to provide an early warning about an impending respiratory disease (Fig. 4).

Previous on-farm experiences demonstrated that regular automated weight monitoring can alert livestock managers about various additional management problems, including housing and general management related issues. (Banhazi et al., 2022a). For example, had the disease been avoided on the Spanish study farm and the pigs maintained their ADG of 882 g d^{-1}, they would have reached the target slaughter weight of 130 kg approximately 14 days sooner (Fig. 5). This could have resulted in considerable cost savings for the producer.

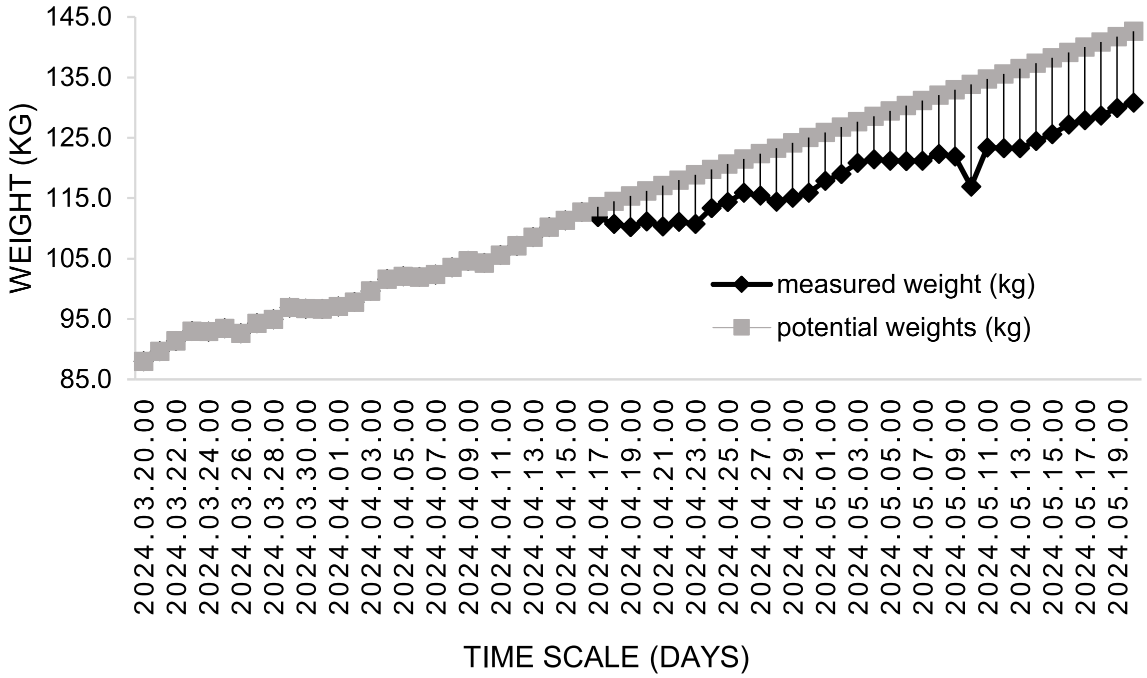

Figure 5. Observed vs. potential growth curves of the pigs in the study pen. The blue line indicates the actual growth curve, while the orange line indicates the potential growth curve, assuming that the initial ADG performance is maintained throughout the growth period.

Farm management practices are crucial in determining the accuracy of weight monitoring systems. For optimal precision, the monitoring team needs to be regularly informed about any changes in farm management, including activities in or around the monitored pen. Such disturbances within livestock buildings can alter animal behaviour, disrupting sampling rates and/or distribution and consequently impacting on weight estimations (Korthals, 2001; Doeschl-Wilson et al., 2005). For instance, during this monitoring period, maintenance work conducted adjacent to the study pen on 10/05/24, caused a brief but noticeable dip in recorded weights. Therefore, any sudden fluctuations in weight should be interpreted in light of these management changes or environmental alterations affecting the animals.

While the reliability of internet connections is usually a problem on many farms, on this particular farm, the internet connection was stable and reliable resulting in a steady data flow.

CONCLUSIONS

These findings highlight the WD system's potential to alert livestock managers to health issues before clinical symptoms manifest. This early detection allows for the timely implementation of mitigation strategies, reducing the adverse effects of diseases on animal welfare and production efficiency. Although the WD instrument has proven dependable in collecting farm data, it's crucial to account for other influencing factors such as camera placement, farm management practices, and animal behaviour. Nonetheless, this case study illustrates that integrating smart technologies into commercial farming can significantly elevate farm management practices and enhance overall profitability.

