EU PiG

EU PiG Innovation Group

Technical Report

Precision Production

Authors:

Technical Validation and Expert Analysis: Flemming Thorup[1], Ramon Muns[2]

Cost Benefit Analysis: Agata Malak-Rewlikowska[3], Monika Gebska[3]

[1] Landbrug & Fodevarer, SEGES, Axeltorv 3, 160 Copenhagen, Denmark, E-mail: ft@seges.dk

[2] AFBI Agri-Food and Biosciences Institute, Large Park, BT26 6DR Hillsborough, Northern Ireland (UK), E-mail: ramon.muns@afbini.gov.uk

[3] Warsaw University of Life Sciences – SGGW, Poland, E-mail: agata_malak_rawlikowska@sggw.pl

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Challenge: Reducing Piglet Mortality

Introduction

Within the EU-PIG project a technical report is written for each challenge. The purpose of the technical report is to formulate a working paper by technical experts in the area covered by the challenge validating the information regarding the selected best practices. The present working paper represents the scientific evaluation of the described best practices for the challenge 'Reducing piglet mortality' and is the background material for production and the end-user material on the project website.

1. The Background to the Challenge

Piglet mortality is a welfare and economical challenge to pig production in all countries. 15-25 % of all born piglets will die before weaning (still births, perinatal and post-natal mortality), accounting for a potential loss of approximately one in five weaned piglets. In early industrial pig production, mortality was primarily due to disease and feeding challenges. The impact of these factors has been reduced with the introduction of efficient vaccines and by adding optimal vitamins and minerals to sows' feed. Later, farrowing crates were introduced in the 60s to prevent piglet crushing by restricting sow movements and providing an area of retreat for piglets. Nonetheless, piglet mortality is still a major challenge for pig production. With the genetic selection of hyper prolific breeds, management of lactating piglets has become even more complex. Certainly, with the increase in complexity, management routines, health status and genetic selection aiming at piglet survival has become increasingly important.

Piglet mortality may be understood in four periods of life, which are of course intermingling into each other's.

Period 1: Prenatal mortality or stillborn piglets. Account for 1/3 of total piglet mortality.

Period 2: From birth to 3 days of lactation. Where live born piglets can die in connection to the birth process (perinatal mortality) or born dead (early postnatal mortality), also account for 1/3 of the total mortality.

Period 3: From 4 to 7 days after birth. Accounts for 1/6 of the total piglet mortality.

Period 4: Also accounts for 1/6 of the total piglet mortality. This period goes from day 8 after birth and cover the rest of the nursing period, which in EU is often 4 or 5 weeks, but may be as long as 8-12 weeks in speciality productions like outdoor or organic farming.

Conclusively, most of the piglets that die, have died within the first week of life.

Handling Piglet Mortality in the Different Periods

Period 1: Prenatal mortality or stillborn piglets. Still born piglets account for approximately 1/3 of total piglet mortality. There is a wealth of documented knowledge about factors influencing stillbirth rate. General advice on prevention of stillbirths exists, but many of the correlations perceived as risk factors for increased piglet mortality occur during or after farrowing. As an example, stillbirth risk is highly correlated to litter size, duration of farrowing and birth weight of the piglet, all of which are evident only when farrowing is over, and it is too late for a specific intervention. Other variables are impossible to change, like the effect of increased parity, or that most stillborn piglets are born in the last third of the litter, regardless of the litter size.

Period 2: From birth to day 3. Piglet mortality from birth to day 3 in lactation account for 1/3 of the total piglet mortality. Among mammals, the sow is unique as she does not create a bond with each piglet individually but with the whole litter. From the time piglets break the umbilical cord they must climb to the udder to get the first colostrum. Colostrum is essential to support the piglets with immunity towards diseases from the environment and with energy to sustain body thermoregulation. Energy is essential as piglets are born with no subcutaneous fat and very little body fat store in total. The energy is essential to keep the piglet warm and to access a teat and suckle while competing against its litter mates. Piglets with inadequate or no colostrum intake will have high risk of dying from chilling, starvation and/or ultimately from crushing by the sow during the first 24-48 hours of life. The sow starts to have periodic milk let-downs shortly after end of farrowing, leading piglets to compete for access to milk. If they should survive the first 24-48 hours, they will be more prone to infection, as they will be lacking maternal immunity, and malnourished. Thus, the need for preventive measures for chilling and starvation and for timely and sufficient care for weak piglets is evident. The mortality in this period varies significantly between herds, due to the quality of management, differences in facilities, breed use, etc.

Period 3: From day 3 to day 7 in lactation, the piglets develop a hierarchy rank at the sow udder, which is stable after the first week of life. Surplus piglets (in litters outnumbering the functional teats), piglets suckling less productive teats (e.g., usually caudal teats), and/or piglets with reduced access to teats due to a low hierarchy rank will most probably suffer from malnutrition (due to suboptimal milk intake). Malnutrition may lead to death by starvation or overlying. A good practice needs to take care of these piglets before they die from starvation or crushing.

Period 4: From day 8 in lactation until weaning. During that period the main causes of pre-weaning mortality are nonspecific infections, insufficient milk production or lactation failure by the sow (leading to piglets suffering from malnutrition/growth retardation and ultimately being culled), or accidents (i.e., accidental crushing).

2. Addressing the Challenge

The challenge of piglet mortality is relevant to all EU-countries. As the causes for piglet mortality are multifactorial, a number of solutions are needed to achieve the full effect. Focus on piglet mortality dates long back in history. Knowledge and experiences about solutions and best practices have been shared internationally for decades.

To the expert's knowledge there is only one other EU-project addressing this challenge (PROHEALTH project: https://www.fp7-prohealth.eu/).

However, ongoing research is extensive in several of the EU-member states, and research areas linked to piglet survival include:

- Improving sow feed composition to improve colostrum production.
- Improving sow feeding to increase sow milk yield throughout lactation.
- Improving sow health after farrowing and therefore milk production.
- Extended knowledge on uptake of maternal immunoglobulins, to optimize strategies for cross fostering of piglets.
- Optimizing design of free farrowing pens to improve piglet survival.
- Understanding the occurrence of IUGR (Intra Uterine Growth Retardation) piglets.
- Understanding and improving litter weight and uniformity at birth.
- Optimal number of piglets with a sow using supplementary feeding to the piglets.

Sow farms in most of Europe have implemented procedures on cleaning and disinfection, vaccination strategies, feeding strategies and supervision and management around farrowing and early lactation. In many countries the pig producers have access to manuals describing best practices in piglet management. In a number of countries these manuals are produced by companies selling feed, feed additives, vaccines or antibiotics, thus promoting procedures with focus on the use of a product instead of improving management procedures aiming at the challenged piglets.

Recommendations for sow feeding before and after farrowing are available in all EU-member states. The aim of using these is the birth of large and healthy piglets and healthy sows that nurse the piglets without losing extensive amounts of body condition during lactation.

Piglet mortality has been a focus for farmers for the last century. The solutions used are, among others, crating of sows during farrowing and often also during lactation, using genetic lines with low mortality, hygiene management in the farrowing section including washing and disinfection, segregation of batches, additional feeding of piglets, cross-

fostering, use of nurse sows, culling of sows with high stillbirth rate or high piglet mortality, heating devices to keep piglets warm, vaccinations and frequent antibiotic treatments. Iron (Fe^{2+}) is an essential mineral for piglets. All piglets in commercial indoor farms are supplied with extra iron (Fe^{2+}).

The economic benefits of a reduction in piglet mortality are huge. One extra surviving piglet can be sold at weaning (transferred into the nursery stage) with nearly no additional cost. The additional cost of feed for the extra piglet and for the sow nursing the extra piglet until weaning is low, as is the additional cost of time for managing the extra piglet. There may be some relevant costs to vaccinate the piglet. Extra time for the needed management procedures may be present, but often the sentence “work smarter-not harder” is useful in the solution. The value of the saved piglet depends of the value at sale of the piglet in the specific production.

Research has shown that additives in the feed of the sow to produce a higher volume of sow milk or to produce especially healthy sow milk, rarely gives a continuous effect in practice. The volume of sow milk will affect growth rate, but not survival, as piglet survival relies on, that every piglet has access to a specific teat, while amount of milk “just” affects growth. However, additional milk replacement supplied in milk cups may increase survival rate due to the increased access to adequate feed.

Some sorts of good management may seem rational, but does not work, or may even have extra costs in the form of investments or in time used to perform the management. Good management has a positive effect on piglet mortality. This management must be described thoroughly to be transferred between herds. The value of different aspects of management is difficult to test as well under laboratory as under practical conditions. Therefore relevant and irrelevant aspects of good management are difficult to distinguish. The end user (and adviser) often has difficulties in choosing between recommendations, that are valuable, and those that just cost money or time to implement.

Breadth of Ideas

The following points indicate the diversity in the suggested good practices:

Elevated floors. Suggestions to avoid crushing of piglets. When the sow rises, the floor under the sow rises several centimetres, nudging the piglets to avoid this place in the pen. Should reduce crushing. The commercial solution has been available for decades.

A similar approach to avoid crushing is used by **Rotavent®**. When the sow rises, a ventilator goes on. The chilling effect motivates the piglets to move away from the sow.

A similar approach to avoid crushing is the **installation of water heating mats** in the piglet area. This motivated the piglets to move away from the sow, and sleep on the soft and warm heating mats instead. The value of heating mats has been investigated by Steffen Hoy.

