EU PiG

EU PiG Innovation Group

Technical Report

Welfare

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Challenge: Reducing Aggression Between Animals

Introduction

In this technical report an overview is provided of good practices that are successfully applied in pig farms in Europe. Pig farmers and farm advisors can use this report to learn more about how good practices have been implemented on the farms and what challenges these practices are able to tackle. This third-year report on the theme "Animal Welfare" deals with the challenge of ***Strategies to reduce aggression between animals.*** This refers to management systems, novel techniques and technologies that lead to a reduction in the level of aggression between farm animals at any stage of production. Aggression is present in many pig farms and may lead to welfare impairments and even carcass depreciation. The factors that contribute to high levels of aggression observed on commercial pig farms need to be understood, so that the negative consequences such as injuries, stress, pain, fear and reduced productivity can be minimised.

1. Background to the Challenge

Aggressive behaviour is inherent in farm animals as the environment is generally constrained and optimized and induces regular changes in the composition of social groups. This reduces the welfare of pigs and may also have consequences in terms of production: abortions or litter size reduction if fights occur at sensitive periods of the reproductive cycle, reduction of animal growth, skin lesions, lameness, increased stress and disease susceptibility. Aggressive behaviour is normal behaviour, but it should be minimised, and negative consequences prevented.

The rules of organization of livestock buildings and the recommendations in terms of equipment (feeders, drinkers, enrichment material, etc.) aim to aggression risks: limiting the number of times growing pigs can be mixed, and pen size requirements to avoid mixing of animals during the different growth phases are examples, as is ensuring each animal has an easy access to resources.

However, breeding performance changes regularly and may undermine this type of breeding organization, especially when reproduction and finishing are present on the same farm. In addition, many specifications related to labels, by imposing an increase of surface per animal, may change management practices, induce new building constructions, and no longer make it possible to guarantee the stability of groups over time. In fact, the beneficial effect of increasing the available floor area per animal on limiting aggression is partially mitigated/reduced by changing the composition of the groups. Other modifications in equipment and management practices on farms can also generate aggression. Keeping pregnant sows in large dynamic groups leads to regular changes in the social structure of the group, animals entering and leaving the group regularly; challenging the existing hierarchy, and sows competing for access to the Electric Sow Feeder.

The rearing of entire males is another situation leading to aggressive behaviour. Entire males initiate more fights than castrated males or females. The management of the environment and the animals are then necessary to limit aggression. At present, the rearing of boars concerns only a few countries in Europe, but the extent of this production will become more and more important in the future. The consequences in terms of aggression levels will also depend on the age at slaughter of these animals.

Finally, the departure for the slaughterhouse of pigs is a last phase at risk of aggression on the farm. Limiting mixing of animals from different finishing pens requires modular pens where familiar animals can be kept together before leaving the farm, reducing aggression in the waiting phase at the abattoir.

In summary, aggressive behaviour is a common welfare and management problem in intensive pig production, and this topic is of interest to most EU pig producers.

2. Addressing the Challenge

Aggressive behaviour, also called agonistic behaviour, has evolved as an adaptation to regulate the social life of pigs, including the establishment of a dominance hierarchy in stable groups. Under natural conditions, agonistic behaviour arises as an interplay of adaptive social strategies of individuals, thus forming the rules that govern living in social groups (Lorenz, 1966). In pigs, aggression in natural or semi-natural conditions is rare (Stolba and Wood-Gush, 1989), once a dominance hierarchy has been established. Indeed, the establishment of a dominance hierarchy is a strategy to reduce the number of aggressive encounters of pigs living in groups. By contrast, unfamiliar animals will engage in repeated contests through which individuals learn their place in the social hierarchy (East and Hofer, 2010), and this limits the need for repeated fighting. There are three aspects to be considered concerning dominance hierarchies. First, a hierarchy is specific to the members of a particular group, and, as such, if individuals are added to or removed from the group the hierarchy often needs to be settled again (Ewbank, 1976). Second, the rank of an individual in one group is not always indicative of the rank it will hold in another group (Lindberg, 2001). Third, even in stable groups an individual's rank can change with age and/or the need or value placed on a resource being competed for (Lindberg, 2001).

The level of aggression among pigs living under commercial conditions can be high in certain periods, and is more frequent compared to semi-natural conditions, because disruption of the established social order can happen frequently and because the allocated resources do not always meet the needs of all pigs (Velarde, 2007). Thus, the two main forms of aggression in commercial settings are (1) those observed post-mixing and (2) those observed once a hierarchy has been formed. Note that outbreaks of tail biting have also been labelled as '(severe) aggression', as the behaviour involves injury and the (intense) pursuit of victim pigs. However, tail biting is an abnormal behaviour ethologically related more to (frustrated) foraging behaviour, and not to aggression/agonistic behaviour *per se*.

The mixing of unfamiliar pigs is a common practice at many stages of commercial pig production. Often pigs are mixed with conspecifics that are similar in age, size and sex and into groups that differ markedly from those encountered in wild conspecifics (where typically a sow and a few of her daughters form a group together with their offspring). The first time pigs are normally mixed is after weaning with a second mixing during the (start of the) growing/finishing phase. Group housed sows are often mixed into groups with unfamiliar conspecifics early in each gestation. Aggression associated with mixing and hierarchy formation can be intense, but is normally short-lived, with most fights occurring within 2-3 days following mixing (Fels et al., 2014). In comparison, once a hierarchy has been formed, aggressive interactions are normally shorter in duration but can occur frequently (Spoolder et al., 2009). It typically occurs over competition for access to, or defence of, a restricted resource. All these triggering mechanisms (mixing and competition over access to resources) should be considered when looking for strategies to reduce aggression, which may be classified under the following areas: (1) genetics; (2) avoidance of mixing and/or mitigation of the effects of unavoidable mixing of unfamiliar animals; (3) proper management and allocation of resources (4) early experiences and resemblance of natural behaviour.

