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Welfare of pigs on farm

EFSA Panel on Animal Health and Welfare (AHAW),
Søren Saxmose Nielsen, Julio Alvarez, Dominique Joseph Bicout, Paolo Calistri,
Elisabetta Canali, Julian Ashley Drewe, Bruno Garin-Bastuji, Jose Luis Gonzales Rojas,
Gortázar Schmidt, Mette Herskin, Virginie Michel, Miguel Ángel Miranda Chueca,
Olaf Mosbach-Schulz, Barbara Padalino, Helen Clare Roberts, Karl Stahl, Antonio Velarde,
Arvo Viltrop, Christoph Winckler, Sandra Edwards, Sonya Ivanova, Christine Leeb,
Beat Wechsler, Chiara Fabris, Eliana Lima, Olaf Mosbach-Schulz, Yves Van der Stede,
Marika Vitali and Hans Spoolder

Abstract

This scientific opinion focuses on the welfare of pigs on farm, and is based on literature and expert opinion. All pig categories were assessed: gilts and dry sows, farrowing and lactating sows, suckling piglets, weaners, rearing pigs and boars. The most relevant husbandry systems used in Europe are described. For each system, highly relevant welfare consequences were identified, as well as related animal-based measures (ABMs), and hazards leading to the welfare consequences. Moreover, measures to prevent or correct the hazards and/or mitigate the welfare consequences are recommended. Recommendations are also provided on quantitative or qualitative criteria to answer specific questions on the welfare of pigs related to tail biting and related to the European Citizen's Initiative 'End the Cage Age'. For example, the AHAW Panel recommends how to mitigate group stress when dry sows and gilts are grouped immediately after weaning or in early pregnancy. Results of a comparative qualitative assessment suggested that long-stemmed or long-cut straw, hay or haylage is the most suitable material for nest-building. A period of time will be needed for staff and animals to adapt to housing lactating sows and their piglets in farrowing pens (as opposed to crates) before achieving stable welfare outcomes. The panel recommends a minimum available space to the lactating sow to ensure piglet welfare (measured by live-born piglet mortality). Among the main risk factors for tail biting are space allowance, types of flooring, air quality, health status and diet composition, while weaning age was not associated directly with tail biting in later life. The relationship between the availability of space and growth rate, lying behaviour and tail biting in rearing pigs is quantified and presented. Finally, the panel suggests a set of ABMs to use at slaughter for monitoring on-farm welfare of cull sows and rearing pigs.

Keywords: on-farm pig welfare, pig categories, husbandry systems, welfare consequences, animal-based measures, end the cage age, tail biting

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Correspondence: ahaw@efsa.europa.eu

Panel members: Søren Saxmose Nielsen, Julio Alvarez, Dominique Joseph Bicout, Paolo Calistri, Elisabetta Canali, Julian Ashley Drewe, Bruno Garin-Bastuji, Jose Luis Gonzales Rojas, Christian Gortázar Schmidt, Mette Herskin, Virginie Michel, Miguel Ángel Miranda Chueca, Barbara Padalino, Paolo Pasquali, Helen Clare Roberts, Hans Spoolder, Karl Stahl, Antonio Velarde, Arvo Viltrop and Christoph Winckler.

Waiver: In accordance with Article 21 of the Decision of the Executive Director on Competing Interest Management, a waiver was granted to Sandra Edwards, an expert of the Working Group WG/P/AHAW/2020/05 – AHAW Welfare Farm to Fork. Pursuant to Article 21(6) of the aforementioned Decision, the concerned expert was allowed to take part in the drafting and in the discussion of the scientific output but was not allowed to take up the role of, or act as, chairman, vice-chairman or rapporteur of the Working Group. Any competing interests are recorded in the respective minutes of the meetings of the Working Group WG/P/AHAW/2020/05 – AHAW Welfare Farm to Fork.

Note: Figure 1 is based on Baumgartner et al. (2005); Figures 2A and 2B are based on Heidinger et al. (2022); Figure 3A is based on Weber and Schick (1996); Figure 3B is based on Baxter and Edwards (2021); Figure 4 is based on Hagmüller et al. (2017); Figure 5A is based on Rzezniczek et al. (2015); Figure 5B is based on Weber et al. (2015); Figure 6 is based on Vermeer et al. (2012); Figure 7 is based on Auinger et al. (2015); Figure 10 is based on a photo courtesy of Vermeer H.

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Summary

Background

The European Commission is undertaking a comprehensive evaluation of the welfare legislation regarding pigs kept on farm under the framework of its Farm to Fork Strategy. This includes Council Directive 98/58/EC concerning the protection of animals kept for farming purposes and Council Directive 2008/120/EC laying down minimum standards for the protection of pigs. The scientific opinion that was used for the current legislation was published in 1997 (SVC, 1997). Since then, EFSA adopted opinions on the welfare of pigs in 2004, 2005, 2007, 2012 and 2014.

Commission request

According to the above-mentioned background, the European Commission requested EFSA to give an independent view on the welfare of pigs kept on farms for different categories of animals in different husbandry systems. The terms of reference as provided by the requestor, followed by EFSA's interpretation of the ToRs, are described in Chapter 1. There are five 'General ToRs'. ToR-1 asks for a description of the existing pig categories and their husbandry systems. For ToR-2, the welfare consequences considered as the most relevant for pigs are to be identified, and for ToR-3, their related animal-based measures (ABMs). For each of the systems, EFSA was asked to identify the hazards leading to the welfare consequences (ToR-4) and to provide recommendations to prevent the hazards or mitigate the welfare consequences (ToR-5).

The second part of the request provides a list of five 'Specific ToRs' (Sp.ToRs). They are:

1) The welfare of gilts and dry pregnant sows after weaning in individual and group housing systems during the first 4 weeks of pregnancy (Sp.ToR 1);
2) The welfare of gilts and dry pregnant sows 1 week before farrowing in different housing systems offering different degrees of behavioural freedom (Sp.ToR 2);
3) The welfare of sows and piglets from farrowing to weaning in different housing systems offering different degrees of behavioural freedom (Sp.ToR 3);
4) The welfare of weaners and rearing pigs, in particular with the risks associated with weaning, space allowance, types of flooring, enrichment material, air quality, health status, diet and the practice of mutilations (tail docking, tooth clipping, castration) (Sp.ToR 4);
5) The assessment of animal-based measures collected in slaughterhouses to monitor the level of welfare on pig farms (such as tail damages, stomach ulcers, lung lesions) (Sp.ToR 5).

EFSA explored the relationship between relevant exposure variables and the welfare consequences for the pigs for each scenario. An 'exposure variable' can be any factor to which pigs are exposed (e.g. space allowance) and that may be associated with an impact on their welfare (e.g. restriction of movement).

As part of Chapter 1, the scientific questions behind the mandate questions were interpreted by EFSA and a number of exposure variables identified as the most relevant for assessment. Following a clarification of the mandate provided by the European Commission, the criteria for selecting the relevant exposure variables were (i) relevance to the European Citizen Initiative (ECI) 'End the cage age' and (ii) possible relevance to the problem of tail biting.

Materials and methods

The opinion then continues in Chapter 2 to describe the data obtained and the methodologies applied. The assessment of pig categories and husbandry systems was based on data from literature, expert opinion and suggestions provided by stakeholders via a public consultation. The Specific ToRs were addressed via quantitative (Expert Knowledge Elicitation (EKE)), semiquantitative, qualitative (y/n or only a narrative approach).

Uncertainties related to the data collection and the assessment are described in Chapter 10 and are related to language used in publications, publication types, search strings, source of the studies, inclusion and exclusion criteria, the number and type of experts, the pig categories, farming conditions and practices considered in the studies, the time and resource allocation to this mandate, the lack of data on ABMs and the type of assessment used. Conclusions from the EKE exercises were expressed along with their certainty, which was derived as part of the EKE process. For all other conclusions, the EFSA experts provided their individual judgement on the certainty for each conclusion according to three predefined agreed probability ranges (> 50–100%; 66–100%, 90–100%), which are derived

from the approximate probability scale from the guidance on uncertainty (EFSA, 2019). Individual answers were then subjected to group discussion and the consensus outcome is reported in the opinion.

Animal categories

In Chapter 3, the following categories of pigs are presented and discussed: Gilts and dry sows, farrowing and lactating sows, piglets (from birth to weaning, including artificial rearing), weaners (from weaning to 10 weeks of age), rearing pigs (from 10 weeks of age to slaughter or retention for breeding), boars (retained for breeding) and animals in need of separation or treatment. They are described in terms of their biological functioning and welfare needs.

Husbandry systems

Chapter 3 continues with a description of the current husbandry systems and the practices used for keeping the pigs. A total of 21 systems were identified, of which 14 were considered the most relevant systems and therefore selected for further description and assessment. Some systems were not selected because they were of low prevalence in Europe, high variability in structure or had characteristics similar to (combinations of) other selected systems.

Gilts and dry sows: Individual housing in stalls, indoor group housing and outdoor paddock systems. Not selected were indoor systems with access to an outdoor concrete area.

Farrowing and lactating sows and piglets: Individual housing in crates, individual housing in pens and outdoor paddock systems. Not selected were individual housing in temporary crates, individual farrowing in pen + group suckling in pens and indoor systems with access to an outdoor concrete area.