Rescue deck: A heated box with artificial nutrition is used to save weak or supernumerous piglets. Commercially available for 20-30 years. The system gives disappointing results when used for small or weak piglets. For large piglets the system is useful but using the rescue deck for piglets less than 21 days old violates the definition of minimum weaning age in EU member states.

Milk cups: The concept of Rescue decks taken into the pen, without weaning the piglets before acceptable age. Commercially available. Developed through the last decade. Research proves that the system reduces mortality. The system is expensive, and thus only relevant in large intensive productions.

Keeping piglets warm/heating for piglets.

Feeding an energy supplement to young small piglets. Feeding fat or protein rich supplements to the smallest piglets to improve survival.

Selection for high piglet survival. Using genetic sow lines, which have been selected for high piglet survival or using sows, which in their previous litter showed good mothering abilities.

Loose farrowing sows are **crated around farrowing**.

Following recommendations for good management of piglets. Concepts based on a few or several activities, that should be performed, to improve piglet survival.

The trends are that recommendations are directed towards the traditional piglet production where the sow is in a stall while farrowing. Only one of the 26 “best practices” are specifically directed towards sows in free-farrowing stalls.

Chronologically, the “best practices” focus on how to support the piglets with energy when being born, keeping the piglets warm during lactation, avoid the piglets being crushed, taking care of small or supernumerous piglets, selecting for good sows or to include all these in management procedures heading for the previous focusses. The management procedures also focus on cleaning and hygiene before farrowing, to reduce the microbial load on the piglets, farrowing surveillance to reduce the frequency of stillborn piglets, split milking to support all piglets with colostrum and maternal antibodies, strategies to achieve optimal litter size including the use of nurse sows and motivating employees to follow the guidelines.

3. EU PiG Best Practice

In order to identify the top five best practices for pig mortality a series of criteria aiming at measuring the effectiveness of the collected practices to match the specific challenge were defined.

The following set of criteria have been scored for each practice.

- **Excellence/Technical Quality**
  - Clarity of the practice being proposed;
  - Soundness of the concept;
  - Knowledge exchange potential from the proposed practice;
  - Scientific and/or technical evidence supporting the proposed practice.
- **Impact**
  - The extent to which the practice addressed the challenges pointed out by the Regional Pig Innovation Groups (RPIGs);
  - Clear/obvious benefits/relevance to the industry;
  - Impact on cost of production on farm and/or provide added value to the farming business or economy;
  - The extent to which the proposed practice would result in enhanced technical expertise within the industry e.g. commercial exploitation, generation of new skills and/or attracting new entrants in to the industry;
- **Exploitation/Probability of Success**
  - The relevance of the practice to each Member State (MS) or pig producing region/system;
  - Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
  - Level of innovation according to the Technology Readiness Level (TRL)
  - The extent to which there are clear opportunities for the industry to implement the practice/innovation;
  - Degree of development/adaptation of the practice to production systems of more than one MS

Scores had to be in the range of 0-5 (to the nearest full number). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guidelines for scoring are shown below (no half scores could be used).

0	The practice cannot be assessed due to missing or incomplete information.
1 – Poor	The practice is inadequately described, or there are serious inherent weaknesses.

2 – Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3 – Good	The practice addresses the criterion well, but a number of shortcomings are present.
4 – Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5 – Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The selection of the top five practices followed a procedure in six steps:

1. All members of the Thematic Group (TG) had the opportunity to send their scoring sheets to the TG leader
2. The TG members provided brief comments to the first 10 practices they have chosen as best practices, as these comments facilitated the discussion about the first five
3. The TG leader standardized all individual scores by calculating Z-scores
4. The first 10 practices have been ranked according to the average Z-scores of all participants of the Thematic Group. All other lower ranked practices have been excluded.
5. The TG leader collected all the comments of the individual members of the TG for each of these 10 practices and sent them around to the TG.
6. In a dedicated meeting, the TG discussed the results and finally decided on the top five best practices for each challenge based on the comments provided by the group.

4. Results and Discussion

4.1. Validation of the Top Five Best Practices

The following top 5 best practices within the challenge of ‘Reducing piglet mortality’ have been selected by the thematic group:

Title of Best Practice	Country
Reducing Pig Mortality Through High Care	The Netherlands
Reducing Piglet Mortality: Scientific Approach	The Netherlands
Sow Lift to Save Piglets	France

Socks to Small Pigs (>800 gram) so They Get Warm and It Will Prevent Piglet Mortality	Denmark
Pigletsaver 'ROTIVENT'	Spain

Reducing Pig Mortality Through High Care

"Reducing pig mortality through high care" is in the proposal in the Dutch language called "Ambassador Bigvitaliteit"

The concept of "high care" is based on improved and defined management. This is a useful solution, as piglet survival can be improved in most herds if existing knowledge is implemented. The descriptions of the different objects must be precise, to be easy to follow correctly, as the improvement is only achieved if the knowledge is used at the right time for the right piglets.

The expert group selected this ambassador as the concept focusses on the whole period of lactation in which piglet mortality can occur. The recommendations are clear and if they are performed accordingly, many of the recommendations are expected to support the goal to increase piglet survival. The value of the specific recommendations is difficult to elucidate, as the literature is generally sparse in the area of testing the value of specific management factors affecting piglet survival.

After being selected to be the winning ambassador, a detailed description of the concept has been received from the Ambassador. Here the recommendations are detailed in three protocols. The three protocols are added this technical report as appendices.

- Protocol 1. Cleaning and disinfection
- Protocol 2. Health at farrowing
- Protocol 3. Piglet management (named "checklist pig vitality").

Reducing Piglet Mortality: Scientific Approach

The concept is similar to number one, but the descriptions were less specific. The description was the following:" The challenge is reducing piglet mortality based on a scientific basis. During the test phase sows were weighed before insemination, before giving birth and after weaning. During pregnancy the sows were fed according to their optimal weight depending on their age and phase of pregnancy. The data collected was piglet weight, vitality and drinking of milk. Part of the reduction is achieved by putting in more labor during birth of the piglets and control rounds afterwards. It is important that all the piglets get the first milk and drink enough during the first days after birth. Most piglets die because of vitality and crushing by the sow. Better care during birth, directly after birth (e.g. milk consumption) and monitoring afterwards reduces mortality. It is important that

sows are fit, with an optimal weight. Good care during birth and afterwards proves to be important to ensure good care and lower mortality. The best practices found on this farm can be 'translated' to other farms.

Sow Lift to Save Piglets.

The farm owns 240 sows which are organised into 4 lots. The farrowing room (60 boxes of sows) was renovated and equipped with lift boxes. This innovation involves cages where the ground level, beneath the sow, rises by about 25cm when the sow stands up. This process reduces the mortality of the piglets by crushing as they are no longer beneath the sow when she lays down. Once the sow is lying, the cage then moves back down to the same level as the box, so that the piglets are able to suckle. The breeder provided his findings from 21 lots, reporting box by box, the number of piglets crushed. Without immediate aggregated statistics, he found that there were 1.2 more weaned piglets per litter. One of the main advantages of this best practice is the effect on the moral of the farmer and his employees as fewer crushed piglets had to be collected.

Concept: When the sow rises, a sensor activates a hydraulic system. This system raises the floor under the sow app. 20 cm. The rest of the floor remains stable. The piglets are supposed to fall of the lifted floor. Thus, they are not in the risk of being overlaid, when the sow lies down to nurse the piglets.

This concept was expected to have an impact on piglet mortality. The concept has been available for decades, and thus did not score high on novelty. The complicated use and high cost also prevents the use in all piglet productions.

Socks to Small Pigs (>800 gram) so They Get Warm and It Will Prevent Piglet Mortality

This solution has been evaluated, in a Danish test of the concept, mortality increased when using socks to the smallest piglets in the litter. The concept was chosen due to the expected good effect, which was by then expected to be achieved in all kinds of production, as the solution was simple and cheap.

After farrowing: small pigs (<800 gram) gets cold and increase a high risk of mortality. Old socks from children are cut to fit the pigs – holes for the front legs. Female pigs get the long model and the male pigs get the short model. After farrowing/before litter equalization the small pigs wearing a sock until 4 days after farrowing (the day when they castrate the male pigs). The idea with the socks is to prevent piglet mortality. Implement: see above. It only takes about 5 minutes to dress the pigs (<800 gram) with socks in a litter. The socks are free of charge as they are collected from children in the local area. They can be washed and reused several times. The farmer estimates that 50% of the small piglets (<800 gram) will be saved by using the socks (1,5 piglet). The price for a piglet is estimated at about 26,80 €.

Concept: New born small piglets are covered by a used woolen sock. This both reduces the emission of body temperature and makes the manager keep focus on the health and welfare of these piglets.

Pigletsaver “Rotivent”

“During the first 2-3 days of life, when the mother gets up, the piglets roam underneath, being at risk of being crushed when the sow lies down again. Especially in hyperprolific farms, there is a high percentage of crushing losses, which quickly undoes the great work done before by genetics and management in mating. Our innovation is called "Pigletsaver ROTIVENT" and is based on the fact that pigs are very sensitive to any airflow. The "Pigletsaver ROTIVENT", should be attached to the cage before delivery and must be left functioning there until day 3 postpartum. When the sow gets up, the "Pigletsaver ROTIVENT", produces a sheet of air which sweeps the danger area (under the sow). The piglets do not like the airflow and look for another place to stay, like the heated nest area. Piglets usually learn within three days where they are NOT comfortable (underneath the sow) and the farmer can move the equipment to another cage. The farmer estimates that 90% of the crushing losses resolved. More weaned piglets. The sows are calmer because they do not have piglets under them. Small investment with a quick amortization. Negligible energy consumption. More profit for exploitation. Increased productivity: 1.92 piglet/year/sow”

The solution is a ventilator, which blows wind under the sow when she rises. This should keep piglets away from being under the sow, thus reducing the risk of being overlaid, when the sow lies down again to nurse the piglets.