(1) Genetics is a factor affecting the level of aggressive behaviour of individual pigs. Pigs of the same breed produced by the same company may differ greatly in their

aggressiveness. A positively skewed distribution whereby a minority of pigs engage in very high levels of aggression has been found in populations studied, each from different breeding organisations (Turner et al., 2009; Desire et al., 2015). Some aggressive behavioural traits have heritability's as high as that of growth rate (e.g. duration of reciprocal fighting h^2=0.43, Turner et al 2009). For gilts and sows, aggression received post-mixing is moderately heritable (h^2= 0.42, Stukenborg et al. 2012), whereas the heritability of severe aggression is lower (h^2= 0.24, Løvendal et al 2005). The number and location of skin injuries is predictive at the genetic level of the severity and type (reciprocated or non-reciprocated) of aggression that pigs engage in. Therefore, breeding for reduced aggressiveness appears to be a sensible strategy, although there are potential drawbacks and knowledge gaps which need to be addressed, such as the effects of this selection on other behavioural traits and on productivity (Desire et al. 2015; Turner et al., 2018).

(2) Avoidance of mixing of unfamiliar animals is obviously one of the most powerful strategies to reduce aggression in pigs. However, under the present production schemes this is quite difficult to achieve. Therefore, farmers have to consider other aspects of management and allocation of resources to mitigate aggression. Provision of sufficient space, specially to be able to allow pigs to define different activity areas and of other resources such as feeders, drinkers and point-source enrichment materials is necessary to avoid high levels of aggression after mixing and after hierarchy formation. Some studies have suggested that the incorporation of small boxes along the pen walls reduces the frequency of attacks after mixing (McGlone and Curtis, 1985) and solid partitions were also investigated without (significant) beneficial effect on reducing aggression (Olesen et al. 1996). Enrichment material of the pre- and post- weaning pen may be more successful to reduce aggression once a hierarchy has been established than it does following mixing (Oostindjer et al., 2011). Although the exact mechanism is unclear, environmental enrichment may reduce aggression by providing distraction for pigs, an outlet for highly motivated behaviour (e.g. rooting) or opportunities for the pig to express control over its environment. However, considerations of the novelty, accessibility and availability of an enrichment as well as its relevance to pigs is required if it is to effectively reduce aggression (van de Weerd et al. 2006, Fàbrega et al., 2019).

(3) Proper management and allocation of resources. Administration of pheromones has also been reported as a methodology to reduce stress and aggressive behaviour in different studies, mainly the pig appeasing pheromone (PAP) which is found in the sebaceous glands of the mammary glands of the lactating sow (Temple et al., 2016; Ramírez et al., 2019). Pageat (2001) developed a synthetic analogue of the PAP based on a mixture of fatty acids similar in composition to sow skin secretions. Several recent studies have examined the effect of the PAP spray on the behaviour and physiology of sows and growing pigs during mixing and transport, finding reductions in the level of aggression and skin lesions 24h after mixing (Guy et al. 2002, Ramírez et al., 2019).

(4) Early experiences and resemblance of natural behaviour. A final strategy to reduce aggression could be early socialisation of piglets, in which case piglets of different litters

are allowed to mix between 7 and 14 days of age. This strategy resembles the natural behaviour of the sow and her litter, in which she returns to the herd following a period of isolation around farrowing (Stolba and Wood-Gush, 1989). Thus, it is argued that allowing piglets to mix at this age would not be associated with overt fighting, but only result in aggressive elements as part of/also shown in play behaviour (Newberry and Wood-Gush, 1988). Previous trials have found this strategy to reduce aggression later on in life (Fàbrega et al., 2013; Rydhmer et al., 2013).

Aggression is a common behaviour problem in intensive pig production and many of the strategies described previously can be implemented similarly in different countries. This is why many farmers are testing management techniques to limit its impact.

3. EU PiG Best Practice

In total, 34 best practices were scored.

In order to identify the top five best practices across all the EU PiG regions a number of criteria were used, which enabled an assessment of the effectiveness of the collected practices to match the specific challenge. 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 addresses the challenges pointed out by the R-Pigs Groups;
    - 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 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 Member State

- **Innovation**
  - How innovative is the best practice?

Scoring was done on a scale from 0-5 (to the nearest integer). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guideline for scoring is shown below.

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 five steps:

1. All members of the thematic group (TG) received all relevant information on the candidate good practices that were submitted to EU-PiG.
2. The TG members scored all the candidates for the above-mentioned criteria.
3. The average score for each of the three criteria was calculated for the score that were provided by the TG-members.
4. A final score was calculated for each of the applications as the average of the mean scores of the four main criteria.
5. The applications with the top five overall scores were proposed as candidate best practices.