Piglets: Artificial rearing systems.

Weaners: Indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems.

Rearing pigs: Indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems.

Boars: Indoor individual housing in pens. Not selected were indoor systems with access to an outdoor concrete area and outdoor paddock systems.

Animals in need of treatment or separation (all categories): Hospital/recovery or separation pens were listed, but not described in detail.

Welfare consequences

Chapter 3 then describes 16 welfare consequences considered highly relevant to farmed pigs based on expert opinion combining their severity, duration and frequency of occurrence. The reason why they are considered highly relevant and for which animal category is included in the description. A list of ABMs that allow the assessment of the welfare consequences is presented. The ABMs are described, and a qualitative indication of their sensitivity and specificity is given. ABMs which are commonly used but which were not considered sensitive or specific by the EFSA experts were also included, with reasons why they should be used with caution.

The 16 highly relevant welfare consequences identified are restriction of movement, resting problems, group stress, isolation stress, separation stress, inability to perform exploratory or foraging behaviour, inability to express maternal behaviour, inability to perform sucking behaviour, prolonged hunger, prolonged thirst, heat stress, cold stress, locomotory disorders (including lameness), soft tissue lesions and integument damage, respiratory disorders and gastro-enteric disorders. Of these, only inability to perform exploratory or foraging behaviour was considered highly relevant for all the pig categories under consideration.

Other welfare consequences may negatively affect the welfare of gilts and dry sows, but they were classified as less or moderately relevant. An overview of the expert judgement on the welfare consequences is presented in Appendix B.

Assessment of welfare per pig category

Chapters 4–9 address the General ToRs and Specific ToRs (where applicable) per pig category. Chapter 4 deals with the welfare of dry sows and gilts, Chapter 5 is on the welfare of farrowing and lactating sows and their piglets, Chapter 6 considers additional questions on the welfare of piglets in relation to mutilations, Chapter 7 is on the welfare of weaners and rearing pigs, Chapter 8 is on the welfare of boars and finally Chapter 9 is on the use of ABMs (collection of data) in slaughterhouses to monitor the level of welfare on pig farms.

For each of these chapters (except Chapter 6 on piglet mutilations), the highly relevant welfare consequences are listed at husbandry system level, hazards and preventative/corrective measures are identified as are the ABMs used to assess the welfare status. If they exist, measures to mitigate the welfare consequences are also proposed. These aspects are summarised in an 'Outcome Table' per animal category. Then, where applicable, the Sp. ToRs that relate to the animal category are addressed. Each chapter ends with a comparison between the assessed systems and a set of summary conclusions and recommendations in response to the general and the Sp. ToRs.

Three systems were discussed in detail for **gilts and dry sows** (Chapter 4): Individual housing in stalls, indoor group housing and outdoor paddock systems. The following highly relevant welfare consequences were identified for one or more of them: restriction of movement, resting problems, group stress, inability to perform exploratory or foraging behaviour, prolonged hunger, locomotory disorders (including lameness) and soft tissue lesions and integument damage.

The panel concluded that there are measures to mitigate some of the highly relevant welfare consequences experienced by gilts and dry sows in stalls (e.g. mitigate resting problems by cleaning the floor and/or providing bedding); however, other welfare consequences (e.g. restriction of movement and inability to perform exploratory behaviour) cannot be mitigated except by removing the animals from the stalls.

In Sp.ToR 1, the welfare consequences of mixing gilts and dry sows into a group (grouping) were assessed. The assessment focussed on the timing of grouping relative to weaning. It highlighted potential differences in welfare consequences dependent on factors such as the occurrence of oestrous behaviour during the first week after weaning.

Nevertheless, the welfare consequences associated with grouping gilts and sows can be mitigated at any stage by adhering to the principles of good mixing, including the use of mixing pens, good home pen design/layout and good feeding and general management.

The welfare of pregnant gilts and sows, from the time they are transferred into the farrowing facilities up to the completion of farrowing (Sp. ToR 2) is discussed in Chapter 5 together with the farrowing and lactating sows, as they share the same (farrowing) systems.

Three husbandry systems were described for **farrowing and lactating sows** (Chapter 5): Individual housing in crates, individual housing in pens and outdoor paddock systems. Highly relevant welfare consequences were only identified for housing in farrowing crates: Restriction of movement, resting problems, group stress, inability to perform exploratory or foraging behaviour, inability to express maternal behaviour, heat stress and soft tissue lesions and integument damage. Individual farrowing pens and outdoor farrowing systems were also assessed, but no welfare consequences were classified as having high relevance.

Four systems were described for **piglets** (Chapter 5) housed in systems with individual farrowing crates, individual farrowing pens, outdoor paddock systems and artificial rearing systems. Identified highly relevant welfare consequences were restriction of movement, group stress, separation stress, inability to perform exploratory or foraging behaviour, inability to perform sucking behaviour, prolonged hunger, prolonged thirst, cold stress and soft tissue lesions and integument damage.

Sp.ToRs 2 and 3 consider the design and management of the farrowing system before and after farrowing, respectively. In Chapter 5, welfare consequences were assessed in relation to three exposure variables:

- Effects of the temporal availability of access to space (i.e. temporary crating).
- Effects of the quantity of space (in terms of m^2 accessible to the sow).
- Effects of the quality of space (in terms of environmental enrichment).

For each of these, several conclusions are drawn. They include the following:

The panel concludes that with an average space for the sow of ~ 4.3–6.3 m^2 in the temporary crating systems, the same piglet survival level can be achieved as for a permanent crating system. The minimum confinement time of a sow in a temporary crating system to achieve this is 7 days after farrowing (90% uncertainty range between 3.4 and 16 days).

Reducing the space available to the lactating sow below 6.6 m^2 in a pen reduces her freedom of movement and increases the mortality of piglets. Above 6.6 m^2, the behavioural freedom of sows and piglets is increased, but piglet mortality does not further improve.

In the absence of sufficient scientific evidence for quantification, a semiquantitative analysis based on expert opinion identified enrichment materials such as long-stemmed or long-cut straw, hay or haylage as the most suitable for nest-building. However, these materials need to be provided in an amount which allows all behavioural elements of nest-building to be performed at a functional level.

Overall, the EFSA experts are positive about moving from a crated farrowing systems to pen systems from an animal welfare point of view. However, time is needed for staff and animals to adapt to the change from crated to free farrowing systems. The EFSA experts consider that on an average farm, this will take at least 6 months. Secondly, litter size is important and breeding goals resulting in litter sizes that consistently exceed the sows' number of functional teats are hampering progress in improving the welfare of sows and their piglets. It is recommended that artificial rearing should only be used as a last resort and not as a routine management practice.

Chapter 6 focusses on **mutilations**: tooth reduction, castration and tail docking. It describes the reasons for these mutilations and the methods that are applied.

Tooth reduction is a stressful procedure that, if performed incorrectly, causes short- and longer term pain. In particular, clipping is inherently injurious. Grinding to blunt the sharp tip of the tooth does not injure sensitive tissue when correctly performed. In individual litter situations where tooth reduction can be justified, the most important measure to prevent and mitigate welfare consequences is training of staff in correct procedures.

Since castration is a painful procedure, keeping entire male pigs is a viable alternative if the welfare consequences for penmates due to aggressiveness and mounting behaviour are prevented or mitigated. From a welfare point of view, immunocastration has advantages compared to keeping entire male pigs due to less mounting behaviour, reduced number of skin lesions, penile injuries and fewer locomotory disorders, although the method also has some welfare disadvantages.

Tail docking should not be performed routinely. Whilst tail docking can be effective in reducing the risk of tail biting lesions, it is not necessary if husbandry practices, and management are appropriate. If tail docking is performed under derogation, the following aspects minimise harm: dock at a young age, use a cautery method (instead of a cold method) and do not dock the tail close to the first caudal vertebra as it has larger impact on soft tissue, bone and nervous tissues.

Three systems were described **for weaners** (Chapter 7): indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems. They are associated with one or more of the following highly relevant welfare consequences: group stress, inability to perform exploratory or foraging behaviour, cold stress, soft tissue lesions and integument damage and gastro-enteric disorders.

Rearing pigs (Chapter 7) in indoor group housing and indoor systems with access to an outdoor area experience one or more of the following highly relevant welfare consequences: Restriction of movement, resting problems, group stress, inability to perform exploratory and foraging behaviour, locomotory disorders (including lameness), soft tissue lesions and integument damage and respiratory disorders. For outdoor paddock systems, no welfare consequences were identified as having highly relevance, although other welfare consequences, classified as less or moderately relevant, may negatively affect the welfare of rearing pigs.

In addition to the mutilations discussed in Chapter 6, Specific Scenario 4 asked for an assessment of several husbandry aspects, which are likely to affect tail biting in weaners and rearing pigs. They are weaning age, space allowance, type of flooring, enrichment material, air quality, health status and the diet composition.

The EFSA experts consider that the welfare consequences associated with weaning age increase exponentially with decreasing weaning age and are particularly pronounced at weaning ages of less than 21 days and with artificial rearing systems. However, there is great variability between different studies and housing systems. Furthermore, there are inadequate data to assess the welfare consequences of weaning ages greater than 28 days. Still, these indicate that any welfare benefits are less pronounced under good management. For animal welfare reasons, it is recommended that the current legal minimum weaning age of 28 days remains and the exception allowing earlier weaning in specific circumstances should be reconsidered.