This solution resembles the concept of the “Sow lift”. The concept is cheaper to implement. Despite being marketed for several years, the effect on piglet mortality has not been documented. The board were therefore worried if the concept was functional in a pig barn, and if the concept had the expected effect in keeping the piglets away from being under the sow.

4.2. Cost and Benefit Analysis of the EU PiG Ambassador

Best practice ‘reducing piglet mortality through high care’ from the Netherlands was chosen as EU PiG ambassador 2019 for the challenge ‘reducing piglet mortality’. The innovation in this best practice involves a system of special care of the animals that is based on special equipment (e.g. anoxia euthanasia box, heat lamps) and an individual approach. The costs and benefits of this system have been analysed and take into account the estimated changes in technical performance parameters as a result of the introduction of the system and the necessary investments on the farm of Theo Vernooij. Based on both the real farm data and calculations made using the Interpig model, the following parameters have been assumed:

Benefits:

- Piglets mortality decreased and as a result the number of piglets weaned per sow per year increased by 2%;
- Sow mortality decreased by 2 percentage points.
- Rearing daily weight gain increased by 5%.

Costs:

- Due to the system, the time usage per sow/year in hours increased by 10%;
- Additional bedding and nesting material increased costs by €1/sow/year;
- An investment cost in euthanasia box and heating lamps in total 4000 €, maintenance (gas) costs of the euthanasia box 20 euro per month.

Based on these assumptions **variable production costs** after implementation of best-practice **decreased by 1,5% per piglet**, mainly due to lower breeding costs (as result of sow and piglet mortality reduction). On the other hand an increase was observed in case of **fixed costs by 2,8%** per piglet, mainly as a result of increased labour costs. In total, the entire costs of piglet production were **only 0,4% lower per piglet.** The benefit could be higher if the costs of additional labour were lower and the system was more efficient in terms of technical parameters improvement. Another possibility is to utilise the opportunity of adding value to piglet price produced in high welfare care system.

4.3. Expert Analysis

Evaluation from the authoring expert is that average piglet mortality of 15-25 % can potentially be reduced to 10-20 %.

A reduction in piglet mortality, by 5 percentage point, enables the producer to wean 0.5-1 piglet more per litter, which will have economic benefits, and also improve the welfare of the saved piglets. In herds suffering from defined contagious diseases, vaccination will be a cheaper and more efficient solution to piglet mortality.

In herds using loose housing for welfare reasons, using crates during and shortly after farrowing will be an efficient solution in improvement of piglet survival and piglet welfare, which may not improve sow welfare.

Some member states may still have general challenges handling specific diseases, that should be addressed first. E.g. PRRS, Clostridium perfringens, PED. In most member states the winning ambassador "**Ambassador Bigvitaliteit"** addresses the major challenges to achieve a higher piglet survival.

4.4. Conclusions and Advice to Industry

The winning ambassador "**Ambassador Bigvitaliteit"** addresses the major challenges to achieve a higher piglet survival in most member states. If the recommendations described in the 3 protocols are implemented, then a number of challenges to the piglets will be reduced.

5. The Future

There is a general gap in understanding the dynamics in a nursing litter of piglets. Piglets are born with a high variation in size. The smallest piglet in the litter is the first to suffer, whenever something is wrong. The farmer will focus on this small piglet instead of solving the problem leading to high piglet mortality.

With increased number of piglets per litter, management must be improved to assure all piglets have access to an appropriate intake of colostrum and milk through improved knowledge and training.

Most management factors recommended for piglet management are based on "standard operational procedures". There is a great need for documentation of each of these management practices.

Benefits of some management practices like the use of nurse sows are well documented, while others are less documented but still widely accepted as good practices by farmers. An example of this is the practice of sorting the piglets by size or the exchange of small and large piglets between litters only. Further research is needed to assess the benefits on piglet survival with regard to each management practice. The positive and negative effects of different methods of cleaning and disinfection have not been documented. The area is rather complex as it involves both the sow and piglets and factors leading to piglet death are multifactorial. However, research should continue focusing on management routines and isolated factors as being either beneficial or redundant in relation to piglet survival. Research should especially focus on the factors causing piglets to die within the first week of life. Among the most important subjects are ensuring that piglets are dry and warm, securing nutrition and avoid crushing.

References

1. Rutherford, K. M. D.; Baxter, E. M.; D'Eath, R. B.; Turner, S. P.; Arnott, G.; Roehe, R.; Ask, B.; Sandøe, P.; Moustsen, V. A.; Thorup, F.; Edwards, S. A.; Berg P.; Lawrence, A. B.; 2013. *The welfare implications of large litter size in the domestic pig I: biological Factors*. Animal Welfare 2013, 22: 199-218

2. EM Baxter, KMD Rutherford, RB D'Eath, G Arnott, SP Turner, P Sandøe, VA Moustsen, F Thorup, SA Edwards and AB Lawrence 2013. *The welfare implications of large litter size in the domestic pig II: management factors*. Animal Welfare 2013, 22: 219-238

3. Hurley, W. L.; Theil, P. K.; 2011. *Perspectives on Immunoglobulins in Colostrum and Milk*. Nutrients. 3, 442-474.

4. Vanderhaeghe, C.; DeWulf, I. H.; Ribbens, S. De Kruif, A. Maes, D.; 2010. *A cross-sectional study to collect risk factors associated with stillbirths in pig herds*. Anim. Reprod. Sci. 118,

5. Pedersen, M. L.M.; Velander, I. H.; Nielsen, M. B. F.; Lundeheim, N.; Nielsen, B. 2019. *Duroc boars have lower progeny mortality and lower fertility than Pietrain boars*. Translational Animal Science, Volume 3, Issue 2, Pages 885–892,

6. Schmitt, O.; Baxter, E. M.; Boyle, L.; Driscoll, K. 2018*. Nurse sow strategies in the domestic pig: II. Consequences for piglet growth, suckling behaviour and sow nursing behaviour*. Animal. 13. 590-599.

Appendix A: Reducing Piglet Mortality

The Three Protocols of the Winning Ambassador

Protocol 1: Cleaning and disinfecting

On behalf of the Dutch Ministry LNV, the Steering group PigVitality and the Partners PigVitality has been looking for the success factors for a good biosecurity. Based on an extensive survey a Pig Vitality checklist has been produced. The protocol cleaning and disinfection is part of this checklist and provides tips and advice on cleaning and disinfecting of the farrowing rooms and the central corridor.

Good hygiene is indispensable in the fight against bacterial diseases and viruses. Good hygiene starts with an ' Effective ' protocol for cleansing and disinfection. This applies to both the farrowing stalls/rooms and the central Corridor. In working order, this protocol describes the most appropriate factors for proper cleaning and disinfection.

You work with chemical agents. Therefore, think of your own health and that of your staff by wearing protective clothing and accessories such as waterproof clothing, protective goggles and facemasks. For questions about detergents and cleaning products, please visit the website www.ctgb.nl and www.nvz.nl You will find information about the safety of the products for humans, animals and the environment. Some infectious agents may induce resistance to certain bacteria (see report resistance by disinfectants, Health Council 2016).

1. Dry cleaning
   • During the whole process, set the ventilation to maximum for removal of microbes.
   • Remove residual manure, litter and feed from the pens and walkway (s) before wet cleaning (clean the brooms/brushes).
2. Soaking
   - Use hot water. With cold water and a detergent you get the pens and hallways not sufficiently fat-free.
   - Make everything fat-free. The layer that remains on the floor and other materials consists of skin cells (dandruff), food residue and manure. This is an oily/fatty layer
   - Compare the soaking of pig houses with the washing of a mayonnaise spoon: when soaking with only water you will not get it fat free.
   - Use a soap or detergent to penetrate the dirt.
   - Preferably use a long-adhesive foaming agent (this gives a good check whether all surfaces are touched and the foam gets enough time to properly dissolve all the grease).
   - There are specific methods/protocols for specific germs and desired exposure/disinfection time.
   - Follow the manufacturer's prescribed dosage and instructions for use. Prevent drying of the disinfection agent.
   - Apply the disinfectant from bottom to top (otherwise you will get runs, areas of exposed and unexposed surfaces).
3. Cleaning
   - Clean - spraying with water and high pressure hose/nozzle.
   - When possible, use hot water of at least 65˚C (degreases better).

- Clean the hard to reach places! Behind feeding bins, in corners, bottom sides of pen/stall separations, etc.
- Check the cleaned department at critical points, where animals come into contact directly (feeding bowl, drinking bowl, floor, corners and bottom bracket separation).

4. Disinfecting

Preparation

- Pens must be drip-free and there should be no standing water; these reduce the concentration of the disinfectant used.
- If necessary, remove excess water with a scraper tractor, for example. It drains Microorganisms, such as worm eggs.
- Accelerate, only when necessary, the drying with hot air. Caution: Water-drying keeps microorganisms behind!
- Wait at least three hours after cleaning because (mist) particles remain in the air for as long as they continue to ventilate. Maximum ventilation can shorten this process.