4. Results and Discussion

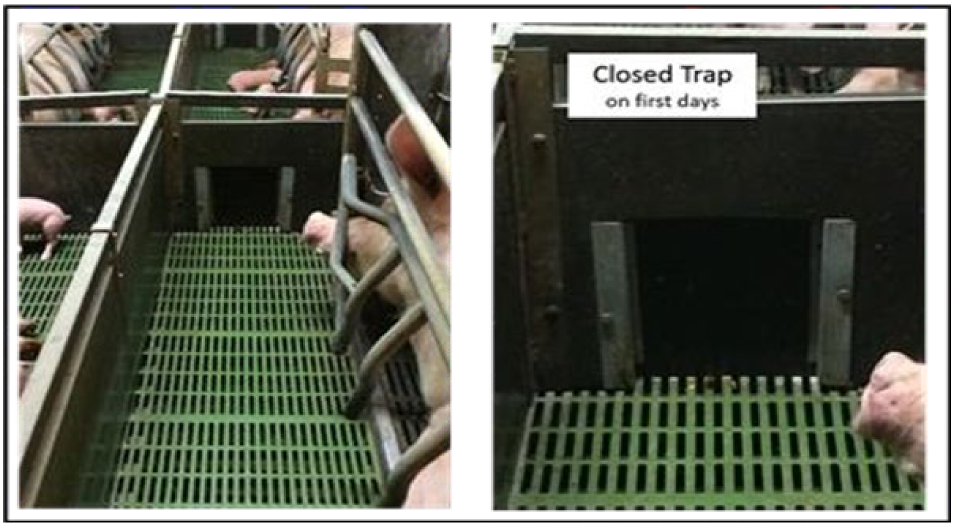
4.1. Validation of the Top Five Best Practices

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

Title of Best Practice	Country
Doors for Piglets	France
Preventative Fence	France
Choice of Genetics to Limit Bites	France
Use of Maternal Pheromones to Reduce Stress	Belgium
Higher Feeding the First Week to Prevent Aggression (Sows) in Loose Housing Gestation Systems	Denmark

Doors for piglets

The sows and their piglets are housed in individual farrowing pens. The practice is to drill openings in the panels (20 cm x 30 cm) between the pens so that the piglets can move from one pen to another. Doors are placed on these openings during the first week of life of the piglets, then removed. The piglets of 5 boxes can thus be mixed during the lactating period, which facilitates the adaptation to mixing at weaning. At weaning, pens have groups of 26 piglets. Observations of these piglets compared to piglets not familiarized during the lactating period show that the number of lesions is much lower 5 days after arrival in the nursery, especially on the ears and the front of the piglets: 26% of the familiarized piglets have scratches, while 98% of unfamiliar piglets have scratches.



EU PiG Evaluation of the Idea

Familiarization of piglets at an early stage is a practice that has been proposed by several countries for this challenge. This one was chosen because it was supported by technical data and measurements showing the effectiveness of this practice in reducing post-weaning aggression and improving piglet growth. Moreover, it consists in removing part of the separation between two farrowing pens by the creation of an easily removable door, unlike certain/other practices based on a total removal of the separation. This makes it possible to quickly restore the initial pen if it is necessary, e.g. to treat and manipulate the piglets making it possible to catch them more easily. Especially also in case of diarrhoea or contagious disease, it may be wise the be able to separate the groups to (perhaps) contain spread of disease.

Grouping the animals at an early age is expected to limit the number and severity of lesions resulting from aggression following mixing; the data presented confirm this. Access to the udder is hardly disturbed as sows rapidly synchronize their suckling activity, with most piglets returning to their original pen and their mother. In addition, the presence of passages between the farrowing pens increases the accessible area for the animals (e.g. to explore) and makes it possible to better distribute the animals on the totally available area when litter sizes vary. While this practice has many benefits in behavioural terms, it must take into account the health risk of spreading diseases (diarrhoea). The resting behaviour also needs to be monitored. Will the piglets all pile up in a too narrow resting area, thus forcing some piglets to rest on the cold(er) slatted floor and/or near the sow (with the risk of getting injured)? Further research is to be conducted on this subject.

Preventive Fence

The practice is about the use of a fence similar to that used in outdoor sow pens to separate a free space when sows are introduced into the large group with an automatic feeding system. The day before, or several days before the arrival of a new lot of sows (according to the number of sows present and the space available), a space is released/allocated in the box and delimited by this flexible fence. This fence is removed just before the introduction of the new group/batch of sows, which will quickly colonize this area. The sows were fed before being moved. The observations show that when the fence is removed, the new animals will rest in the empty area, and the level of aggression with the sows already present in the room is limited.

The new sows (in pink) stay together	The sows already there in first view, the new sows at the back of the picture
	

EU PiG evaluation of the idea

Housing sows in large groups with an electronic sow feeder (ESF) is one of the most attractive systems for pregnant sows. The animals have more space, have secure access to the food in the ESF, and can use the space by defining functional areas (resting area, dunging area, activity area). The main problems to deal with are the fights when a new group of sows enters the main group, with possible consequences for embryo resorption, returning to heat/empty sows and litter size /on the pregnancy and birth rate, and the risk of injury and lameness if the floor is slippery. The proposed technique is simple to implement and helps to limit aggression. It supplements other farmers' practices with the aim of creating a free area for new sows; this temporarily limits the space available for sows already present but as hierarchy is already established within this group, this restriction has little consequence. This is easily transferable to any country with large dynamic groups of sows without extra costs.

Choice of Genetics to Limit Bites

The farmer manages a farrow to finish unit of 170 sows. It has a post-weaning capacity of 850 places on slatted floors and a finishing capacity of 12 places on straw litter. The breeder is committed to a "Red certification label" approach for meat quality, so all boars have the Halothane NN genotype. The females are all European-Sino crossbred sows (Large White * Landrace * <10% Chinese breed). The breeder performed a test comparing 4 different male genetics, each time making comparisons 2 to 2. She reported her observations by performing tail length measurements and the severity of the bites (referring to a scoring grid) measured in 50 animals at each of the following stages: immediately post weaning, before entry in the finishing unit and before the departure to the slaughterhouse. These tests show a very strong influence of genetics on the propensity of animals to bite and cause tail/skin lesions!