Although it is recommended that current space allowances increases, there is no clear cut-off value for space allowance above which further welfare improvements do not occur. Insufficient space prevents pigs from performing highly motivated behaviours, including exploratory, social, resting and thermoregulatory behaviours, and from maintaining separate dunging and lying areas. Reduced space allowance promotes damaging behaviours such as tail biting and compromises growth. A quantification of the effects of different space allowances on these aspects is in Chapter 7.

The analyses of the type of flooring stresses the importance of providing solid flooring for lying. It concludes that, in addition to a separate dunging and activity area, at least 0.77 m^2 (for a 110-kg pig) of a solid-floored area is needed for lying at thermoneutral conditions.

Several conclusions about enrichment material express the relative importance of different materials. Loose organic substrates (e.g. straw, hay, silage) are preferred and are usually more effective in reducing tail biting than point-source enrichment objects.

There is limited quantitative information on air quality. Specific thresholds at which ammonia levels detrimentally affect respiratory health and tail biting risk are difficult to define because of interactive influences. However, levels exceeding 10–15 ppm may be considered a risk factor for health-related welfare consequences.

The health status of pigs affects the likelihood of tail biting and *vice versa*. Tail biting and health problems are often found jointly on farms for several reasons. This is because they share several risk factors but also because tail biting directly causes health problems while health problems may indirectly cause tail biting.

Furthermore, various aspects of the diet can affect tail biting: deficiencies in feed composition and method of provision (such as feeding space) are major risk factors for tail biting. Correct formulation of diets to minimise tail biting risk must take account of the growth stage, genetic potential and health status of the animals, with particular attention to amino acid and mineral composition.

Finally, the highly relevant welfare consequences identified for **boars** (Chapter 8) kept in indoor individual pens are restriction of movement, isolation stress, inability to perform exploratory or foraging behaviour, prolonged hunger and locomotory disorders (including lameness). However, the scientific information on the husbandry systems and the welfare consequences pertaining to boars are very limited.

Chapter 9 describes the use of ABMs **in slaughterhouses** to monitor the level of welfare on pig farms. It focusses on rearing pigs and cull sows. For rearing pigs, the following ABMs were considered the most appropriate for further development: Tail lesions, carcass condemnation (excluding abattoir contamination) and lung lesions (pleuritis and pneumonia). For cull sows, the most appropriate ABMs were body condition, skin lesions – shoulder ulcers, vulva lesion and carcass condemnation (excluding abattoir contamination). The Technology Readiness Levels of automated monitoring of the ABMs at slaughterhouse is currently low. Methods for monitoring tail lesions and lung lesions are the most advanced. For all ABMs, it was considered necessary to develop unified and standardised scoring systems and protocols to monitor and benchmark the welfare of cull sows and rearing pigs across different regions/countries.

Summary conclusions of the various pig categories are presented in Chapters 4–9. Chapters 10 presents the identification of the sources of uncertainty, after which in Chapter 11, the conclusions are presented together with the results of the uncertainty analysis. Recommendations on the welfare of the various pig categories are listed in Chapters 4–9, and brought together in an overview table in Chapter 12.

Table of contents

Abstract ... 1
Summary ... 3
1. Introduction ... 15
1.1. Background and Terms of Reference as provided by the requestor ... 15
1.1.1. Background ... 15
1.1.2. Terms of Reference (ToRs) ... 16
1.2. Interpretation of the Terms of Reference ... 17
2. Data and methodologies ... 21
2.1. Data ... 21
2.1.1. Data from literature ... 21
2.1.2. Data from Member States ... 21
2.1.3. Data from Public Consultation ... 22
2.2. Methodologies ... 22
2.2.1. Literature search ... 26
2.2.1.1. General ToRs ... 26
2.2.1.2. Specific ToRs ... 26
2.2.2. Expert opinion ... 26
2.2.2.1. General ToR-2: Selection of the highly relevant welfare consequences for pigs ... 27
2.2.2.2. General ToRs-4 and -5: Development of outcome tables ... 30
2.2.2.3. Assessment of the Specific ToRs ... 30
2.2.3. Uncertainty analysis ... 32
3. Assessment of General ToRs 1, 2 and 3 ... 33
3.1. Pig production in the EU ... 33
3.2. Pig categories ... 33
3.2.1. General characteristics of pigs ... 33
3.2.2. Gilts ... 34
3.2.2.1. Definition, biology and background information on the production cycle ... 34
3.2.3. Sows ... 35
3.2.3.1. Definitions, biology and background information on the production cycle ... 35
3.2.4. Piglets ... 36
3.2.4.1. Definition, biology and background information on the production cycle ... 36
3.2.5. Weaners ... 36
3.2.5.1. Definition, biology and background information on the production cycle ... 36
3.2.6. Rearing pigs ... 38
3.2.6.1. Definition, biology and background information on the production cycle ... 38
3.2.7. Boars ... 38
3.2.7.1. Biology and some background information on production cycle ... 38
3.2.8. Animals in need of treatment or separation ... 38
3.3. Describing pig husbandry systems (General ToR 1) ... 39
3.3.1. Overview of pig husbandry systems per animal category ... 39
3.3.2. Gilt and dry sow systems ... 40
3.3.2.1. General management ... 40
3.3.2.2. Individual housing in stalls ... 40
3.3.2.3. Indoor group housing ... 41
3.3.2.4. Indoor systems with access to an outdoor concrete area ... 42
3.3.2.5. Outdoor paddock systems ... 42
3.3.3. Farrowing and lactation systems ... 42
3.3.3.1. General management of farrowing and lactating sows ... 42
3.3.3.2. General management of piglets ... 42
3.3.3.3. Individual farrowing crates ... 43
3.3.3.4. Individual housing in temporary farrowing crates ... 44
3.3.3.5. Individual farrowing pens ... 44
3.3.3.6. Individual farrowing pen with group suckling in pens ... 45
3.3.3.7. Indoor farrowing pen with access to an outdoor concrete area ... 46
3.3.3.8. Outdoor farrowing paddocks ... 46
3.3.4. Piglet systems ... 47
3.3.4.1. Artificial rearing systems ... 47
3.3.5. Weaner systems ... 48
3.3.5.1. General management ... 48
3.3.5.2. Indoor group housing ... 48
3.3.5.3. Indoor systems with access to an outdoor area ... 49

3.3.5.4. Outdoor paddock systems ... 50
3.3.6. Rearing pig systems ... 50
3.3.6.1. General management ... 50
3.3.6.2. Indoor group housing ... 51
3.3.6.3. Indoor systems with access to an outdoor area ... 52
3.3.6.4. Outdoor paddock systems ... 52
3.3.7. Boar systems ... 52
3.3.7.1. General management ... 52
3.3.7.2. Indoor individual housing in pens ... 53
3.3.7.3. Indoor systems with access to an outdoor concrete area ... 53
3.3.7.4. Outdoor paddock systems ... 53
3.3.8. Hospital and separation pens ... 53
3.4. Describing pig welfare: most relevant welfare consequences for pigs and related ABMs (General ToRs 2 and 3) ... 54
3.4.1. Restriction of movement and related ABMs ... 56
3.4.2. Resting problems and related ABMs ... 61
3.4.3. Group stress and related ABMs ... 62
3.4.4. Isolation stress and related ABMs ... 69
3.4.5. Separation stress and related ABMs ... 70
3.4.6. Inability to perform exploratory or foraging behaviour and related ABMs ... 71
3.4.7. Inability to express maternal behaviour and related ABMs ... 75
3.4.8. Inability to perform sucking behaviour and related ABMs ... 78
3.4.9. Prolonged hunger and related ABMs ... 79
3.4.10. Prolonged thirst and related ABMs ... 82
3.4.11. Heat stress and related ABMs ... 83
3.4.12. Cold stress and related ABMs ... 85
3.4.13. Locomotory disorders (including lameness) and related ABMs ... 88
3.4.14. Soft tissue lesions and integument damage and related ABMs ... 90
3.4.15. Respiratory disorders and related ABMs ... 95
3.4.16. Gastro-enteric disorders and related ABMs ... 97
4. Assessment of the welfare of gilts and dry sows ... 99
4.1. Highly relevant welfare consequences for gilts and dry sows: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5) ... 100
4.1.1. Restriction of movement ... 100
4.1.2. Resting problems ... 100
4.1.3. Group stress ... 101
4.1.4. Inability to perform exploratory or foraging behaviour ... 102
4.1.5. Prolonged hunger ... 103
4.1.6. Locomotory disorders (including lameness) ... 104
4.1.7. Soft tissue lesions and integument damage ... 105
4.2. Outcome table on the welfare of gilts and dry sows ... 106
4.3. Comparison of the systems for gilts and dry sows ... 113
4.4. Assessment of Specific ToR-1: The welfare of gilts and sows – from entering the service area until the end of the fourth week of pregnancy ... 113
4.4.1. Background ... 113
4.4.2. Introduction ... 114
4.4.3. Approach ... 115
4.4.4. Characterisation of the period under assessment ... 115
4.4.5. Condition of the sow post-weaning ... 115
4.4.6. Results of the ELS of grouping time on sow welfare and reproductive performance ... 117
4.4.6.1. Welfare ABMs ... 117
4.4.6.2. Effects on reproductive performance of grouping sows in the period under assessment ... 117
4.4.7. Results of the consensus exercise on welfare consequences affecting sows when grouped in the period under assessment and related mitigation measures ... 121
4.4.7.1. Identification of the welfare consequences ... 121
4.4.7.2. Identification of the mitigation measures ... 123
4.4.7.3. General principles when grouping sows ... 125
4.4.7.4. Description of the welfare consequences and related preventive and mitigation measures ... 126
4.5. Summary Conclusions on the welfare of gilts and dry sows ... 128
4.5.1. Summary Conclusions from the General ToRs ... 128
4.5.2. Summary Conclusions from Specific ToR 1 ... 129
4.6. Recommendations on the welfare of gilts and dry sows ... 129
4.6.1. Recommendation from the General ToRs ... 129