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REFERENCES

Artmann, R. 1999. Electronic identification systems: state of the art and their further development. *Computers and Electronics in Agriculture* **24**(1–2), 5–26.

Banhazi, T. 2013. Environmental and management effects associated with improved production efficiency in a respiratory disease free pig herd in Australia. *Livestock housing: Modern management to ensure optimal health and welfare of farm animals*, 49–56.

Banhazi, T.M. & Black, J.L. 2009. Precision livestock farming: a suite of electronic systems to ensure the application of best practice management on livestock farms. *Australian Journal of Multi-disciplinary Engineering* **7**(1), 1–14.

Banhazi, T. & Dunn, M. 2016. Image analysis for making animal measurements including 3-D image analysis. US Patent 9,311,556.

Banhazi, T., Dunn, M. & Banhazi, A. 2022a. Case study: is growth curve monitoring a useful tool for identifying production efficiency problems on commercial livestock farms? In *10th European Conference on Precision Livestock Farming* **1**, 963–970 (Eds Berckmans, D., Oczak, M., Iwersen, M. & Wagener, K.). Vienna, Austria: University of Veterinary Medicine.

Banhazi, T.M., Dunn, M. & Banhazi, A. 2022b. Weight-Detect™: on-farm evaluation of the precision of image analysis based weight prediction system. In *Practical Precision Livestock Farming: Hands-on experiences with PLF technologies in commercial and R&D settings* **1**, 94–107, (Eds Banhazi, T.M., Halas, V. & Maroto-Molina, F.). Amsterdam, The Netherlands Wageningen Academic Publishers.

Banhazi, T.M., Dunn, M. & Banhazi, A. 2022c.Weight and environment monitoring: growth curve differences of fast and slow growing pigs under commercial farm conditions. In *Practical Precision Livestock Farming: Hands-on experiences with PLF technologies in commercial and R&D settings* **1**, 59–77, (Eds Banhazi, T.M., Halas, V. & Maroto-Molina, F.). Amsterdam, The Netherlands Wageningen Academic Publishers.

Banhazi, T.M., Lehr, H., Black, J., Crabtree, H., Schofield, P., Tscharke, M. & Berckmans, D. 2012. Precision livestock farming: an international review of scientific and commercial aspects. *International Journal of Agricultural and Biological Engineering* **5**(3), 1–9.

Banhazi, T., Tscharke, M., Ferdous, W., Saunders, C. & Lee, S. 2011. Improved image analysis based system to reliably predict the live weight of pigs on farm: Preliminary results. *Australian Journal of Multi-disciplinary Engineering* **8**(2), 107–119.

Black, J.L. & Banhazi, T.M. 2013. Economic and social advantages of Precision Livestock Farming in the pig industry. In *6th European Conference on Precision Livestock Farming* **1**, 199–208, (Eds Berckmans, D. & Vandermeulen, J.). Leuven, Belgium: Catholic University of Leuven.

Black, J.L. & Banhazi, T.M. 2022. Integrated biological-economic simulation models to aid real-time application of precision livestock farming to the pig industry. In *Practical Precision Livestock Farming: Hands-on experiences with PLF technologies in commercial and R&D settings* **1**, 45–52, (Eds Banhazi, T.M., Halas, V. &Maroto-Molina, F.). The Netherlands Wageningen Academic Publishers.

Black, J., Willis, S. & Banhazi, T. 2016. Estimation of Accuracy Needed for Live Weight and Feed Intake Measurements in Precision Livestock Farming Systems Using Auspig Simulation Software. In *Asian Conference on Precision Livestock Farming (PLF-Asia 2016)*, Vol. 1, 38–44 (Eds Zhang, G., Zhao, L., Wang, C., Zheng,W., Tong, Q., Berckmans, D. & Wang, K.). Beijing, China: China Agricultural University.

Brandl, N. & Jorgensen, E. 1996. Determination of live weight of pigs from dimensions measured using image analysis. *Computers and Electronics in Agriculture* **15**(1), 57–72.

Doeschl-Wilson, A.B., Green, D.M., Fisher, A.V., Carroll, S.M., Schofield, C.P. & Whittemore, C.T. 2005. The relationship between body dimensions of living pigs and their carcass composition. *Meat Science* **70**(2), 229–240.