EU PiG Evaluation of the Idea

The proposed practice evaluated the impact of father's genetics on the risk of tail biting. Tail biting is not directly related to aggressive behaviour and depends more on abnormal behaviour usually motivated by frustration. The bibliography has revealed a genetic effect on the risk of aggression. The observations made here show very different/distinct/clear effects of the father['s genetics/race] on the risk of biting, under similar housing conditions. Out of 50 pigs noted, the number of bites was the lowest when a Duroc boar was used, and the highest when a boar of a synthetic line was used. Although intra-breed variability is important for the risk of aggression, these results show the need to take into account the genetic effect in the problem of tail biting and tail docking.

Use of Maternal Pheromones to Reduce Stress

Pheromones are species specific. Sows are secreting pig maternal pheromones that influence the social interactions between pigs and piglets. They have a calming effect on pigs and piglets and reduce stress. Stress causes discomfort and fighting. If stress is reduced, animals are growing better with better technical results, less disease and lower antibiotic use. IRSEA is a French research centre specialized in ethology and semiochemicals. The product that we are testing is SecurePig®. We are testing these maternal pheromones in different groups of pigs: - Gilts: to improve social behaviour - Pregnant sows: to minimize fighting when they are brought in the group housing units. - In the farrowing pen: to make the mother-piglet relationship stronger (a lower piglet mortality due to biting or crushed piglets) - At weaning: to reduce weaning stress, fighting and to have a better feed intake with better technical results; also for disease prevention and lower antibiotic use, e.g. to treat Streptococcus infections.

EU PiG Evaluation of the Idea

The group of experts like the idea of reducing stress by adding pheromones in spray form, but there is no certainty about the effectiveness. The pheromones in block form may be a promising tool to reduce food neophobia and aggression after mixing. Still, further research is needed to increase the effect of the PAP (pig appeasing pheromone) block over time under commercial farming conditions. However, we found it an innovative and inspiring strategy that can be useful for some pig farmers. That's why it's voted into the top 5.

Higher feeding the first week to prevent aggression among sows in loose housing gestation systems

Aggression and fighting occurs in connection with hierarchy formation between the sows after movement to the gestation unit where the sows are loosed housed. About 1-2 sows (5-10 percent) in each batch get injured (legs, scratches and abortion), and sometimes a sow is so badly injured (legs) such that the sow has to be killed. The small and youngest sows are at an elevated risk of getting injured. To prevent aggressive interactions between the sows after movement to gestation pens, the farmer gives the sows a 50 % higher feeding ration during the first week after moving.

The troughs are filled up, when the sows arrive to the pens. They implemented the feeding regime about 6 months ago. Normally, the sows are fed 1.8 FE (feeding value) per day during the first week. In this case, the sows are fed 2.7 FE per day. Because the sows are fed wet feed using a feeding curve, it is easy to set up this elevated feeding level using the feed-computer.

EU PiG Evaluation of the Idea

An elevated feeding level (a higher level of metabolic energy) is one of the strategies to reduce aggression among pigs after mixing. Farmers need to take care, however, that the sows don't get too fat, thus they will have to restrict the feeding level later in gestation. Since gestating sows already have high levels of feeding motivation (want to eat more than they physiologically need), this may reduce welfare later on. Farmers should take care to minimise the level of stress (esp. mixing) around the time of implantation of the embryo's (about 12-26 days after service). An alternative may be to raise the feeding level during the first week by providing feed with a higher fibre and a lower energy content. This improves satiation too. But the question remains if this really reduces aggression at mixing.

Note that this feeding strategy may not work during weaning (McGlone, 1986).

Arey and Edwards (1998) write in their abstract on mixing of gestating sows: “long term stability can be affected by several factors including method of feeding. Fighting is less intense between pigs of unequal sizes, may be reduced by previous exposure but is less affected by the presence of a boar. Larger groups have more hierarchy positions to resolve and therefore more fighting. Greater space allowance appears to have little effect on fighting at mixing but can reduce aggression in the longer term. Barriers can limit aggression by allowing losers to escape more easily. Provision of ad libitum feed has been shown to reduce aggression over the short term. Straw bedding has no effect on fighting. Chemical intervention techniques would appear to delay rather than reduce fighting. Newly mixed sows should be supervised to reduce fighting.” Timing of grouping is also important.

“In a sequential feeding system with plentiful straw, aggression is not influenced by the level of feeding. In these systems, the major factor giving rise to aggression is the introduction of new sows to the resident group.” (Spoolder et al., 1997).

4.2. Cost and Benefit Analysis of the EU PiG Ambassador

Best practice ‘Doors for piglets’ from France was chosen as EU PiG ambassador 2019 for the challenge of “Strategies to reduce aggression between animals”. The farmer has developed a system with door-openings between the individual pens for sows with piglets. That makes possible that piglets from 5 pens can be familiarized during the lactation period. The costs and benefits of this system have been analysed taken into account the changes in technical performance parameters. Basing on the Interpig model with the real farm data implemented, the following parameters of the farm has been assumed for calculation (farm size 600 sows, breeding and finishing):

<u>Benefits:</u> Making openings in panels separating farrowing pens such that piglets can get access to (several) neighbouring pens seems to be a very good idea. The openings can be made at a very low cost to the farmer. It only requires some labour (to make the openings) and material (e.g. metal strips to hold the ‘doors’, where ‘doors’ can be made of a couple of extra side-panels). This solution can be applied widely (by many farmers and across countries and farming systems, e.g. this solution may also benefit organic pigs). The solution is also reversible in that the doors can be closed again, when this is preferred for some reason or other. The largest benefit of this proposal is that it provides at such a low cost more natural conditions for pigs, even in the most intensive of circumstances, i.e. that it allows the piglets to have more space and get acquainted with other piglets of the same age, as well as with other sows. This is expected help them cope better with social stressors, esp. weaning stress, later in life.