4.6.2. Recommendations from Specific ToR 1 129
5. Assessment of the welfare of farrowing and lactating sows and piglets 129
5.1. Highly relevant welfare consequences for farrowing and lactating sows: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5) 130
5.1.1. Restriction of movement 130
5.1.2. Resting problems 131
5.1.3. Group stress 131
5.1.4. Inability to perform exploratory or foraging behaviour 131
5.1.5. Inability to express maternal behaviour 132
5.1.6. Heat stress 132
5.1.7. Soft tissue lesions and integument damage 133
5.2. Outcome table on the welfare of farrowing and lactating sows 133
5.3. Comparison of the systems for farrowing and lactating sows 137
5.4. Highly relevant welfare consequences for piglets: hazards, preventive, corrective and mitigation measures (Specific ToRs 4 and 5) 137
5.4.1. Restriction of movement 137
5.4.2. Group stress 137
5.4.3. Separation stress 138
5.4.4. Inability to perform exploratory or foraging behaviour 138
5.4.5. Inability to perform sucking behaviour 139
5.4.6. Prolonged hunger 139
5.4.7. Prolonged thirst 140
5.4.8. Cold stress 140
5.4.9. Soft tissue lesions and integument damage 141
5.5. Outcome table on the welfare of piglets 142
5.6. Comparison of the systems for piglets 148
5.7. Assessment of Specific ToRs 2 and 3: welfare of sows and piglets in different farrowing house systems offering different degrees of behavioural freedom 148
5.7.1. Combining two Specific ToRs 148
5.7.2. Relevant 'exposure variables' and how to assess them 148
5.7.3. Temporal availability of space: temporary crating of the sow 149
5.7.4. Pre-farrowing crate closing time 150
5.7.4.1. Evaluation of the scientific evidence 150
5.7.5. Post-farrowing crate opening time: sow welfare 151
5.7.5.1. Evaluation of the scientific evidence 151
5.7.6. Post-farrowing crate opening time: piglet welfare 152
5.7.6.1. Choice of ABM 152
5.7.6.2. EKE 1: live-born piglet mortality in relation to the time the sow is crated 153
5.7.7. Summary Conclusions on farrowing systems: temporal availability of space 155
5.7.7.1. Summary Conclusions on pre-farrowing crate closing time 155
5.7.7.2. Summary Conclusions on post-farrowing crate opening time (sow perspective) 156
5.7.7.3. Summary Conclusions on post-farrowing crate opening time (piglets' perspective) 156
5.7.8. Quantity of space: sow space allowance 156
5.7.9. Pre-farrowing quantity of space 157
5.7.9.1. Choice of ABM 157
5.7.9.2. EKE 2: farrowing duration 158
5.7.10. Post-farrowing quantity of space: sow welfare 161
5.7.10.1. Choice of ABM 161
5.7.10.2. EKE 3: sow locomotory behaviour 162
5.7.11. Post-farrowing quantity of space: piglet welfare 164
5.7.11.1. Choice of ABM 164
5.7.11.2. EKE 4: live-born piglet mortality in relation to space allowance 165
5.7.12. Summary conclusions on the quantity of space in farrowing systems 167
5.7.12.1. Summary conclusions on the amount of sow space pre-farrowing 167
5.7.12.2. Summary conclusions on the amount of sow space post-farrowing (sow perspective) 168
5.7.12.3. Summary conclusions on the amount of sow space post-farrowing (piglets' perspective) 168
5.7.12.4. Summary conclusions on the combination of sow and piglet ABMs post farrowing – quantity of space 168
5.7.13. Quality of space: provision of enrichment materials 170
5.7.14. Pre-farrowing enrichment 170
5.7.14.1. Evaluation of the scientific evidence 170
5.7.14.2. Description of nest-building behaviour 170
5.7.14.3. Description of nest-building material 170

5.7.14.4. Comparison of nest-building materials 171
5.7.14.5. Semi-quantitative assessment of the suitability of different nest-building materials 171
5.7.15. Post-farrowing enrichment – welfare of sows and piglets 174
5.7.15.1. Evaluation of the scientific evidence 174
5.7.15.2. Description of behaviour directed at enrichment material 175
5.7.15.3. Description of enrichment material 175
5.7.15.4. Assessment of enrichment material 176
5.7.15.5. Effects of enrichment during lactation on pig behaviour after weaning 177
5.7.16. Summary Conclusions on quality of space in the farrowing systems 177
5.7.16.1. Summary Conclusions on pre-farrowing enrichment materials 177
5.7.16.2. Summary Conclusions on post-farrowing enrichment materials (sow and piglets perspective) 178
5.7.17. Time needed for adaptation from crate to free farrowing system 178
5.7.17.1. Summary Conclusions on the time needed for adaptation 179
5.7.18. Effects of litter size on sow and piglet welfare 179
5.7.18.1. Background 179
5.7.18.2. Rearing surplus piglets of highly prolific sows 179
5.7.18.3. Welfare implications of large litter size on the piglets 180
5.7.18.4. Welfare implications of large litter size on the sows 180
5.7.18.5. Number of functional teats in European sow breeds 180
5.7.18.6. Summary Conclusions on the effects of litter size on sow and piglet welfare 181
5.8. Summary Conclusions on the welfare of farrowing and lactating sows and piglets 181
5.8.1. Summary Conclusions from the General ToRs 181
5.8.2. Summary Conclusions from Specific ToRs 2 and 3 181
5.9. Recommendations on the welfare of farrowing and lactating sows and piglets 182
5.9.1. Recommendations from the General ToRs 182
5.9.2. Recommendations on Specific ToRs 2 and 3: space allowance on farrowing systems 182
5.9.3. Recommendations on Specific ToRs 2 and 3: pre-farrowing enrichment materials 182
5.9.4. Recommendations on Specific ToRs 2 and 3: post-farrowing enrichment materials 182
5.9.5. Recommendations on the time needed for adaptation 183
5.9.6. Recommendations on the effect of litter size to sow and piglet welfare 183
6. Assessment of the welfare of piglets in the context of the practice of mutilations 183
6.1. Tooth clipping 183
6.1.1. Introduction 183
6.1.1.1. Description of the procedure of tooth reduction 184
6.1.1.2. Welfare consequences of tooth reduction 184
6.1.1.3. Welfare consequence due to handling related to the whole procedure 184
6.1.1.4. Welfare consequence due to tooth reduction and comparison between methods 184
6.1.2. Welfare consequences of leaving teeth intact 186
6.1.2.1. Effect on piglets 186
6.1.2.2. Effect on sows 187
6.1.2.3. Preventive and corrective measure to reduce the practice of tooth reduction 187
6.1.3. Measures to mitigate the welfare consequences of tooth reduction 188
6.1.4. Summary conclusions on tooth reduction 189
6.1.5. Recommendations on tooth reduction 189
6.2. Castration 189
6.2.1. Introduction 189
6.2.2. Welfare consequences of surgical piglet castration 190
6.2.3. Keeping entire male pigs 190
6.2.3.1. Nutritional strategies 190
6.2.3.2. Management strategies 191
6.2.3.3. Pre-slaughter conditions 191
6.2.3.4. Genetics 191
6.2.4. Immunocastration 191
6.2.5. Surgical castration 192
6.2.5.1. Tools for castration 192
6.2.5.2. Effect of age 192
6.2.5.3. Pain mitigation 192
6.2.6. Review of previous EFSA Conclusions and Recommendations on castration 195
6.2.7. Summary conclusions on castration 196
6.2.8. Recommendations on castration 197
6.3. Tail docking 197
6.3.1. Introduction 197
6.3.2. Welfare consequences of tail docking 197