Emmans, G.C. & Kyriazakis, I. 1997. Models of pig growth: problems and proposed solutions. *Livestock Production Science* **51**(1), 119–129.

Hicks, T.A., McGlone, J.J., Whisnant, C.S., Kattesh, H.G. & Norman, R.L. 1998. Behavioral, endocrine, immune and performance measures for pigs exposed to acute stress. *Journal of animal science* **76**(2), 474–483.

Honeyman, M.S. & Kent, D. 2001. Performance of a Swedish Deep-Bedded Feeder Pig Production System in Iowa. *American Journal of Alternative Agriculture* **16**(2), 50–56.

Kollis, K., Phang, C.S., Banhazi, T.M. & Searle, S.J. 2007. Weight estimation using image analysis and statistical modelling: a preliminary study. *Applied Engineering in Agriculture* **23**(1), 91–96.

Kopler, I., Marchaim, U., Tikasz, I., Opaliński, S., Kokin, E., Mallinger, K., Neubauer, T., Gunnarsson, S., Soerensen, C., Phillips, C. & Banhazi, T. 2023. Farmers' Perspectives of the Benefits and Risks in Precision Livestock Farming in the EU Pig and Poultry Sectors. *Animals* **Animals** (**13**), 2868.

Korthals, R.L. 2001.Monitoring Growth and Statistical Variation of Grow-Finish Swine. In *Livestock Environment VI. Proceedings of the Sixth International Symposium*, 64–71 (Eds Stowell, R.R., Bucklin, R. & Bottcher, R.W.). Louisville, Kentucky: The Society for engineering in agricultural, food, and biological systems.

Lind, N.M., Vinther, M., Hemmingsen, R.P. & Hansen, A.K. 2005. Validation of a digital video tracking system for recording pig locomotor behaviour. *Journal of Neuroscience Methods* **143**(2), 123–132.

Liu, Z., Zhang, X., Ji, B., Banhazi, T., Li, C. & Zhao, S. 2023. Analysis of diurnal variations in body weight of wean-to-finish pigs. *Biosystems Engineering* **228**, 80–87.
Losinger, W.C. 1998. Feed-conversion ratio of finisher pigs in the USA. *Preventive Veterinary Medicine* **36**(4), 287–305.
O'Connell, N.E., Beattie, V.E. & Weatherup, R.N. 2004. Influence of group size during the post-weaning period on the performance and behaviour of pigs. *Livestock Production Science* **86**(1–3), 225–232.
Parsons, D.J., Green, D.M., Schofield, C.P. & Whittemore, C.T. 2007. Real-time Control of Pig Growth through an Integrated Management System. *Biosystems Engineering* **96**(2), 257–266.
Schofield, C.P. 1990. Evaluation of image analysis as a means of estimating the weight of pigs. *Journal of Agricultural Engineering Research* **47**, 287–296.
Schofield, C.P., Marchant, J.A., White, R.P., Brandl, N. & Wilson, M. 1999. Monitoring Pig Growth using a Prototype Imaging System. *Journal of Agricultural Engineering Research* **72**(**3**), 205–210.
Tscharke, M. & Banhazi, T. 2013a. Determining the growth of pigs in commercial facilities using machine vision: On-farm and offline results. *Australian Journal of Multi-disciplinary Engineering* **10**(1), 26–40.
Tscharke, M. & Banhazi, T. 2013b. Growth recorded automatically and continuously by a machine vision system for finisher pigs. *Australian Journal of Multi-disciplinary Engineering* **10**(1), 70–80.
Van der Stuyft, E., Schofield, C.P., Randall, J.M., Wambacq, P. & Goedseels, V. 1991. Development and application of computer vision systems for use in livestock production. *Computers and Electronics in Agriculture* **6**, 243–265.
Wang, Y., Yang, W., Winter, P. & Walker, L.T. 2006. Non-contact sensing of hog weights by machine vision. *Applied Engineering in Agriculture* **22**(4), 577–582.
Willis, S., Black, J.L. & Banhazi, T.M. 2016. Estimation of production losses associated with short term growth rate reduction and sub-optimal thermal conditions on pig farms using Auspig simulation software. In *Asian Conference on Precision Livestock Farming (PLF-Asia 2016)*, Vol. **1**, 45–52 (Eds G. Zhang, L. Zhao, C. Wang, W. Zheng, Q. Tong, D. Berckmans and K. Wang). Beijing China: China Agricultural University.