- Piglets growth rate increased by 25% (familiarised piglets - 552g/day vs. unfamiliarised 442g/day). 12 days after weaning, familiarized piglets are 1 kg heavier (13.3 kg per piglet) than unfamiliar piglets (12.3 kg per piglet).
- The weight at slaughter (at 151 day on this farm) was 1,7 kg higher in case of familiarized piglets comparing to unfamiliarised group. It means that the same slaughter weight could be obtained ca 2 days earlier in case of familiarized piglets.
- Piglets were less aggressive - proportion of piglets scratched in the batch after 48h after weaning in case of familiarised piglets was 26% and in case of unfamiliarised 98% of piglets).
- Veterinary costs per piglets were lower because the Metaphylaxic treatment with Amoxicillin at weaning was avoided in case of almost all familiarized piglets (the 2% prevalence of arthritis was observed in case of not-treated familiarised piglets, which was the same as for unfamiliarised with antibiotic treatment); (Vetrimoxyn PO oral 5 days at 1 gr / per piglet for 5 days - Extra cost per piglet: 0.2 € per piglet for antibiotic metaphylaxis - being for this farm of 600 sows, a saving of 3900 euros per year (6,7% less per sow/per year).

Costs: The economic costs to the farmer of this solution is, as indicated above, very low. Another 'cost' may be that the farmers who adopt it will have to learn to work with the system. The thorough cleaning of farrowing pens will also take a little longer, and diseases may spread a bit more easily. However, though this may be the case, it may also prevent disease problems later in life (when these piglets will probably be mixed anyway). The main pig-welfare bottleneck of current farrowing pens, esp. in intensive pig farming, is the fact that sows cannot turn around.

- The costs of labour does not change
- Investments: 5 euro/pen/year

Based on these assumptions variable production costs after implementation of best-practice decreased by **0,5%** as per kilogram of slaughter weight, mainly due to better piglet growth and lower vet costs. Decrease was also observed in case of fixed costs by **2,3%** per kg since the production cycle was slightly shortened. As result, the **total costs were lower by 1%** per kg of slaughter weight (€ 1,407/kg vs € 1,42/kg hot slaughter weight)**.** When recalculating the benefits per piglet production, where the highest changes are observed, the total costs of producing one piglet **decreased by 1,9%.**

4.3. Expert Analysis

Though considered a very nice idea, its value will have to be confirmed, both in research and in practice. Farmers may benefit from exchanging information about what works best (and what doesn't work) regarding this appreciated suggestion to enhance piglet welfare in the farrowing pen in a feasible way and to reduce social stress later in life. The early developed social skills will be beneficial during mixing just after weaning, as a growing-finishing pig, but also as a gilt during the first pregnancy among the older sows. Different types/breeds of pig and/or types of housing/management systems may require finetuning of the suggested solution, e.g. with respect to the (minimum/maximum) age the piglets may be mingled and the number of pens than can be connected without e.g. too much risk of cross-suckling or other malfunctioning of the system.

Potential costs and benefits were described in the previous section. The theoretical benefit was described in section 3. Addressing the challenge, under point the fourth point to deal with aggression (besides 1. Genetics, 2. Avoidance of mixing and 3. Proper management and allocation of resources):

(4) Early experiences and resemblance of natural behaviour. A final strategy to reduce aggression could be early socialisation of piglets, in which case piglets of different litters are allowed to mix between 10 and 14 days of age. This strategy resembles the natural behaviour of the sow and her litter, in which she returns to the herd following a period of isolation around farrowing (Stolba and Wood-Gush, 1989). Thus, it is argued that allowing piglets to mix at this age would not be associated with overt fighting, but only result in aggressive elements as part of/also shown in play behaviour (Newberry and Wood-Gush, 1988). Previous trials have found this strategy to reduce aggression later on in life (Fàbrega et al., 2013; Rydhmer et al., 2013).

4.4. Conclusions and Advice to Industry

If the industry is to adopt this practice, several considerations should be made: Farmers will have to learn to work with this solution. This may take time and should be facilitated. Farmers should also try to exchange information such that they do not have to invent the wheel time and time again.

5. The Future

Although aggression has been a topic receiving much attention and there is a substantial body of research, it remains a key welfare topic for commercial pig farmers. Probably the main reason is that aggression has evolved as an adaptive trait to form hierarchies in a social animal like the pig, and, therefore, to reduce it under commercial settings becomes a challenging issue. Genetic selection for less aggressive pigs could be a tool, but there is a need to fully understand the potential effects on other behavioural and productive traits. Thus, further research on housing design and management practices which meet the social demands of the pigs are still required. For example, investigations on strategies to reduce competition over feed and other resources, which permit pigs to escape or actively avoid aggressive encounters could yield new tools. It has to be remarked that both legislation and societal pressure worldwide, are pushing towards group housing systems, with a tendency to keep pigs in larger groups and, therefore, the challenge remains to find strategies to reduce or maintain acceptable levels of aggression and functional social groups. Another interesting topic of research would be not only to reduce negative agonistic behaviour but also to promote positive social encounters and environments, focusing specially on submissive pigs which may experience more extensive welfare compromises. Research on early experiences of pigs (e.g. early socialisation) and the effects of the pre-weaning environment later on in life, on pheromone use and on genetics, may help to open new doors. Some studies on these topics are already in progress and are yielding promising results.

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Challenge: The Quality of the Farm Atmosphere

Introduction

For this challenge we're looking for the best practices regarding to improvement of the quality of the farm atmosphere, in connection with the health of the farmer and pigs. This technical report highlights solutions developed and used by some European farmers.