6.3.3. Consideration before carrying out tail docking 198
6.3.4. Description of the procedure of tail docking 198
6.3.4.1. Age at which docking is performed 198
6.3.4.2. Tools for tail docking 199
6.3.4.3. Length of the tail 199
6.3.5. Mitigation of pain and prevention of infection during and after tail docking 199
6.3.6. Summary conclusions on tail docking 200
6.3.7. Recommendations on tail docking 200
7. Assessment of the welfare of weaners and rearing pigs 200
7.1. Highly relevant welfare consequences for weaners: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5) 201
7.1.1. Group stress 201
7.1.2. Inability to perform exploratory or foraging behaviour 202
7.1.3. Cold stress 202
7.1.4. Soft tissue lesions and integument damage 203
7.1.5. Gastro-enteric disorders 204
7.2. Outcome table on the welfare of weaners 205
7.3. Comparison of the systems for weaners 209
7.4. Highly relevant welfare consequences for rearing pigs: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5) 209
7.4.1. Restriction of movement 209
7.4.2. Resting problems 209
7.4.3. Group stress 210
7.4.4. Inability to perform exploratory or foraging behaviour 211
7.4.5. Locomotory disorders (including lameness) 211
7.4.6. Soft tissue lesions and integument damage 212
7.4.7. Respiratory disorders 213
7.5. Outcome table on the welfare of rearing pigs 213
7.6. Comparison of the systems for rearing pigs 218
7.7. Assessment of the welfare of weaners and rearing pigs in particular with the risks associated with: (a) weaning, (b) space allowance, (c) types of flooring (d) enrichment material, (e) air quality, (f) health status, and (g) diet (Specific ToR 4) 218
7.7.1. Weaning age 218
7.7.1.1. Introduction 218
7.7.1.2. Specific methodology 218
7.7.1.3. The acute stress of weaning 219
7.7.1.4. The health-related welfare consequences of weaning age 219
7.7.1.5. The effect of weaning age on behaviour-related welfare consequences 222
7.7.1.6. Artificial rearing 225
7.7.1.7. The effect of weaning age on tail biting risk 225
7.7.1.8. Summary conclusions on Specific ToR 4: weaning 225
7.7.1.9. Recommendations on Specific ToR 4: weaning 225
7.7.2. Space allowance 226
7.7.2.1. Introduction 226
7.7.2.2. Approach 227
7.7.2.3. Rearing pig behaviour in relation to k-values 227
7.7.2.4. Analysis to explore the relationship between space allowance and growth rate 228
7.7.2.5. Analysis to explore the relationship between space allowance and tail biting 230
7.7.2.6. Summary of the effects of space allowance 232
7.7.2.7. Summary conclusions on Specific ToR 4: space allowance 234
7.7.2.8. Recommendation on Specific ToR 4: space allowance 234
7.7.3. Types of flooring 234
7.7.3.1. Introduction 234
7.7.3.2. Links between floor type and tail biting 235
7.7.3.3. Appropriate level of solid flooring in part-slatted systems 236
7.7.3.4. Summary conclusions on Specific ToR 4: types of flooring 236
7.7.3.5. Recommendations on Specific ToR 4: types of flooring 236
7.7.4. Enrichment material 237
7.7.4.1. Introduction 237
7.7.4.2. Assessment of the types of material 238
7.7.4.3. Ranking of the enrichment materials that can be used to reduce tail biting 239
7.7.4.4. Summary conclusions on Specific ToR 4: enrichment material 239
7.7.4.5. Recommendations on Specific ToR 4: enrichment material 239

7.7.5. Air quality ... 239
7.7.5.1. General introduction ... 239
7.7.5.2. Ventilation and air flow patterns ... 240
7.7.5.3. Composition of the atmosphere ... 240
7.7.5.4. Summary conclusions on Specific ToR 4: air quality ... 241
7.7.5.5. Recommendations on Specific ToR 4: air quality ... 241
7.7.6. Health status ... 241
7.7.6.1. Introduction ... 241
7.7.6.2. Cause- effect relationship between health status and tail biting ... 241
7.7.6.3. Does poor health cause tail biting? ... 242
7.7.6.4. Does Tail biting cause poor health? ... 242
7.7.6.5. Risk factors shared between tail biting and health problems ... 242
7.7.6.6. Summary conclusions on Specific ToR 4: health status ... 243
7.7.6.7. Recommendations on Specific ToR 4: health status ... 243
7.7.7. Diet composition ... 243
7.7.7.1. Introduction ... 243
7.7.7.2. Dietary minerals ... 244
7.7.7.3. Dietary protein ... 244
7.7.7.4. Dietary energy ... 244
7.7.7.5. Other hazards relating to diet formulation and processing ... 245
7.7.7.6. Summary conclusions on Specific ToR 4: diet composition ... 245
7.7.7.7. Recommendations on Specific ToR 4: diet composition ... 245
7.8. Summary conclusions on the welfare of weaners and rearing pigs ... 245
7.8.1. Summary conclusions from General ToRs ... 245
7.8.2. Summary conclusions on Specific ToR 4 in relation to tail biting ... 246
7.9. Recommendations on the welfare of weaners and rearing pigs ... 246
7.9.1. Recommendations from General ToRs ... 246
7.9.2. Recommendations on Specific ToR 4 in relation to tail biting ... 246
8. Assessment of the welfare of boars ... 246
8.1. Highly relevant welfare consequences for boars: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5) ... 247
8.1.1. Restriction of movement ... 247
8.1.2. Isolation stress ... 248
8.1.3. Inability to perform exploratory or foraging behaviour ... 248
8.1.4. Prolonged hunger ... 248
8.1.5. Locomotory disorders (including lameness) ... 249
8.2. Outcome table on the welfare of boars kept in individual pens ... 250
8.3. Summary conclusions on the welfare of boars ... 253
8.4. Recommendations on the welfare of boars ... 253
9. Assessment of ABMs collected in slaughterhouses to monitor the level of welfare on pig farms (Specific ToR 5) ... 253
9.1. Introduction ... 253
9.2. Methodology ... 253
9.3. Results of the consensus exercise ... 255
9.4. Animal-based measures ... 257
9.4.1. Tail lesions ... 257
9.4.1.1. Animal category ... 257
9.4.1.2. Description of the ABM ... 257
9.4.1.3. Interpretation ... 257
9.4.1.4. Assessment ... 257
9.4.2. Lung lesions (pneumonia and pleuritis) ... 258
9.4.2.1. Animal category ... 258
9.4.2.2. Description of the ABM ... 258
9.4.2.3. Interpretation ... 258
9.4.2.4. Assessment ... 259
9.4.3. Skin lesions – shoulder ulcers ... 260
9.4.3.1. Animal category ... 260
9.4.3.2. Description of the ABM ... 260
9.4.3.3. Interpretation ... 260
9.4.4. Body condition ... 261
9.4.4.1. Animal category ... 261
9.4.4.2. Description of the ABM ... 261
9.4.4.3. Interpretation ... 261

9.4.4.4. Assessment 262
9.4.5. Carcass condemnations 263
9.4.5.1. Animal category 263
9.4.5.2. Description of the ABM 263
9.4.5.3. Interpretation 263
9.4.5.4. Assessment 263
9.4.6. Vulva lesions 264
9.4.6.1. Animal category 264
9.4.6.2. Description of the ABM 264
9.4.6.3. Interpretation 264
9.4.6.4. Assessment 264
9.4.7. Lameness 265
9.4.7.1. Animal category 265
9.4.7.2. Description of the ABM 265
9.4.7.3. Interpretation 265
9.4.7.4. Assessment 265
9.5. Summary conclusions on Specific ToR 5 266
9.6. Recommendations on Specific ToR 5 266
10. Sources of uncertainty 266
11. Conclusions with results of the uncertainty analysis 268
12. Recommendations 275
References 278
Abbreviations 314
Appendix A – Literature Searches 315
Appendix B – Experts' judgement on relevance of the welfare consequences 318

1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

In the framework of its Farm to Fork strategy, the Commission will start a comprehensive evaluation of the animal welfare legislation. This will include the following acts:

1) Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes[1];
2) Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens[2];
3) Council Directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves[3] (Codified version);
4) Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs[4] (Codified version);
5) Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production[5];
6) Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97[6];
7) Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing.[7]

In the context of possible drafting of legislative proposals, the Commission needs new opinions that reflect the most recent scientific knowledge.

Since the EFSA has already accepted mandates on the protection of animals at the time of killing, no opinion is requested on this topic. Furthermore, a European Citizen Initiative (ECI) "end the cage age" was registered in September 2018. The ECI calls for banning the use of cages or individual stalls, in particular for laying hens, pigs and calves, where specific EU legislation exists.

The concept of "cage" is not defined in the legislation. In its common meaning "cage" means a box or enclosure having some openwork (e.g. wires, bares) for confining or carrying animals. It can cover either individually confined animals or animals kept in group in a limited space.

In the case of pigs, the legislation requires Member States shall ensure that sows and gilts are kept in groups during a period starting from four weeks after the service to one week before the expected time of farrowing.

Against this background, the Commission would like to request the EFSA to review the available scientific publications and possibly other sources to provide a sound scientific basis for future legislative proposals.

This request is about the protection of pigs. The scientific opinion which was used for the current legislation was published in 1997.