Implementation

- Correct concentration is essential!
    - Follow the manufacturer's prescribed dosage and instructions for use.
    - Check the concentration: Use an indicator paper (not in foam) and/or measure the amount of water used per hour or department and calculate the utilized dosage.
    - Always make a fresh solution and never use leftovers from previous times: The Used disinfectants/cleaning agents lose effectiveness once dissolved!
- Best application methods/forms are: Atomize or foam.
- Consider the efficacy of the chemical (Action against specific germs and at certain temperature of the water). Rinse after disinfection is necessary.
- Rinse feeding and drinking bins always out afterwards! These are a potential gathering point for the solutions used, which can be absorbed by the animals.
- Check periodically with RODAC images. This can be through your veterinarian.

5. Dry
    - For farrowing, the department must be well dried and at the right temperature. In a wet environment, germs can easily survive. Best drying is a minimum of four days of vacancy. You can possibly shorten this using hot air.
6. Before bringing in sows to farrow
    - Flush water pipes

The Pig Vitality (Bigvitaliteit) checklist has been put together by Wageningen Livestock Research, De Varkenspraktijk, VGTZ, AdVee Dierenartsen, Varkensartsen, De Oosthof Dierenartsen, SUVITA Varkensartsen, Lintjeshof Dierenartsen, Dierenartsencombinatie ZuidOost en de KNMvD vakgroep gezondheidszorg varken in opdracht van en gefinancierd door het Ministerie LNV, de Stuurgroep Bigvitaliteit en de Partners Bigvitaliteit.

Protocol 2: Health at farrowing

Good health around the birth of piglets is important to reduce piglet mortality. The Dutch ministry LNV requested the steering group pig vitality and the partners of pig vitality undertake research into the successful factors for a good piglet survival rate. On the basis of an extensive questionnaire, a checklist for Pig Vitality was constructed. This protocol ‘Health at farrowing’ goes together with the

checklist and gives tips and advice about work instructions and health factors around the birth of piglets.

The protocol ‘Health at farrowing’ focuses on basic practices around housing of livestock, climate, health and hygiene. It also covers a structured intervention/cross fostering policy, as a piglet can, at birth or just after, become infected via the sow if she carries one or more transmittable bacteria. These infections can take place during the birth process (in the birth canal), through the naval or nose to nose contact with an infected pig or carrier sow. Good care around birth is therefore very important.

A good starting point of minimising piglet mortality is that all piglets are raised by the sow. Good care around the birth of a piglet is therefore the most important success factor.

A - General hygiene protocol for farrowing stalls

Make sure that the chance of infections from different vectors are as small as possible

1. Production group
    - Keep animals of different ages (Different batches) strictly separated
    - Husbandry of the animals of different stages of production should take place from young to old
    - In an ‘All in - All out’ system this should occur at all stages of production and in each room i.e. from farrowing to weaning to growth. No mixed groups.
    - Ensure that there is a good biosecurity system for cleaning and disinfection
2. Production stage
    - Ensure that any working tools or materials stay within each barn or room. This also improves work efficiency
        - Deadstock buckets/transport with disposable inner bags, manure shovels etc
        - Work hygienically: Wash hands after every rooms/barn/building (Supply soap dispensers and washing facilities in the hall between barns/rooms. Hand hygiene is important to prevent the spread of infections
3. Farrowing pens
   Access farrowing pens as little as possible

B - Basic management of the farrowing stalls

Along with hygiene, the basic management must also be standardised. The climate must be optimised and also the milk production of the sow should be checked to ensure adequate output and access by piglets. This should be done per litter not a small sample. The passive resistance of the piglets is determined by the milk intake in the first days (colostrum). The factors listed below are of importance:

1. Warmth
    - Provide a warm environment directly after birth, this can be done using a heat lamp behind the sow or warming creep area set at a temperature of 32°C
    - Make sure that the piglets do not cool down causing chill (Hypothermia)
2. Milk yield
    - Provide a good milk yield/output from the sow, stimulate the sow to eat and drink if you suspect that the milk yield is suboptimal
    - The water flow rate of the nipple drinkers in the farrowing stalls must be minimal 2litres per minute (Even if all animals are drinking at the same time)
3. Piglet nipple allocation

- If necessary introduce the piglet to the sow's nipple

4. Split suckling
    - Apply split suckling in large litters
        - Put larger piglets with a good fat layer in a heated box first to allow lighter piglets first access to the colostrum. Make sure that same amount of piglets as the sow has nipples are in each litter, do not remove too many piglets during split suckling.
        - Keep piglets a maximum of 2hours from the sow during split suckling
        - The piglets that have been placed in the heated box should have enough warmth and be placed in open crates to retain contact with the sow.
5. Sow reproductive health (Post Farrowing).
    - Be aware of uterus and udder infections in the sow, signals of these are:
        - Poor intake of feed by the sow
        - Temperature increase in the sow >39.5˚C
        - Sows that are lying on their stomach
    - In case of a poor milk yield from the sow:
        - Offer the piglets supplementary milk
        - Make sure that the sow can produce milk again as soon as possible, by using an adequate treatment protocol (Based on that described by the vet/company)

C - Hygiene protocol around farrowing

Good hygiene around farrowing reduces the chance of infecting the piglets.

- Before and during farrowing, remove manure from behind the sow
- During farrowing make use of powdered disinfectants throughout the farrowing stall
- Work hygienically when acting as farrowing assistance: Wash your hands, use gloves and enough lubricant and clean the water sack of the sow to prevent manure getting into the birth canal.

D - Intervention Policy

Judge if intervention is necessary

1. Check per sow how many piglets this sow can rear

   Criteria for judging sows rearing capacity

    - Amount of functional nipples/mammary gland packages
    - Sow body condition (Feed intake)
    - Amount of piglets weaned from previous litter
    - If intervention is needed, intervene as little possible with the litter. It is better to take half the litter completely to a nurse sow/additional litter rather than shared equally across multiple sows. This limits cross contamination of infections such as diarrhoea.
2. Timeframe of intervention/cross fostering
    - Take piglets between 12 – 24 hours of birth
3. Guarantee goof colostrum supply
    - Disinfect the naval with designated products
    - During the first 24 hours, do not carry out any piglet interventions such as iron injecting, castration, docking of tails etc
    - Castrate (if necessary) and perform iron injection from three days after birth.

4. Fostering/Use of a nurse sow
    - Leave a few farrowing pens at each farrowing group when moving the sows.
    - On Day 4 - A sow who 3-4 weeks ago moved to the farrowing room/barn
        - Move the lighter piglets from a separate/large litter onto this sow
    - Key aspects for choosing a foster sow:
        - A sow with a good udder package (teets and active glands)
        - A sow with a good appetite.
        - Move the sow and not the piglets

E – Hygiene Protocol for Piglet Treatments

Do undertake piglet interventions for the first 24 hours, such as iron injecting, castration, docking of tails etc. Perform the necessary standard treatments as much as possible at the same time. One stressful moment is better than several in succession. Tail docking is recommended at day 4 after birth.

1. Hygiene
    - Use clean materials/bins per room
    - Clean the crates (or swap) per room and spray the cart
    - Wear gloves.
    - Use a needle per litter or inject needle-less.
    - Set the standard treatments for litters with diarrhoea.
    - Treat piglets of a foster sow last in a batch
2. Teeth Grinding

    If the piglets damage the teets/udder of the sow, teething grinding can be considered at the piglets.

    - Ensure a clean and well-functioning grinding tool.
    - Smooth and round the teeth so that no sharp edges remain.
    - Do not grind too far, so that no open wound occurs in the tooth
    - Grind on day seven after birth at the latest. As young as possible deserves preference.
3. Tail docking
    - Ensure a sufficiently hot, clean and sharp docking iron
    - Dock right, not too fast and from bottom to top
    - Dock on day 4 after birth
4. Castration method
    - Provide clean and sharp materials.
    - Ensure clean hands, overalls and boots.
    - Disinfect the blade after every pig.
    - Make two small vertical cuts in both sides of the scrotum. The spermatic cord must be cut. You cannot take it off!
5. Method of administering Iron
    • Work with clean syringes and clean and sharp needles.
    • Preferably use a different (disposable) needle per litter.
    • Check that the correct dose is administered.

The Pig Vitality (Bigvitaliteit) checklist has been put together by Wageningen Livestock Research, De Varkenspraktijk, VGTZ, AdVee Dierenartsen, Varkensartsen, De Oosthof Dierenartsen, SUVITA Varkensartsen, Lintjeshof Dierenartsen, Dierenartsencombinatie ZuidOost en de KNMvD vakgroep gezondheidszorg varken in opdracht van en gefinancierd door het Ministerie LNV, de Stuurgroep Bigvitaliteit en de Partners Bigvitaliteit.

Protocol 3: Checklist Pig Vitality

By filling in this checklist, you will see an increase in key performance indicators and business performance (profitability). A cross or tick in column 'Yes' means a task has been completed that helps to limit the loss of piglets in the farrowing process. 'No' means there is potential improvement in the farrowing protocol that could be made to limit the loss of piglets during farrowing. Some improvement points have more impact than others.

Scope of Pig Vitality

The checklist is based on extensive research using the best practice found across 84 farms. The farm staff completed a questionnaire and during a vet visit to the farm; the vets completed a questionnaire looking at factors that led to reduced piglet mortality. After analysis of the 84 completed questionnaires, the most relevant factors linked to the loss of piglets in the farrowing house where identified in the checklist. This checklist give you the opportunity to work with goals to reduce the loss of piglets.