1. The Background to the Challenge

In modern livestock barns, proper indoor air quality is imperative to maintain the health and productivity of farm workers and animals. Some problems related to the health of farm workers have been noticed, especially since the 1970's, coinciding with the rapid changes from small traditional farms to large intensive livestock operations.

Good indoor air quality depends on barn management, feeding and manure handling systems, the ventilation system, as well as on the overall cleanliness of the operation, and type of livestock. It is assumed that to maintain good growing and production levels, the animals need good air quality. The primary role of any ventilation and heating system is to provide an adequate supply of fresh air inside the barn, to control the temperature and to obtain acceptable levels of moisture, gas, dust and odours. However, during the cold season, the ventilation system alone is very often insufficient to maintain ideal indoor air quality conditions.

In modern livestock operations, many producers work in the barn between 4 and 8 hours per day. Past research on barn ventilation focused towards animal productivity and comfort without adequate emphasis on the health of the workers themselves. It is likely that gas and dust levels inside most barns are harmful for most producers and their employees, especially during the winter.

Among all the gases present in the ambient barn air, the most dangerous ones to worker health are hydrogen sulphide (H_2S), carbon dioxide (CO_2), ammonia (NH_3) and methane (CH_4).

Ammonia is produced by the decomposition of the nitrogenous compounds (e.g. non-degraded proteins) in manure. Its characteristic strong odour makes it easily detectable as soon as levels reach 5 to 10 ppm. High levels of ammonia, above 20 ppm, irritate the eyes, nose and throat.

Methane levels encountered in livestock operations are not normally a health hazard, however cases of barn explosions due to this gas have been reported.

Hydrogen sulphide is the most dangerous gas produced by the manure. Its odour is easy to detect even at very low levels. At high concentration levels, hydrogen sulphide overcomes the sense of smell, so workers do not smell this gas after a short period of exposure. Consequently, the pulmonary system of the victim is paralysed and rapid death occurs. Normally, there is very little hydrogen sulphide inside livestock barns, however in-barn manure agitation can release large amounts of H_2S which can be very dangerous.

Dust is composed of fine aerosol particles in suspension. Dust can be characterized according to three important factors:

1. The source and type of particles

Dust found inside livestock barns is composed of numerous components of various shapes and sizes, both organic and inorganic. In animal housing, 70 to 90% of the dust is organic. This means that it is biologically active and will react with the defence system of the respiratory system. Included in the organic barn dust are feed components, dried faecal material, hair and skin cells, feather particles, pollen, insect parts, moulds, fungi, viruses and bacteria. Endotoxins are produced by bacteria. These endotoxins are generally strong allergens causing immediate or delayed reactions in the respiratory system. The inorganic dust is composed of numerous aerosols originating from such building sources as concrete, mineral or fibreglass insulation, or material, such as soil particles, drawn into the barn by the fresh air supply.

2. Size of particles

When mouldy hay or straw is shaken, large dust particles fall rapidly to the ground; the dangerous fine particles remain in suspension. These are called respirable dust since they can be inhaled deeply into a worker's lungs. Their size is smaller than 5 micrometres You cannot see these particles with the naked eye.

The dust problem inside livestock barns results from the fact that 80 to 90% of the dust inside swine barns are smaller than 5 microns and can be taken deeply into the lungs. On most livestock farms, the operator is exposed to a large quantity of very small particles.

3. Number of particles

In the atmosphere, there are always dust particles in suspension from soil, pollen and seeds.

In the swine industry, the highest levels of dust occur during feeding and feed grinding. Pig activity has a very large effect on dust levels. An Ontario study showed that 27% of operators were exposed to levels exceeding the 10 mg/m^3 limit during the normal working day.

It is strongly recommended that you wear a respiratory protection system such as an adequate face mask or the more efficient positive pressure respirator, especially during feeding and animal handling time.

Therefore, the challenge of this topic "improving quality of farm atmosphere" is of great interest for all EU farmers.

2. Addressing the Challenge

Research work on feed additives, manure handling and proper management are currently being undertaken to solve or at least attenuate the ammonia problem. However, it has been demonstrated that it is feasible to maintain acceptable levels of ammonia with proper manure management and adequate ventilation and heating in all livestock and poultry barns.

Wageningen University did a study with regard to reducing health risks of neighbouring residents of livestock farms, this study explored which existing and new measures can be taken to reduce emissions of bioaerosols from animal houses with a reduction percentage that is greater than the 30% which is currently in place for fine dust for poultry housing systems, as laid down in the national 'regulation on low-emission housings'. For promising measures, the yearly costs (investment costs and operating costs) were estimated. In addition, an exploratory calculation model was developed to determine effects of barn measures on the health of local residents. Finally, a synthesis was made on which emission measures provide good prospects based on their reduction performance and cost effectiveness.

3. EU PiG Best Practice

In total, 22 best practices were scored.

In order to identify the top five best practices across all the EU PiG regions a number of criteria were used, which enabled an assessment of the effectiveness of the collected practices to match the specific challenge. 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 addresses the challenges pointed out by the R-Pigs Groups;
- 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 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 Member State

- **Innovation**
  - How innovative is the best practice?

Scoring was done on a scale from 0-5 (to the nearest integer). When an evaluator identified significant shortcomings, this was reflected by a lower score for the criterion concerned. The guideline for scoring is shown below.

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 five steps:

1. All members of the thematic group (TG) received all relevant information on the candidate good practices that were submitted to EU PiG.
2. The TG members scored all the candidates for the above-mentioned criteria.
3. The average score for each of the three criteria was calculated for the score that were provided by the TG members.
4. A final score was calculated for each of the applications as the average of the mean scores of the four main criteria.