Since then the EFSA adopted opinions on the welfare of pigs in 2004[8], 2005[9], 2007[10,11,12], 2012[13] and 2014.[14]

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1 OJ L 221, 8.8.1998, p. 23.
2 OJ L 203, 3.8.1999, p. 53.
3 OJ L 10, 15.1.2009, p. 7.
4 OJ L 47, 18.2.2009, p. 5.
5 OJ L 182, 12.7.2007, p. 19.
6 OJ L 3, 5.1.2005, p. 1.
7 OJ L 303, 18.11.2009, p. 1.
8 Opinion of the Scientific Panel on Animal Health and Welfare to welfare aspects of the castration of piglets. EFSA Journal 2004;91, 1–18.
9 https://www.efsa.europa.eu/en/efsajournal/pub/268
10 https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/j.efsa.2007.572
11 https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/j.efsa.2007.564
12 https://www.efsa.europa.eu/en/efsajournal/pub/611
13 https://www.efsa.europa.eu/en/efsajournal/pub/2512
14 https://www.efsa.europa.eu/en/efsajournal/pub/3702

1.1.2. Terms of Reference (ToRs)

The Commission therefore considers opportune to request EFSA to give an independent view on the welfare of pigs.

The request includes the different aspects of keeping the following categories of pigs during the production cycle[15]:

- gilts and dry pregnant sows before farrowing (service and gestation),
- farrowing sows and piglets (birth to weaning),
- weaners (weaning to 10 weeks of age), rearing pigs (10 weeks of age to slaughter or service) and boars.

The killing of animals on farm is not part of the request.

For this request, the EFSA will for each category of animals:

- Describe, based on existing literature and reports, the current husbandry systems and practices of keeping them (General ToR 1),
- Describe the relevant **welfare consequences**. Relevance will not need to be based on a comprehensive risk assessment, but on EFSA's expert opinion regarding the severity, duration and occurrence of each welfare consequence (General ToR 2),
- Define qualitative or quantitative measures to assess the welfare consequences (**animal-based measures**) (General ToR 3),
- Identify the **hazards** leading to these welfare consequences (General ToR 4),
- Provide **recommendations** to prevent, mitigate or correct the welfare consequences (resource and management-based measures) (General ToR 5).

The current legislation requires gilts and sows to be kept in groups for part of their production life. In the context of the European Citizen Initiative "end the cage age", the EFSA will explore scientific information regarding risks and benefits of possible alternative housing systems to the ones presently allowed or of further increasing the period of time during which gilts and sows can be kept in groups.

For the following scenarios, the Commission has identified practical difficulties or insufficient information in ensuring the welfare of animals. At least for them, the EFSA will propose detailed animal-based measures and preventive and corrective measures with, where possible, either qualitative (yes/no question) or quantitative (minimum/maximum) criteria (i.e. requirements to prevent and/or mitigate the welfare consequences):

1) The welfare of gilts and dry pregnant sows after weaning in individual and group housing systems, during the first four weeks of pregnancy (Specific ToR 1);
2) The welfare of gilts and dry pregnant sows one week before farrowing in different housing systems offering different degrees of behavioural freedom (Specific ToR 2);
3) The welfare of sows and piglets from farrowing to weaning in different housing systems offering different degrees of behavioural freedom (Specific ToR 3);
4) (Specific ToR 4) The welfare of weaners and rearing pigs, in particular with the risks associated with:
   a) weaning;
   b) space allowance, including competition for space;
   c) types of flooring, including poor cleanliness and comfort;
   d) enrichment material;
   e) air quality;
   f) health status;
   g) diet, including competition for food; and
   h) the practice of mutilations (tail docking, tooth clipping, castration).
5) The assessment of Animal Based Measures collected in slaughterhouses to monitor the level of welfare on pig farms (such as tail damages, stomach ulcers, lung lesions) (Specific ToR 5).

[15] The wording used here is based on the definitions of Directive 2008/120/EC. This categorisation is indicative.

1.2. Interpretation of the Terms of Reference

In the framework of its Farm to Fork (F2F) strategy, the European Commission will start a comprehensive evaluation of the animal welfare legislation and has asked EFSA to review the available scientific publications and possibly other sources to provide a sound scientific basis for future legislative proposals on the protection of pigs.

This scientific opinion (SO) concerns the welfare of pigs on farm, whereas the killing of pigs on farm is not part of the request.

A welfare assessment may consist in two components, i.e. the risk assessment, with identification of the negative welfare consequences (adverse effects) that occur to an animal in response to a factor, and the benefit assessment, with identification of positive welfare consequences; however, in the current document, EFSA addressed the European Commission mandate by focusing on the adverse effects only. In the context of this opinion, the adverse effects are called 'welfare consequences'.

This scientific assessment takes mainly two approaches. To address the first set of ToRs listed in the mandate (so-called 'General ToRs'), for each pig category, a list of husbandry systems was identified and described. The husbandry systems considered to be the most relevant, or with potential to be developed (e.g. piglets in artificial rearing systems) were assessed in terms of welfare consequences, animal-based measures (ABMs), hazards leading to the welfare consequences and recommendations to prevent the hazards or correct/mitigate the welfare consequences. Secondly, for the five specific scenarios listed in the mandate (see Sections 1.1.2 and 1.2.2) for which there are practical difficulties in implementation of the legislation, or for which there is insufficient information, EFSA provided more detail. Where possible this included binary (yes/no) or quantitative preventive or corrective measures.

The European Commission requested EFSA to assess the different aspects of keeping the pigs during the production cycle and listed the pig categories that EFSA should consider in its assessment (see Table 1). It is specified that this list is based on the definitions of the current legislation (Council Directive 2008/120/EC[16]) and that the categorisation provided in the mandate (Section 1.1.2) is indicative.

According to the current legislation, a 'gilt' is defined as a female pig after puberty and before farrowing. In the context of this opinion, a gilt is a young female pig that has started her reproductive life but has not yet farrowed a litter.

In the case of 'sows', the Directive provides the following definitions: (i) 'sow': a female pig after the first farrowing; (ii) 'farrowing sow': a female pig between the perinatal period and the weaning of the piglets; (iii) 'dry pregnant sow': a sow between weaning her piglets and the next perinatal period. Across this opinion, 'dry sows' are sows from weaning to farrowing, and 'farrowing and lactating sows', from farrowing to weaning. Sows that are sent to the slaughterhouse are called 'cull sows' (see also Chapter 9).

The legislation defines a 'piglet' as a pig from birth to weaning; in the current opinion, this definition is extended to artificial rearing. In fact, there is no official definition of 'weaning' and the special case of piglets which are removed from the mother and placed in artificial rearing accommodation within the first few days after birth is included in the 'piglet' rather than 'weaner' category.

In both the Directive and this opinion, a 'weaner' is defined as a pig from the time of weaning until 10 weeks of age.

According to the Directive, a 'rearing pig' is a pig from 10 weeks to slaughter or service. Similarly, for the purposes of this document, a rearing pig is defined as a pig that is between 10 weeks of age and either slaughter or retention for breeding. Finally, in this opinion and according to the current legislation, 'boars' are male pigs after puberty retained for breeding.

In this document, 'animals in need of separation or treatment' have been also taken into consideration as one of the pig categories. This category includes pigs of any of the other categories that are obviously sick, weak, injured (e.g. lame or tail bitten) and/or have problems coping with social aspects of the husbandry system, such as being bullied. It also includes pigs that are not injured and appear well but are affected by conditions which cause health risks (e.g. hernias), or pigs which damage other pigs in the group (e.g. through tail biting).

Table 1 shows the **pig categories** listed in the European Commission mandate in comparison to the ones applied in this opinion; the description of the pig categories is reported in Section 3.2.

[16] Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs (Codified version). OJ L 47, 18.2.2009, p. 5–13.

In some cases, e.g. procedures carried out in suckling piglets and housing and management immediately prior to farrowing, some of the welfare consequences occur in a different animal category to that where the exposure variable is experienced. Where this is the case, it has been indicated in the general considerations for the welfare consequence under which animal category this is reviewed in detail.

The SO used for the current legislation on the protection of pigs was published in 1997 (SVC, 1997); however, since then, EFSA adopted also other outputs on the welfare of pigs on farm (EFSA, 2004, 2005, 2007a,b,c, 2014; EFSA AHAW Panel, 2012, 2014) that served as basis for this opinion.

Table 1: Pig animal categories as listed in the European Commission mandate and applied in the current scientific opinion, for the General and Specific ToRs

Animal categories as listed in the mandate	Animal categories as applied in this scientific opinion
General ToRs	**General ToRs**
Gilts and dry pregnant sows before farrowing (service and gestation)	Gilts and dry sows
Farrowing sows	Farrowing and lactating sows
Piglets (from birth to weaning)	Piglets (from birth to weaning, including artificial rearing)
Weaners (from weaning to 10 weeks of age)	Weaners (from weaning to 10 weeks of age)
Rearing pigs (from 10 weeks of age to slaughter or service)	Rearing pigs (from 10 weeks of age to slaughter or retention for breeding; grower and finisher pigs)
Boars	Boars (retained for breeding)
	Animals in need of separation or treatment
Specific ToRs	**Specific ToRs**
Gilts and dry pregnant sows after weaning during the first 4 weeks of pregnancy	Gilts and dry sows from entering the service area until the end of the fourth week of pregnancy
Gilts and dry pregnant sows 1 week before farrowing	Gilts and dry sows from the time they are transferred into the farrowing facilities up to the completion of farrowing
Sows from farrowing to weaning	Farrowing and lactating sows (from farrowing to weaning)
Piglets from farrowing to weaning	Piglets from farrowing to weaning
Weaners	Weaners
Rearing pigs	Rearing pigs
	Cull sows

1.2.1. General ToRs

The mandate asks EFSA to **describe for each pig category the husbandry systems and practices that are currently used in the EU for keeping pigs**. This description was based on the previous EFSA SOs listed above and revised by expert opinion based on the most updated knowledge (General ToR 1; see Section 3.3). Certain husbandry systems may expose animals to greater risks of important epidemic diseases (e.g. African Swine Fever in outdoor paddock systems). These risks will be not presented in this opinion because they have been extensively investigated by EFSA elsewhere (e.g. in EFSA AHAW Panel, 2021).