The less relevant questions consisted of factors such as: number of sows on the farms, percentage of sow mortality, usage of nesting material, using a heat mat at birth, working in the farrowing stalls is mostly done by women, feeding schedules during labour, amount of feed per sow per year, increasing the feeding schedule after birth, extra drinking water around birth, using dry feed or liquid feed, mains water vs borehole water and number of days the water toughs are dry in the farrowing stalls before a new sow enters.

Original document in Dutch
https://www.wur.nl/upload_mm/4/5/1/516bee42-b436-429e-8afd-5b83d3e53cdd_20180110%20Protocol%20zorg%20rondom%20geboorte.pdf

1. General company instructions

	No	yes
a) There are a minimum of 4.2 piglet places per sow		
b) There is different terminal sire than Pietrain used		

2. Gilt and dry sow selection

	No	Yes
a) Sow or gilt from own herd		
b) Purchased sows served first in quarantine stall		
c) Sows selected for breeding have a minimum 14 teets		
d) Strict adoption protocol is followed		
e) First insemination in farrowing crate at weaning		

3. Feeding, housing and management of pregnant sows

	No	Yes
a) Structured 2 days of boar contact and stimulation before insemination takes place		
b) Pregnant sows fed twice per day		
c) The feeding system is calibrated a minimum of twice a year		

4. Farrowing unit building management

	No	Yes
a) The farrowing crate has a minimum area of 4.25 cubic metres		
b) The floating floor is in place for the first week (to minimise crushing deaths)		
c) The sows lie on slats not concrete		
d) The floor in the farrowing crate is not concrete		
e) There is a ventilation system other than natural ventilation (use of doors)		
f) The floor is in a good state of repair		

5. Farrowing management

	No	Yes
a) Minimum of 10 inspection rounds per day around farrowing		
b) Around farrowing and after the first 2 days, there is someone present for a minimum of 9hrs per day in the farrowing house		
c) The sows, for the last 2 days before farrowing get enough feed (more than 1.5kg of feed per day)		
d) The sows are washed in water that has a temperature of 30°C		
e) Maximum 10% of the sows have a farrowing longer than 6 hours		
f) Vitality of newly born piglets is scored out of 4 (1 being bad and 4 being good)		
g) The % of light piglets(<1000g at birth) is maximum 10%		
h) The piglets after birth are kept in a creep area at 32° C		
i) The % of sows that do not eat after birth is maximum 5%		
j) The temperature of the sows that do not eat well after birth is measured		
k) The % of sows with udder problems around birth is maximum 4%		
l) The % of sows that in day one after birth are laying on their stomach is maximum 4%		
m) The % of sows with leg problems is maximum 5%		
n) The manure consistency around birth and pregnancy and is loose enough. Sows are not constipated		

6. Management after farrowing

	No	Yes
a) Piglet numbers and information are recorded within 12 – 24 hours		
b) Data is collected according to on farm protocol		
c) Split suckling is applied to all litters		
d) The amount of piglets per sow is based on the amount of working nipples		
e) All piglets are left to suckle on the sow until they reach weaning age		
f) Piglets are getting supplementary feed		

7. Health and piglet procedures

	No	Yes
a) Boars do not get castrated		
b) If they are being castrated this follows a clear protocol		
c) Birth diarrhoea isn't present in any gilt pigs		
d) Symptoms of scour are not present in any pigs		
e) Maximum 2% of pre weaning mortality caused by diarrhoea		
f) Maximum 5% of mortality post weaning is caused by diarrhoea		
g) The order of husbandry duties around the farm follows the biosecurity protocol (High risk animals first, low risk animals last)		
h) The control of risk in farrowing is youngest to oldest		
i) Access by stockmen to the farrowing crates is kept to a minimum		

j) Day to day care of litters with diarrhoea are met only after non-infected litters.		

The Pig Vitality (Bigvitaliteit) checklist has been put together by Wageningen Livestock Research, De Varkenspraktijk, VGTZ, AdVee Dierenartsen, Varkensartsen, De Oosthof Dierenartsen, SUVITA Varkensartsen, Lintjeshof Dierenartsen, Dierenartsencombinatie ZuidOost en de KNMvD vakgroep gezondheidszorg varken in opdracht van en gefinancierd door het Ministerie LNV, de Stuurgroep Bigvitaliteit en de Partners Bigvitaliteit.

Original document in Dutch https://www.wur.nl/upload_mm/5/a/3/3562c5ef-ed95-4782-af1d-11f1ed8d12f8_20180112%20Checklist%20bigvitaliteit.pdf

Appendix B

Reviewers Detailed Comments on the Recommendations from the Winning Ambassador.

Comments to protocol 1: **Cleaning and disinfection**

The recommendations in this part of the protocol are detailed and useful. Some confusion arises, which is probably due to misunderstandings during translation from Dutch to English, then it gives a clear description of the different steps of traditional washing and disinfection procedures in a pig barn. Detailed descriptions of purpose are missing and methods are not clearly described, which calls for some level of knowledge from the manager, who is responsible for the quality of the washing and disinfection. Clear control points are missing, which prevent the user from controlling, if things are done correct. Thus, the presented protocol lacks revision, but the idea of the protocol is highly relevant.

The use of titles and subtitles is confusing in this protocol. This probably has occurred during the translation to English. This confusion may also explain, that “disinfection” happens at different occasions in the procedure, as it should only be performed at the end of the cleaning procedure.

The advice for the cleaning process is useful and is described in 6 steps.

1. Dry cleaning (before washing)
2. Soaking
3. Cleaning (should be “washing”)
4. Disinfection (remove the confusing subtitles “Preparation” and “Implementation”.
5. Dry (should be drying)
6. Before bringing sows (in) to farrow

1. Dry cleaning

This procedure is useful as it increases the effectivity of soaking and washing and reduces the time used for washing.

2. Soaking

If time allows for soaking, then this increases the efficiency of washing and reduces the time used for washing.
An optimal time for soaking is missing.
Soaking with hot water and soap to remove fat is sane. Soaking, Washing and disinfection is mixed in an unlogical “order” under this point, but the recommendations are sane.
It could be mentioned, that many pig barns are equipped with spray systems for cooling of sows, which can also be used for soaking, which enlightens the following washing procedure.
The advice to use maximum ventilation to remove microbes from the environment is poorly documented in literature. This procedure may interfere with the wish to achieve the optimal room temperature for the following procedures.
Procedures for disinfection under this point should be moved to “4. Disinfection”. Changing the word “disinfection” to “soaking solution” under the section “2. Soaking” makes sense.

3. Cleaning (should be “washing”)

The washing procedure is described in a very general way in the protocol. As washing is the most important variable of the concept, then it should be described in detail. If washing is not performed efficiently, then the disinfectants in section 4. does not remove germs efficiently.

4. Disinfection

This section is long, which is relevant, as disinfection is important. The recommendations are sane, and well argued for, which will motivate the worker to follow the recommendations.
It should be mentioned, that most disinfectants work well on wet surfaces, while free water as mentioned, should be removed by scraping, as this dilutes the disinfectants, and thus reduces the effect.

5. Dry (should be “Drying”)

Drying the surfaces after disinfection is important both to reduce these microbes, that may have survived the disinfection, but also to assert that the pregnant sows are moved to pens, where they can maintain their optimal body temperature. This is important for both welfare and health. It is recommended to use 4 days for drying, which makes sense.
Alternatives to drying out before entering the sows should be mentioned, as most commercial production systems only allows for a few days between batches. This may be heating, if temperatures are below 20C, while ventilation is at 15 % of maximum.

6. Before bringing in sows

It is sane to flush water pipes. The argument to remove germs and minerals after the pipes has been out of use should be mentioned, as well as the recommendation to remove the last nipple on the water pipe, and let the water flush until it is clean.

Check points for cleanliness and dryness of floors should also be included here, as should a recommendation to check all water nipples to give 2 liter of water per minute and to repair all malfunctioning parts.

Protocol 2: Health at farrowing

The protocol for health at farrowing is sane and detailed, with many useful check points. The protocol begins with a introduction about transmission of bacteria, and is divided into a checklist divided into five sections.

A – General hygiene protocol for farrowing stalls

B – Basic management of the farrowing stalls

C- Hygiene protocol around farrowing

D – Intervention policy

E- Hygiene protocol for Piglet treatment

A – General hygiene protocol for farrowing stalls

This short section describes the need to keep different batches (age classes) separated, to avoid transmission of disease between age classes. The advice is useful. The same accounts for the advice

of using specific tools in the different sections of the herd, and of hand washing when moving between batches. A point on shifting/changing boots when entering barns with different batches of piglets is missing. This may have been forgotten during translation.

B – Basic management of the farrowing stalls

This section focusses on the health after farrowing of the specific sows and piglets. The advice given is useful and based on scientific literature.

C - Hygiene protocol around farrowing

This very short protocol describes the recommended procedures during farrowing and how to do farrowing assistance.

D – Intervention policy

This section describes the techniques for adjusting the litter size to capacity of the individual sow. Thus the check points in this section are not aiming at hygiene. The checkpoints are relevant.

The recommendation for transferring the smallest piglets to the foster sow is not up to date. Probably a mixing done during translation from Dutch to English of the recommendations for small nurses (for small piglets) and two step nurse sows (for large piglets).

E- Hygiene protocol for Piglet treatment

This protocol is divided into 4 sections.

1. Hygiene
2. Teeth grinding
3. Tail docking
4. Castration method
5. Method of administering iron

The effect of these recommendations has been tested and described in literature, but the recommendations are relevant. Under 1. Hygiene, line 2 is confusing. “Clean the crates (or swap) per room and spray the cart. Probably the text is: “After each crate or room, you should clean all utensils or discard these. If using a box for holding the piglets, this should at the same time be cleaned and disinfected.”