The applications with the top five overall scores were proposed as candidate best practices.

4. Results and Discussion

4.1. Validation of the Top Five Best Practices

The following top 5 best practices within the challenge of 'The quality of farm atmosphere' have been selected by the thematic group.

Title of Best Practice	**Country**
Ammonia Emission Reduction Technique for Fatteners Inside the Stable by Separating Faeces and Urine	Belgium
Reducing Emissions by Daily Manure Removal	The Netherlands
Electrostatic Particle Ionisation (EPI) – Improving Pig Unit Air Quality	United Kingdom
Chilling of Manure with Cooling Deck System Reduces Ammonia Inside the Stable	Belgium
Farm 5.0	Spain

Ammonia Emission Reduction Technique for Fatteners Inside the Stable by Separating Faeces and Urine

Faeces and urine are separated under the slatted floor. The sloped floor makes sure the urine is collected in a urine gutter, while the faeces are scraped with a newly developed scraper towards a collection pit. The immediate separation and the frequent removal result in the prevention of production of ammonia emission. So this is not an end-of-the-line technique. The air inside the stable is better than the average farm, so the health for farmers and pigs is improved. The fresh faeces are digested in an on farm small scale mono-digester that produces heat and electricity. First Bart reconverted a small existing building in order to experience the technique in practice. He was satisfied with the excellent in-house conditions both for farmers and pigs and the practicability of the technique. This gave him confidence to plan and construct a new and bigger building.

EU PiG Evaluation of the Idea

In-barn manure separation systems are becoming popular due to various environmental pressures on the swine industry. According to the literature, separation of faeces and urine directly underneath the slats should have a positive impact on barn air quality. Removal and rapid separation of the two phases (solid/liquid) would reduce the dust and bioaerosol emissions, which would significantly improve the air quality in pig-housing facilities.

The digestion of the solid manure is a nice bonus because it also reduced greenhouse gas emissions.

Reducing Emissions by Daily Manure Removal

De Hoeve Innovation developed a system that removes fresh manure from the pig house every day. This results in a healthier stable climate and has advantages for animals, humans and the environment. The animals are healthier, grow faster and the farmer has reduced costs for feed and veterinary health services. This results in the possibility of keeping antibiotics-free pigs. In addition, fresh manure delivers up to 40 m^3 of biogas per cubic meter. By removing the manure every day, less ammonia is produced. Emission reduction is tackled at the source by collecting the manure in manure pits or manure gutters. The ammonia level is therefore much lower in the room. As a result, more ventilation can be provided and conditioning is applied, which further improves indoor climate (including CO_2 content). By applying daily removal, the regional requirements for emissions are met and there is no need for an air scrubber. This initiative started already back in 2013.

EU PiG Evaluation of the Idea

This farmer uses conventional pens with pigs kept in accordance with the Better Life Scheme (improved welfare, including e.g. additional space: 1m^2/pig). Normally conventional pens have slatted floors with 40% of the floor being solid (which is a legal requirement in the Netherlands). Underneath the slatted floor is a manure pit at the back of the pen (0.4m^2/pig). In the front is a water channel (0.2m^2/pig). However, at De Hoeve, not 40%, but 60% of each pen's floor is solid, thus reducing the manure-pit surface at the back of the pen by 50% (0.2m^2/pig rather than 0.4). The manure pit is a v-shaped manure gutter (ICV system), which reduces the ammonia-emitting surface by another 50%, roughly. This means that overall about 75% ammonia emission reduction may be achieved. The system requires daily flushing of the manure gutter and uses the water from the water channel for that purpose, resulting in a moderately elevated use of water. The system may help reduce the need to use an air washing installation into reduce ammonia emissions, which is associated with reduced air quality for the pigs and fossil-fuel consumption.

We think this may be a promising solution to improve the environmental impact of conventional pig farming, but scientific measurements are needed to validate the system.

Electrostatic Particle Ionisation (EPI) – Improving Pig Unit Air Quality

Many pigs in a single airspace create a lot of dust. Airborne dust in pig units can cause serious problems for both stockmen and stock. Electrostatic particle ionization (EPI) is an air cleaning system designed to reduce dust and microbial load in a contained environment, by ionizing particles and causing them to drop out of "suspension" in the air, so they settle and can't be inhaled. The farm unit is relatively high health with top levels of performance, and the EPI significantly contributed to reduce respirable dust and Gram negative bacteria resulting in a reduction of EP (enzootic pneumonia)-like lung lesions in finishers, giving benefits for pigs and stockpeople. Greater emphasis should be on reducing dust in pig units. It's important to keep the ionisation bar as low as possible so the air particles accumulate on surfaces that are easily washed when cleaning between batches. Installation of the EPI unit, particularly in situations where there are clinical indications of lung disease present, shows positive results.

EU PiG Evaluation of the Idea

This seems to be a viable technique to reduce dust and improve pig health. It is also used in poultry buildings. ASHRAE, 1988. Fundamental Handbook. American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA.

Lung lesions, esp. related to EP, are prevalent in slaughter pigs across Europe (Krejci and Mazerolles, 2018). EPI has been shown to be able to reduce dust (up to 96%, George and Feddes, 1995) and airborne pathogens (Alonso et al., 2016) in pig units.

Nilsson (1982, cited from Atia, 1995) found that 80% of the dust in swine finishing building were between 0.5 micron and 2.5 micron, and electrostatic precipitators can remove particles less than 2 micron in diameter (ASHRAE, 1988, cited from Atia, 1995).