For each pig category, EFSA was also requested to describe **relevant welfare consequences**. To address this ToR, a list of specific welfare consequences was firstly developed, focusing on the effect on the pigs' welfare. These specific welfare consequences can lead to negative affective states such as fear, pain and/or distress. Subsequently, according to the mandate, relevance of the welfare consequences was assessed on the basis of expert opinion as a combination of the severity, duration and frequency/prevalence of occurrence of the welfare consequence. This expert opinion was elicited through a structured expert consensus exercise in a qualitative way, as a quantitative method was not always possible due to lack of published data on the welfare consequences. For each husbandry system, welfare consequences were classified into four categories: (i) non-applicable, (ii) clearly not relevant, (iii) less relevant and (iv) highly relevant. As a common criterion for relevance was used across systems, so not all systems had welfare consequences in each of the four categories (General ToR-2, see Section 3.4).

The present opinion focuses on the welfare consequences that were found to be pertaining to the fourth category above (highly relevant). For each of these welfare consequences, one or more **animal-based measures** (ABMs) were identified and listed. It's worthwhile to highlight that the ABMs reported in this opinion represent a number of the possible ones that can be used under on-farm conditions to assess a certain welfare consequence, although they might not be specific to it. In some cases, ABMs were included that indirectly relate to the welfare consequence, e.g. group stress (welfare consequence) may result in agonistic behaviour (direct ABM) which in turn may lead to claw lesions (indirect ABM) if e.g. slipping occurs during fighting (Table 11, Section 3.4.3). For each ABM, definition, interpretation and some qualitative assessment of its specificity and sensitivity for the welfare consequence are also reported (General ToR-3; see Section 3.4). In the context of animal welfare risk assessment, the sensitivity of the ABM is defined by the proportion of animals truly affected by the welfare consequence that are detected as affected by the indicator (i.e. equivalent to the diagnostic sensitivity of a test for a given disease). Example: in group-housed sows, the ABM that assesses presence or absence of 'Agonistic behaviour' is considered sensitive for the welfare consequence 'Group stress', as a high proportion of 'Group stressed' sows will show the presence of 'Agonistic behaviour'. Therefore: the presence of group stress will be detected by assessing aggression. Specificity is calculated as the proportion of animals truly NOT affected by the welfare consequence that the ABM identifies as not affected. Example: in group housed sows, the ABM 'Agonistic behaviour' is considered specific for the welfare consequence 'Group stress', as a high percentage of NOT 'Group stressed' sows will also NOT show 'Agonistic behaviour'. Therefore: the absence of group stress will be correctly identified by assessing aggression.

In this opinion only a broad qualitative indication of sensitivity and specificity (Yes/No), based on expert opinion, is given as guidance to the usefulness of the ABMs to assess each welfare consequence. No attempt has been made to quantify this indication, but arguments are provided to explain the reasoning by the experts.

The ABMs described in the current opinion are the ones that are applicable to the farming conditions. However, it might be that no ABMs are sensitive enough or specific to a welfare consequence or that they are not feasible to use for some categories of pigs; in these cases, assessors should rely on resource-based measures.

To entirely address the General ToRs of the mandate, EFSA experts also identified the most important **hazards leading to the highly relevant welfare consequences** (ToR 4). Resource- and management-based **measures that could be put in place to prevent or correct each hazard, or to mitigate the welfare consequence** were proposed for each pig category (ToR 5; see Sections 4.1, 5.1, 5.4, 7.1, 7.4 and 8.1). Moreover, for each pig category, an outcome table linking all the mentioned elements requested by the General ToRs was produced. It identifies the relevant welfare consequences, welfare hazards, preventive and corrective measures or mitigating measures and the related ABMs. Theses outcome tables provide an overall outcome in which all retrieved information is presented concisely. Finally, for each pig category, a comparison of the assessed systems is presented, as a basis for the conclusions of the opinion.

1.2.2. Specific ToRs

To address the second set of ToRs listed in the mandate (the so-called 'Specific ToRs'), EFSA has explored the relationship between relevant exposure variables and the welfare consequences for the pigs as indicated by ABMs. As part of the assessment, EFSA has proposed requirements and recommendations to prevent the hazards or correct/mitigate the welfare consequences.

In the context of this SO an 'exposure variable' can be any factor to which pigs are exposed (e.g. space allowance) that may be associated with an impact on their welfare (e.g. restriction of movement). Potentially, the number of exposure variables is huge.

For each Specific ToR, EFSA proposed to the European Commission a number of exposure variables as the most relevant for further assessment. The European Commission subsequently provided further clarification to the mandate, and indicated that there are two main criteria for selecting the relevant exposure variables. The first one refers to the European Citizen Initiative (ECI) 'end the cage age'. Although EFSA is not asked to provide the definition of a cage system, in the case of pigs it is often associated with the use of stalls or crates. The second criterion is their possible relevance to the problem of tail biting. It was acknowledged that other exposure variables interact with the prioritised exposure variables and these interactions are discussed in the narrative text, but not analysed in a quantitative way. This led to the following interpretation of the Specific ToRs, which is summarised in Table 2.

Extensive literature searches (ELSs) were carried out (see Section 2.2.1.2) to retrieve the most updated evidence. Published information was considered to assess the quantitative information on different ABMs relevant to each exposure variable. In several cases, one ABM was chosen on the basis of relevance and availability of information to be used for detailed analysis through an Experts Knowledge Elicitation (EKE) process (see Section 2.2.2.3) with the aim of quantifying welfare implications. Other ABMs, for which insufficient quantitative data were available, were considered in brief narrative text to include additional elements characterising animal welfare qualitatively. This was done using recent scientific review papers where available to avoid the necessity of an extensive repetition of information. This narrative approach was also used when insufficient quantitative evidence was available to conduct an EKE.

Specific ToR 1 refers to gilts and dry sows from entering the service area until the end of the fourth week of pregnancy. Council Directive 2008/120/EC allows these animals to be kept in individual stalls during these 4 weeks, after which they have to be housed in groups. The exposure variable that has been assessed relates to a reduction of the time they are housed in individual stalls, and was labelled 'grouping time' (see Section 4.4).

Specific ToR 2 considers the same pig categories included in Specific ToR 1 during a different phase of production: from the time they are transferred into the farrowing facilities up to the completion of farrowing in different housing systems (please note that this causes slight overlap with Specific ToR 3 as it starts with the birth of the first piglet – however, this does not affect the outcomes of this SO). During this time the animals are generally kept in individual farrowing crates, without the possibility to turn around or build a nest. EFSA has identified three exposure variables relating to 'different degrees of behavioural freedom' in this context: (i) space allowance, (ii) nesting/enrichment material and (iii) the period that the gilt/sow is confined in a crate.

Specific ToR 3 refers to sows and piglets from farrowing to weaning. Farrowing starts when the first piglet is born. During this part of the reproductive cycle the sows are predominantly kept in farrowing crates to reduce the overlying of their piglets. The exposure variables related to 'different degrees of behavioural freedom' were interpreted by EFSA experts to be the same as for Specific ToR 2: (i) space allowance, (ii) enrichment material and (iii) the period the sow is confined in a crate. 'Space allowance' needs to be differentiated between the space available to the sow and the total space of the farrowing pen. In this opinion, the latter was conventionally assumed to be equal to space available to the sow plus 1.2 m^2 of space available only for the piglets.

The assessment of the welfare of sows and piglets in the farrowing facilities, involving Specific ToRs 2 and 3, is reported in Section 5.7. Considerations on the welfare of sows and piglets depending on the litter size and on the time sows need to adapt to new farrowing systems are also provided in the same section.

In addition, the European Commission mandate asked EFSA to comment on the practices of tooth clipping, castration and tail docking. Although this was requested in the context of Specific ToR 4 (as these mutilations are associated with welfare outcomes of weaners and rearing pigs) the practices are applied in suckling piglets. Therefore, in this SO, they have been assessed in relation to the assessment of the welfare of piglets, i.e. when the welfare consequences of immediate pain are experienced (see Chapter 6).

Specific ToR 4 regards the welfare of weaners and rearing pigs and addresses particularly the issue of tail biting. The seven exposure variables that will be assessed are considered as possible risk factors for tail biting and are listed in the mandate (see Section 1.1.2 and Table 2). The assessment focused on the prevention of tail biting (see Section 7.7).

Particularly, in relation to the exposure variable 'health status' it is important to highlight that it has been looked at from the perspective of tail biting and not in the broader context of animal diseases.

Specific scenario 5 focuses on the ABMs which can be assessed in pig slaughterhouses to monitor the level of welfare on farm. The ABMs currently used are reported, together with information on their feasibility, relevance and the link to the welfare consequences experienced on farm. This Specific ToR considers cull sows and slaughter pigs. As the outcome of this scenario, a set of ABMs suitable to be measured at slaughter were provided (see Chapter 9).