Challenge: Dashboard Systems/Benchmarking

Authors:

Technical validation and expert analysis: Kees Lokhorst[1], Claus Hansen[2], Ramon Muns[3]

Cost benefit analysis: Agata Malak-Rewlikowska[4], Monika Gebska[4]

[1] Wageningen Livestock Research, PO Box 338, 6700AH Wageningen, The Netherlands, E-mail: kees.lokhorst@wur.nl

[2] Landbrug & Fodevarer, SEGES, Axeltorv 3, 160 Copenhagen, Denmark, E-mail: cha@seges.dk

[3] AFBI Agri-Food and Biosciences Institute, Large Park, BT26 6DR Hillsborough, Northern Ireland (UK), E-mail: ramon.muns@afbini.gov.uk

[4] Warsaw University of Life Sciences – SGGW, Poland, E-mail: agata_malak_rawlikowska@sggw.pl

Introduction

Within the EU-PIG project, a technical report has been written for each challenge. The purpose of the technical report is to formulate a working paper by technical experts in the area covered by the challenge validating the information regarding the selected best practices. The present working paper represents the scientific evaluation of the described best practices for the challenge "**Use of dashboards and benchmarking tools in precision production"** and is the background material for production and the end user material described on the website for the project "EU-PIG".

The present evaluation of good practices includes mainly the supplied descriptions and only sparsely follow up regarding outstanding questions or clarification of lack of description of the good practice. It is the assumption that the description of the good practice contains all and relevant information needed to evaluate the practice.

1. The Background to the Challenge

From data to action in precision production

Datafication is happening in the pig sector. In general *precision production* is based on data. Having data does not mean that you are able to take proper actions. It is important to be aware of the steps that can be identified to add value to data and use it for timely and proper action. Data collection will always be done to support a specific process or targeted goal. Even just observation can be such a process. The concept is illustrated in Figure 2.1[1]. It is important to be aware of the difference between data, information, knowledge and action. They are strongly related, but in terms of decision support they vary quite a lot.

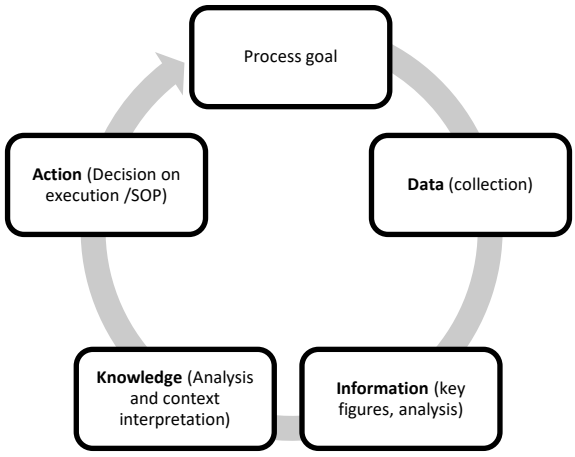

Figure 2.1 Scheme from data to action[1]

In essence data are presentations of basic quantified raw measures and observations. If we would like to give meaning to data we would have to add value by transforming data into information. Calculation, correction, aggregation and clustering are well known strategies to create information like indices such as feed conversion and number of pigs produced per year. After giving meaning to data we must interpret the information and put it in the right context. By using the context of the information we can compare the information to what we expect, or what is normal for that context. If we know the context we can also reason with the information. The next step in the cycle of Figure 2.1 is to make a decision (based on information and context) and execute that action. Execution of an action needs identification of who has to do what, when, where and how. The action must be concrete in such a way that a human or a system can perform a specific task.

[1] From Kees Lokhorst (2018) An introduction to smart dairy farming. https://doi.org/10.31715/20181

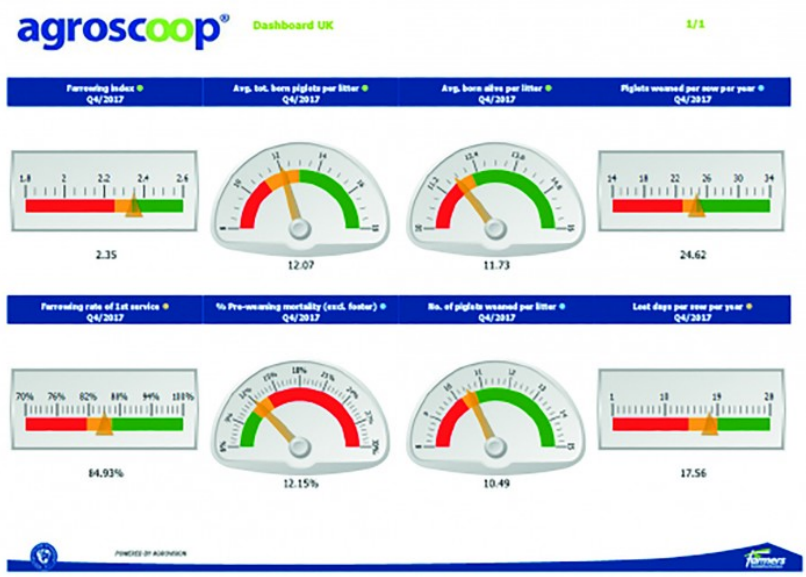

Figure 2.2 An example of a dashboard[2]

Dashboard systems

Best practices will be selected for dashboard systems. Dashboards are intermediates between (process) computers, phones and humans and the purpose is to guide the user in the direction of the best translation of data. Visualisation of data, information and knowledge can take place in various ways. Figure 2.2 is a random example to get an idea of a dashboard. The best practices will clearly describe for what type of computers and phones the dashboard is designed and/or it will be scalable. Another factor is the choice for the presented information. Will it be only one variable that is presented, or will the dashboard combine different variables at the same time. Of course data, information and knowledge will appear differently on a typical dashboard. Also the frequency of updating the dashboard might be worthwhile to describe per best practice. From user perspective the best practices need to fit to their needs and expectations. Can the dashboard system be easily used by different people, can it be adjusted so that it fits to preferred variables, graph or colour schemes.

Benchmarking systems

Benchmarking is used to get an idea of the relative position of a specific 'object of interest' in a group. Questions such as 'does the feed conversion of farm 145 belong to the top 5% of the farms in the Netherlands', 'what is the rank of batch 16 compared with previous batches' or 'Is sow 145 one of my best producing sows'. Best practices should make clear what the purpose of the benchmark is and how and when it will be used. The best practice should make it clear what the 'object of interest' is. This can be an individual pig, a group of pigs, a compartment, a farm, an integration, a specific breeding line. Based on the object of interest it should then also be clear what the 'group' is. There are many

[2] Retrieved on April 10th 2019 http://www.pig-world.co.uk/features/forfarmers-launches-new-data-analysis-tool.html#prettyPhoto

possibilities to select and describe the group level. The best practices should clearly describe this. Maybe there are more flexible benchmarking systems that provide opportunities to select more levels of 'object of interest' and 'groups' that can be compared with. For example, the production results of a specific farm can be benchmarked against other farms of the same feeding company, or in the same province.

2. Addressing the Challenge

The challenge for the present section of the technical report was "**Use of dashboards and benchmarking tools in precision production"**. This area is of high focus in the EU and many regional projects, and is an essential topic for product and service developers and pig farmers. In the consortium of the EU PIG project a total of 32 good practices were collected addressing the challenge of dashboard systems and benchmarking. From these good practices, the top 5 'Best Practices' were selected.

3. EU PiG Best Practice

In order to identify the top five best practices using dashboards and benchmarking a series of criteria aiming at measuring the effectiveness of the collected practices to match the specific challenge were defined.

The following set of criteria have been scored for each practice.

- **Excellence/Technical Quality**
  - Clarity of the practice being proposed;
  - Soundness of the concept;
  - Knowledge exchange potential from the proposed practice;
  - Scientific and/or technical evidence supporting the proposed practice.
- **Impact**
  - The extent to which the practice addressed the challenges pointed out by the Regional Pig Innovation Groups (RPIGs);
  - Clear/obvious benefits/relevance to the industry;
  - Impact on cost of production on farm and/or provide added value to the farming business or economy;
  - The extent to which the proposed practice would result in enhanced technical expertise within the industry e.g. commercial exploitation, generation of new skills and/or attracting new entrants in to the industry;
- **Exploitation/Probability of Success**
  - The relevance of the practice to each Member State (MS) or pig producing region/system;

- Timeframes for uptake and realisation of benefits from implementation of the proposed practice are reasonable;
- Level of innovation according to the Technology Readiness Level (TRL)
- The extent to which there are clear opportunities for the industry to implement the practice/innovation;
- Degree of development/adaptation of the practice to production systems of more than one MS.

Scores had to be in the range of 0-5 (to the nearest full number). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guidelines for scoring are shown below (no half scores could be used).

0	The practice cannot be assessed due to missing or incomplete information.
1 – Poor	The practice is inadequately described, or there are serious inherent weaknesses.
2 – Fair	The practice broadly addresses the criterion, but there are significant weaknesses.
3 – Good	The practice addresses the criterion well, but a number of shortcomings are present.
4 – Very Good	The practice addresses the criterion very well, but a small number of shortcomings are present.
5 – Excellent	The practice successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.