Chilling of Manure with Cooling Deck System Reduces Ammonia Inside the Stable

Eddy is the only farmer in Flanders that already uses the 'chilling of manure' via a cooling deck system that's coupled with a heat pump. There is a heat exchanger that floats in the manure, and it draws heat out of the manure. This leads to a lower temperature of the manure, which means that a lower ammonia emission is reached. The extracted heat from the manure is the heat source for the heat pump. With the heat the farrowing house (piglets) are warmed. This means that there is almost no need for natural gas or gasoline. There's just a backup in case of emergency or extreme cold. The system already works for 5 years and only one time extra heating was needed. The chilling technique is not an end of pipe technique like the air scrubber but prevents the ammonia to form. This way it also results in a better life and work environment for the pig and the farmer. The climate in the stable is also much better. This concept is proven by the responsible institute from the government.

EU PiG Evaluation of the Idea

Surface cooling of manure with fins using a closed heat exchange system can reduce emissions by 45-75% depending on animal category and surface of cooling fins. This technique is most economical if the collected heat can be exchanged to warm other facilities such as weaner houses.

That the concept made the list from the government is an extra validation of its effectiveness.

Farm 5.0

The objective of our Project Farm 5.0 is to digitalize the farm, so that we can take more advantage of all data collected by the equipment. Data from different monitoring systems is integrated. Amongst these systems, we 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 is used for climatization. All environmental parameters are telemetrically controlled and interconnected to provide warning data which can be controlled on devices such as the mobile. Data which the farm generates are in the cloud and can be accessed by technicians, veterinarians or farmers from anywhere with internet access. In this way, we have reduced the time of intervention for any problematic issue.

EU PiG Evaluation of the Idea

The idea of using precision farming as a tool to improve animal welfare has been recently investigated by several EU Projects (All-Smart-Pigs, EU PLF), and will be a main topic for a new H2020 coordinated project. Precision farming cannot totally substitute proper farmer skills but can help to support farmers' decisions on when intervention is required and can make an increased level of automatization of some processes feasible. At present, technology is becoming more readily available and challenges that remain to be solved include becoming price-effective for farmers and being robust enough to work properly in on-farm conditions. Monitoring of gas levels on farms can certainly help improve the air quality, by using objective measures. Precision farming may also reduce some time-consuming tasks, thus, increasing farmers' well-being and allowing farmers to allocate their time to tasks which need to be conducted by trained stockpeople.

4.2. Cost and Benefit Analysis of the EU PiG Ambassador

Best practice 'Ammonia emission reduction technique for fatteners' from Belgium was chosen as EU PiG ambassador 2019 for the challenge of "the quality of the farm atmosphere". The farmer has developed a system that separates faeces and urine under a slatted floor. The sloped floor allows removal of the collected urine to a gutter, while the faeces are being scraped to the collection pit. Additionally, the mono-digester for production of heat and electricity was installed which allows to use faeces for energy production. The costs and benefits of this system have been analysed taken into account the changes in technical performance parameters. Basing on the Interpig model with the real farm data implemented, the following parameters of the farm has been assumed for calculation (farm size 5000 finishing places):

<u>Benefits:</u>

- Finishing daily weight gain increased by 5% (average for Interpig-BE + 5% = 732g/day).
- Finishing feed conversion ratio improved by 5% (average FCR for Interpig-BE -5% = 2,65).

- Animals are healthier - veterinary costs per slaughter pig are 30% lower (€0,74/slaughter pig (finishing), finishing mortality decreased to 2,5% (by 1 pp).
- Savings in electricity costs are about 40 000 €/year, which makes the investment in mono-digester paid back in 7 years.

Costs:

- The costs of labour increases by 11% per slaughtered pig due to the system maintenance (once per 2 weeks tensioning the chains of the manure scrapers and everyday maintenance of the mono-digester for production of heat and electricity).
- Investments: mono-digester for production of heat and electricity – 270 000 €; Costs for permissions obtained 20 000€ (once during the investment); yearly maintenance and updates of the mono-digester 5000€; yearly maintenance cost for emissions measurements including equipment renting for is 80000 euro/year;
- the system should be integrated in the stable during the construction or (re)construction of the stable.

Based on these assumptions variable production costs after implementation of best-practice decreased by **5,4%** as per kilogram of slaughter weight, mainly due to better feed performance parameters and lower vet costs, but also savings in electricity costs due to mono-digester used to produce own electricity. Increase was observed in case of fixed costs by **5,1%** per kg (mainly due to higher labour costs and depreciation of investments). As result, the **total costs were lower by 3,2%** per kg of slaughter weight (€ 1,38/kg vs € 1,42/kg hot slaughter weight).

What should also be added here that there are additional benefits possible from the system. Namely the separated urine could be easily sold as a specific kind of fertilizer (low phosphor, high nitrogen).

It should be emphasized that the assumptions about benefits and costs could be affected by the short observation period (only 1,5 years after investment was made). The healthiness parameters in case of other farms using the emission reduction techniques were even more promising, but it is difficult to estimate such changes at this farm, since usually all improvements are an outcome of many different factors. It could be verified after some time of the system functioning.

4.3. Expert Analysis

The cost benefit analysis is difficult for this best practise because the farmer is trying out a lot of new thing in his new stable, so it’s quite impossible to pinpoint a benefit to one specific measure.

However, the benefits on energy costs and manure digestion are quite clear.

4.4. Conclusions and Advice to Industry

Improving the air quality inside the stable instead of end-of-the-line emission techniques can have some extra benefits besides the reduction of ammonia. The working conditions for the farmers and employees are improved which is a clear bonus on physical and mental health.

5. The Future

Further measurements are needed so the impact of cleaner air on the pigs can be researched.

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