The selection of the top five practices followed a procedure in six steps:

1. All members of the thematic group (TG) had the opportunity to send their scoring sheets to the TG leader
2. The TG members provided brief comments to the first 10 practices they have chosen as best practices, as these comments facilitated the discussion about the first five
3. The TG leader standardized all individual scores by calculating Z-scores
4. The first 10 practices have been ranked according to the average Z-scores of all participants of the Thematic Group. All other lower ranked practices have been excluded.
5. The TG leader collected all the comments of the individual members of the TG for each of these 10 practices and sent them around to the TG.
6. In a dedicated meeting, the TG discussed the results and finally decided on the top five best practices for each challenge based on the comments provided by the group.

4. Results and Discussion

4.1. Validation of the Top Five Best Practices

The following top 5 best practices within the challenge of 'Dashboard systems/Benchmarking' have been selected by the thematic group.

Title of Best Practice	**Country**
From Pig Data to Big Data	Denmark
Smart Farm 5.0	Spain
IQ-Agrar PORTAL	Germany
Use of Data Integration and Statistical Analysis to Produce Benchmarking Systems to Push Efficiency	United Kingdom
Farm Mother One-Integrated Data	Spain

From Pig Data to Big Data

The aim is to visualize real time productivity using biological parameters. Complete monitoring of feed intake, water intake, performed procedures and traditional farm recordings are presented in real time using the Agrovision Dashboard system. Routine weighing of pigs in a few pens serve as sentinel monitoring for daily weight gain for the pigs. Graphs showing trends serve as alarm system (early warning) decision support tool for all sites. When employees start the day, they check the system for alarms and check the curves for obvious issues not detected by the alarm. Employees find the system motivating as production can be followed while the pigs are alive. When detecting errors, we can often still handle the problem and improve/correct the issues manually. The work with implementing the technology has been underway during the past 20 years.

The described system is a service provided by the Agrovision system (https://www.agrovision.com/pighusbandry/) which also handles the data management. The described data are on the real time level, which in itself is quite innovative to bring that all together. This is a strong point of the system. The system addresses key data on feed, water and animal weight. On the issue of data to action they really describe the involvement of the employees who use the action lists routinely and base their action on it. The practice can be supported using online instruction supplied by SEGES (farmers research organisation in Denmark) (see Figure 4.2). Nevertheless, the underlying models for analysis and used references are not presented in the description, which makes it difficult for others to evaluate.

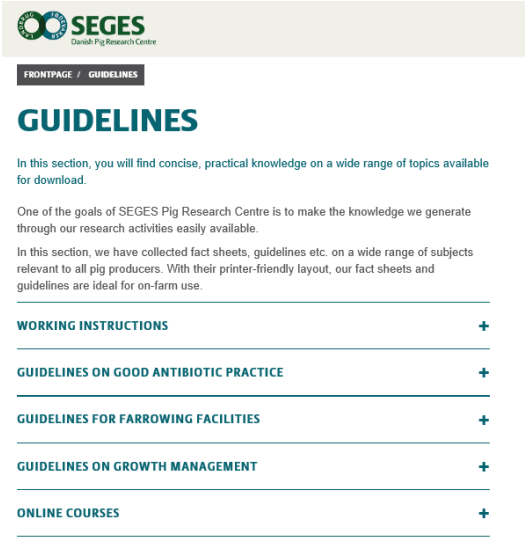

Figure 4.1 Snapshot from SEGES site for work instructions (obtained from https://pigresearchcentre.dk/Guidelines)

On the dashboard issue it is described that they use graphs and figures to explain and show the warnings. For this we have to rely on the professional software of Agrovision, where all these dashboard facilities are incorporated. Although most of the real time data are part of the system, the benchmarking facilities are not described. The focus is on the daily production process and the interaction with the employees. Focus in this system in its current version is to benchmark batches in production to previous batches of pigs and not towards other farms.

Overall, the application of a knowledge from the Danish farmers organisation (SEGES) combined with usage of commercial and professional software has the potential to deliver a rather integral solution for the pig farmers.

Smart Farm 5.0

The objective of the Farm 5.0 project is to digitalize the farm, so that they can take more advantage of all data collected by the equipment. Data from different monitoring systems is integrated. Amongst these systems, they have installed probes to measure ammonia and CO_2, to measure air quality and to control ventilation and automated extractors of semi-forced ventilation. Cooling systems are used for climatization. All environmental parameters are remotely controlled, and interconnected to provide warning data which can be controlled on devices such as a mobile phone. Pens are also equipped with special scales to control feed intake and weight, and data is also sent to the software to be integrated with the rest of information. Data which the farms generates is in the cloud and is integrated and can be accessed by technicians or veterinarians, or farmers from anywhere with internet access. In this way, we have reduced the time of intervention in front of any problematic issue.

The companies in the Vall Companys Group make up a completely integrated production and commercial process at all stages, from feed production, reproduction, and animal rearing (up to slaughter), meat processing, packaging and distribution of the end product, as well as all complementary processes (veterinary pharmacy, integrated logistics, etc.). For the pig production part in Smart farm 5.0 they concentrate on piglet rearing, sow farms and finishing pigs. This policy of verticalization and integration means that any product can be fully traced from its source and ensures the constant quality of the entire production line. In addition, the companies in the Group meet demanding standards for certification and health controls, which are a guarantee of hygiene and integrity.

With regard to the item 'from data to action' the smart farm 5.0 seems to cover the whole range. Data is collected from several processes. The alerting and the control description suggests that these data are also being used to identify and perform specific action. The description is not clear enough to see whether they work with specific key indicators, what their references are and what kind of alerting and decision support models they use. Also, it is not clear from the current description whether they work with specific Standard Operating Procedures to standardise the actions in different farms. It can be assumed that the smart farm 5.0 system works with different dashboards. It is stated that the farmers can use their mobile phone, but it is expected that there will be more users and locations and systems, like the office of the farmer or the central office of the integrator. It is not clear whether they all work with the same dashboards or that they are made specific belonging to the role of the users. With regard to the benchmarking the smart farm 5.0 system is perfectly equipped to benchmark the farms and barns within the smart farm 5.0 environment. Data and information is coming to a central place.

The claim is that by improving air quality, controlling growth curves and integrating all these data in a concept of smart farm it is expected that the number of days that pigs need to get the slaughter weight and the veterinary and treatment costs will be improved. These claims and the total concept need to be elaborated in the coming years. The basics of the system are very promising.

IQ-Agrar PORTAL

IQ-Agrar PORTAL is the internet portal for analysis of data from marketing, animal health, farm management and quality assurance. In addition to basic analysis of slaughter data, other sources of information are connected. The basis is the analysis of the approximately 30 million processed slaughter data (classification of the carcasses and health information per year). User specific analysis options and descriptive graphics are available. Individual filter options are given to users, based on the latest IT-Technologies. To detect the potential in weight sorting losses, it's possible to analyse single slaughter dates and delivery periods for management and marketing decisions. Alarm lists, market info and monitoring information are shown in Widgets for quick overviews. For quality assurance,

customers receive detailed information on antibiotics, salmonella or residue monitoring. Furthermore, auditing management information, aspects of animal welfare and individual labels are presented.

The short description shows that in the area 'from data to action' most elements are present. Data and information are covered quite well. According to the website, the users have the possibility for proactive management by retrieving forecast analysis based on predictive calculation. However, the authoring experts did not find a description of the used models. The lack of a model description reduces the ability to understand how to interpret the resulting forecast predictions, as forecasts are never better than the combination of data and the model. The IQ-Agrar portal therefore is more a well-designed information portal for several users. The user is presented with a variety of dashboards. Figure 4.1 (obtained from the website) shows its diversity. It can be assumed that different users can be supported. Of course this is based on the data that are stored in the database. This database in itself looks huge, but the main focus is on slaughter and market data. How individual pig farmers receive this information and whether they can use it directly for their decisions is not clear form the description.

Figure 4.2: IQ-Agrar dashboard examples (obtained from https://www.iq-agrar.de/iq-agrar-portal/)

The claim of the IQ-Agrar system is that the slaughter, quality and marketing information is scientifically based, beneficial for different users and can be used to optimize different processes. The system is well qualified to benchmark different pig farms and help the network to improve itself. The variety of the dashboards to present the information in different ways might be the strongest point of the IQ Agrar system.

Use of Data Integration and Statistical Analysis to Produce Benchmarking Systems to Push Efficiency

Disparate data sources meant finding meaningful information for evidence based management decisions is a challenge. Aggregate data hides inefficiency and often data sources have no common link from sow and sire data through to slaughter data. Use of RFID tags to link data at an individual level, a logic box system of software that performs statistical analysis of data across the entire production process and actively pushes a report to the farmer that deliberately highlights the inefficiencies in production. The farmer is shown exactly where in the production process improvements are needed. Using a database of 600,000+ sows plus finishers as a benchmark. Sourcing technology and software were the main costs. Pigs were tagged at birth and data was integrated using

APIs into one piece of software. Off the shelf package so ready to install and run immediately. Significantly increased production efficiencies and cost savings. Data integration is key.

What is described is more a concept in which data from individual pigs are brought together in a database. Pigs are identified by using RFID tags. What is not described is the type of data that is harvested and whether this is done by using sensing technology and/or human input. It can be imagined that following pigs from birth until slaughter involve a variety of data. The item from data to action is therefore not clearly described. When it comes to action, only one type of report is mentioned. A report is pushed to the farmer which highlights where the production process can be improved. In itself, this is very valuable information, but it is unclear what type of model is used for that, and traditional statistical analysis is not enough to this difficult job. On the dashboard part the described system seems to be limited to a report that is send to the farmers. It looks like there is no interaction with the farmer and how information is shown is also predetermined. The system is able to use data on individual pig and sow level. In this sense it is quite novel in the pig industry.

The system is a service of the **Agriculture and Horticulture Development Board (AHDB)**. AHDB is a statutory levy board and is funded by farmers, growers and others in the supply chain. They inform and inspire farmers, growers and industry to succeed in a rapidly changing world. The described system is used to help their pig farmers in looking at the critical parts in their production process. The benchmarking facility is the strongest point and is used to give a clear advice to the farmers. What they do with the advice is their own responsibility.

Farm Mother One-Integrated Data

At the OPP Group they recognised the need to create a system that coordinates different software systems that are used in pig farming and they want to manage them in a clever manner. They created Farm's Mother, a unique platform for software integration of different systems, data analysis and management. In this way, benchmark and analysis of KPI's (Key Performance Indicators) is simplified. By using an efficient filtering and data merging process, Farm's Mother One is capable of obtaining and analysing the metrics of a company or facility from any computer connected to the internet. OPP Group created Farm's Mother Batch for facilities where animals do not have RFID chips incorporated, and therefore neither do have electronic sow feeding stations. The functioning of Farm's Mother Batch is identical to the one of Farm's Mother, with the only difference that data are manually introduced in the system. FM Batch's user has the option to keep the software on the cloud, or to have a dedicated computer in the farm.

The OPP group is an integration where sow farms, piglet rearing, and finishing pig farms are working in the same group. This might be the main reason why they could invest in bringing all data form all the different systems together. This might be directly the strongest part of the system that they indeed created a platform to do that. On the issue from data to action Farm's Mother receives data and information from different systems that operate in the farm, interrelate this information, analyse it and generate and send back alerts to the systems as required, keeping the farm personnel informed about potential issues that may arise and contributing to cost optimization and a stricter control over daily operations. Farm's Mother can be easily integrated in the normal functioning of the farm, becoming the true heart of the facility. It looks like the full circle from data to actions is present and by doing this on central level it brings also some standardisation in the decision process. The analysis and decision support techniques used are not clarified.

On the dashboard issue it is stated that users can select their own KPI's. This is a nice option and fits to farm specific management support. How this is coming back in the dashboard is not explained. At the website a mix of lines and graphs can be seen, but from a dashboard perspective this could be improved. The architecture (see Figure 4.3) suggests that there are different user levels for enterprises, mobile phones and reports.

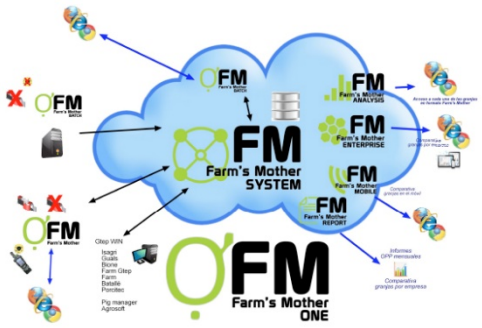

Figure 4.3 Farm's Mothers architecture (obtained from http://oppgroup.com/en/proyectos-i-d-i/farms-mother/)

The Farm's Mother One is perfectly suited to benchmark within the OPP group. Data on different levels and variables is available. However, it is not clear yet whether they use the benchmarking facility for supporting operational decisions or more on the strategic or tactical decision level. The potential of the benchmark is increased quite a lot since there is also an option to bring in data from batches. It is not described how feedback is given to the batch-connected farms.

4.2. Cost and Benefit Analysis of the EU PiG Ambassador

Best practice 'From pig data to big data' from Denmark was chosen as EU PiG ambassador 2019 for the challenge 'dashboard systems/benchmarking'. The best practice innovation basis on the implementation of a complete monitoring system of feed and water intake, performed procedures and all farm records. Additionally, routine weighing of pigs in few pens serve as monitoring of daily weight gain. The costs and benefits of this system have been analysed, taking into account the estimated changes in technical performance parameters being result of introduction of the system and necessary investments on the case study farm Stovgaard. Basing on the real farm data and calculations with the Interpig model the following parameters of the farm has been assumed:

Benefits:

- The feed efficiency increased – estimated extra daily weight gain due to monitoring is 100 gram/day in finishing phase.
- Vet costs are lower by 5-10% due to more precise treatments.
- Mortality of pigs improves due to monitoring by 5-10% depending on the initial level.

Costs:

- An initial investment cost related to the monitoring system was ca. 15 000 € per 6000 pig places (ca. 2,5€/pig place), and additionally 2000 € per year of maintenance costs of all sensors (ca. 0,33 €/pig place). Additionally, the software functionality maintenance costs were ca. 564 € (0,094 €/pig place).

Based on these assumptions variable production costs after implementation of best-practice **decreased by 5,8%** as per kilogram of meat, mainly due to lower feed and vet costs per pig (additional costs of system maintenance had smaller impact than the efficiency gains, which resulted in reduced average variable costs per kg). A decrease was also observed in case of fixed costs by **3,4%** per kg (investment costs were offset by the increase of production). As a result, the total costs were **lower by 5,2%** per kg of slaughter weight (€ 1,44/kg vs € 1,37/kg hot slaughter weight).

4.3. Expert Analysis

The ambassador best practice ‘From pig data to big data’ and the other four were chosen from a long list of good practices. What became clear during the selection process and writing the technical report is that there are a lot of different ways to bring data together. And that there is no one best option. The structure of the pig sector influences this quite a lot. The best practice from Denmark and Spain are very strong in bringing a variety of data together. In Denmark, the practice has been pushed forward by the farmer for many years and has been implemented in collaboration with Agrovision, where the farmer himself has been the driving force. In Spain the practice is dominated by integrations. The best practices show big differences in the cycle from data to action. Some of them stop at the information level. When analysis and knowledge is added, the systems are also able to give warnings and alert. However, none of the described best practices demonstrated what type of analysis, models and references they are using. This can be improved quite a lot and can be used to gain trust by the users. However, it must be stressed that it was outside the scope of this report to follow up with each supplier regarding documentation, thus only the supplied description was included in this expert analysis.

Based on the supplied descriptions of good practices, the IQ-Agrar system seems to be the most outstanding with regard to the supplied dashboard. Regarding dashboards, it is the experts’ opinion that the functionality in all the good practices could be improved.

The benchmarking potential is present in almost all described best practices. It is clear that bringing data from different farms and computer systems together in a more centralized database seems to be a prerequisite for proper benchmarking. However, there is much room for improvement in the manner of bringing data into a streamline of management decision processes enabling farmers to make better decision in managing pigs in the barn and on strategic level.

For the whole topic of dashboards and benchmarking it is very hard to specify where benefits occur. In essence, it is about improving decisions of the users. The variety of users and processes that are managed makes it difficult to give one statement on added value. However, it is clear that digitalisation makes it possible to base decisions more and more on quantitative data. Indirectly, awareness of what is going on at a pig, group and farm level is improved when registrations can be viewed by the farmer in a dashboard.

4.4. Conclusions and Advice to Industry

Based on the described best practices the following statements can be made:

- Many dashboards focus on showing a type of information rather that describing the KPI of a process. The industry should focus on showing relevant KPIs.
- Potential of benchmarking is available, but more emphasis should be put on the level of advice that comes out of the benchmarking systems. Is it for operational, tactical or strategic decisions.
- The industry should showcase how application of the “Dashboard systems” increase performance, revenue on farm/batch level rather than focusing on the “ability to follow water consumption/display alarms for diarrhoea/etc.”.

The advice is to be pro-active in the developments of digitalisation and to create more awareness amongst different users that the systems should be user friendly and fit to their management processes.

5. The Future

The challenges for the future are:

- Be aware that developments in IT will be exponential and more dashboards and systems will emerge. Do not be afraid of this, but be part of it and be critical to what really fits to different users and pig farming systems. As a farmer, choose a system that solves a known challenge at your farm. It will be challenging for the farmer to choose a well suitable system.
- The manufacturers of barn equipment should already now implement and address the challenge of integrating data into one platform. These data include all possible records in any system that can be linked to status of equipment, disease, behaviour of personnel, timepoints of actions, power consumption of engines etc.

If the different producers seek to exclude other partners in the industry the farmers will lose possible benefits. As an advisor I would recommend systems that integrate data exchange well across platforms as this will be a key focus in management in the future.

- Better understanding of the different types of dashboards, and users, will add more value. It can be expected that the platforms to present dashboards and to interact with will also change in the future.
- A big step is needed to work with open and transparent decision models. The current models are not transparent enough, but it could also be argued that the models should be the intellectual property of the commercial companies. Multivariate modelling, time series and Artificial Intelligence will be used in the future, but an important step will be the use of appropriate reference values and the insight that users have a choice in this. Conclusively, either the dynamic/statistical model should be transparent, or the company must present independent validated tests of the performance of the system.
- In education and training, the future generation of pig farmers should be trained in this and they should have some basics in digital skills. Furthermore, the farmer must understand the basics on the link between the measurements and biological concepts of what happens in the barn.
- Systems claim or strongly hint a value of purchasing the system. However, many of the systems have not yet sufficiently and appropriately demonstrated the actual value either as a tool to predict certain biological correlations as an everyday management tool or demonstration of economic value. We need to do a better job of identifying and evaluating the benefits of precision tools and attaching a monetary value to that.
- For adoption of innovations the best advertisement is when users exchange their experiences and are willing to ask for improvements in the system. Organisation of these networks might be the way forward.