Table 2: Overview of Specific ToRs and relevant exposure variables assessed after interpretation of the scientific questions that are behind the mandate questions. The detailed argumentation for exposure variable selection and their interpretation is discussed in the assessment chapters

#	Specific ToRs	Exposure variables
1	The welfare of gilts and dry sows – from entering the service area until the end of the fourth week of pregnancy	Grouping time
2	The welfare of gilts and dry sows – from the time they are transferred into the farrowing facilities up to the completion of farrowing in housing systems offering different degrees of behavioural freedom (to be assessed as part of the Farrowing Systems, see Section 5.7)	Space allowance
		Nesting/enrichment material
		The period the sow is confined in a crate (relative to farrowing)
3	The welfare of sows and piglets from farrowing to weaning in different housing systems offering different degrees of behavioural freedom	Space allowance
		Enrichment material
		The period the sow is confined in a crate
4	The welfare of weaners and rearing pigs, in particular with the risks associated with weaning, space allowance including competition for space, types of flooring, including poor cleanliness and comfort, air quality, health status, diet including competition for food, practice of mutilations (tail docking, tooth clipping, castration)	Weaning age
		Space allowance
		Types of flooring
		Enrichment material
		Air quality
		Health status
		Diet composition
		Tail docking
		Tooth clipping
		Castration
5	Assessment of ABMs collected in slaughterhouses to monitor the level of welfare on pig farms (e.g. tail damage, stomach ulcers, lung lesions). Additional identified by the WG: pericarditis, skin lesions, bruises, liver lesions, etc.)	(no exposure variables to assess)

Summary conclusions of the diverse pig categories are presented in chapters from 4 to 9, respectively. Chapter 10 presents the identification of the sources of uncertainty, after which in Chapter 11, the conclusions are presented together with the results of the uncertainty analysis.

2. Data and methodologies

2.1. Data

2.1.1. Data from literature

Information contained in previous EFSA scientific outputs (SVC, 1997; EFSA, 2004, 2005, 2007a,b,c, 2014; EFSA AHAW Panel, 2012, 2014) from the papers selected as relevant from the literature searches described in Section 2.2.1 and from additional scientific and grey literature identified by EFSA experts was used for a narrative description, and subjected to a qualitative or (when possible) quantitative assessment to address the General and Specific ToRs (see relevant chapters of the assessment). Data on the relation between ABM(s) and the exposure variables of the Specific ToRs were extracted and analysed (see Section 2.2.2.3).

2.1.2. Data from Member States

To address Specific ToR 5 on the assessment of ABMs collected at slaughterhouses to monitor the level of welfare on pig farms, information on the ABMs and their use in practice was requested by EFSA to the Animal Health and Animal Welfare (AHAW) Network representatives[17] and discussed in the context of an

[17] The EFSA AHAW Network includes nationally appointed EU Member State organisations representatives with expertise in the fields of animal health and animal welfare.

exercise during the annual Network meeting (year 2021). The data obtained from the Network were published in EFSA, 2021 and complemented by EFSA experts' opinion. For the list of ABMs, their description, full details on methodology and results of the exercise, see EFSA, 2021 and Chapter 9.

2.1.3. Data from Public Consultation

To consult interested parties and gain feedback on EFSA's ongoing work on the F2F mandate on the protection of pigs and on EFSA's interpretation of the ToRs, a public consultation was launched in the period 27 July to 13 October 2021. In particular, EFSA called for interested parties to:

- comment in the assessment of General ToRs-1, -2 and -3,
- provide additional information on pig husbandry systems and current practices for keeping pigs, not already identified by EFSA in the assessment of General ToR-1,
- comment on the list of relevant exposure variables provided in the Interpretation of Specific ToRs.

The information received in the public consultation was considered by the EFSA experts as part of their work on this SO (see Annex A: Public consultation on the protection of pigs on farm (published under 'Supporting Information')).

2.2. Methodologies

This SO follows the protocol detailed in the methodological guidance that was developed by the EFSA AHAW Panel to deal with all the mandates in the context of the Farm to Fork strategy revision (EFSA AHAW Panel, 2022).

According to the protocol, EFSA translated the assessment questions into more specific subquestions. These are interrelated, meaning that the outcome of each subquestion is necessary to proceed to the next subquestion. The approach to develop the subquestions is based on using both evidence from the scientific literature and expert opinion. The translation of the assessment questions into subquestions is mapped in Table 3.

Table 3: Overview of translation of the mandate assessment questions into subquestions

Assessment questions		Subquestions	
Translation of the General ToRs			
i.	**Describe the current husbandry systems**	***1.*** *Identify the relevant husbandry systems per pig category and select the ones to be fully assessed*	***2.*** *Describe the husbandry systems*
		Aim: Husbandry systems to be considered in the assessment are identified and selected to be representative of the currently used systems in the EU. Most relevant husbandry systems are identified and selected to be fully assessed Approach: expert opinion via group discussion Relationship with assessment question: This subquestion is necessary for the overall assessment question requiring the description of the systems	Aim: All the husbandry systems per pig category identified and selected from subquestion 1 are described narratively Approach: literature review Relationship with assessment question: this corresponds to the assessment question and is necessary for the next assessment question
ii.	**Describe the relevant welfare consequences that may occur in these systems**	***3.*** *Identify the welfare consequences common for all mandates and provide their definitions*	***4.*** *Select the highly relevant welfare consequences for each of the most relevant husbandry systems*
		Aim: To identify the welfare consequences that may impair the welfare of pigs, and to provide a definition for them. EFSA generates a list of welfare consequences common for all Farm-to Fork (F2F) mandates, which was used as a basis for this identification Approach: Expert opinion via group discussion (see focus and full resulting list in Section 2.2.2.1) Relationship with assessment question: The list of all possible welfare consequences is necessary for the next assessment question asking to identify the highly relevant ones per each system	Aim: To identify the highly relevant welfare consequences for each of the previously identified and defined husbandry systems Approach: Expert opinion via EKE (see focus on this in Section 2.2.2.1) Relationship with assessment question: this corresponds to the assessment question and is related to subquestion 1 in which relevant welfare consequences are identified only for current most relevant husbandry systems
iii.	**Define qualitative or quantitative animal-based measures (ABMs) to assess these welfare consequences**	***5.*** *Identify the feasible ABMs for the assessment of the highly relevant welfare consequences*	***6.*** *Describe the feasible ABMs for the assessment of the highly relevant welfare consequences*
		Aim: The ABMs for the assessment of the welfare consequences previously identified as highly relevant are selected. Approach: expert opinion via group discussion	Aim: The ABMs for the assessment of the welfare consequences previously identified as the highly relevant are described Approach: literature review and expert opinion via group discussion

Assessment questions		Subquestions	
		Relationship with assessment question: this corresponds to the assessment question and is related to subquestion 4 in which ABMs are identified only for the highly relevant welfare consequences	Relationship with assessment question: related to subquestion 5
iv.	**Identify the hazards leading to these welfare consequences**	***7.*** *Identify the hazards leading to the highly relevant welfare consequences*	***8.*** *Describe the hazards leading to the highly relevant welfare consequences*
		Aim: The hazards leading to the highly relevant welfare c onsequences are identified Approach: expert opinion via group discussion Relationship with assessment question: this corresponds to the assessment question and is related to subquestion 4 in which hazards are identified only for the highly relevant welfare consequences	Aim: The hazards are described Approach: literature review and expert opinion via group discussion Relationship with assessment question: related to subquestion 6
v.	**Provide recommendations to prevent, mitigate or correct the hazards**	***9.*** *Identify the preventive and corrective measures for hazards and mitigation measures for the highly relevant welfare consequences*	***10.*** *Describe the preventive, corrective and mitigation measures for the highly relevant welfare consequences*
		Aim: measures to prevent and correct hazards leading to highly relevant welfare consequences for the previously identified and defined husbandry per pig category are identified Approach: expert opinion via group discussion Relationship with assessment question: This corresponds to the assessment question and is related to subquestion 4 in which preventive, corrective and mitigation measures are identified only for the highly relevant welfare consequences	Aim: preventive, corrective and mitigation measures are described Approach: literature review and expert opinion via group discussion Relationship with assessment question: related to subquestion 8
		Translation of the Specific ToRs	
vi.	**Propose detailed ABMs and preventive and corrective measures with, where possible, either qualitative (yes/no question) or quantitative (minimum/maximum) criteria (i.e. requirements to prevent and/or mitigate the**	***11.*** *Identify the relevant exposure variables for each of the Specific ToRs (Specific ToRs 1, 2, 3 and 4) of the mandate*	***12.*** *Describe the exposure variables*
		Aim: For Specific ToRs 1, 2, 3 and 4, identify the exposure variables that are relevant for the mandate question. Selection criteria in this Scientific opinion: ECI 'end the cage age' and tail biting Approach: expert opinion via group discussion Relationship with assessment question: This subquestion is necessary for the overall assessment of each of the Specific ToRs	Aim: Description of the exposure variables relevant for addressing each of the Specific ToRs 1, 2, 3 and 4 Approach: literature review Relationship with assessment question: this corresponds to the assessment question of Specific ToRs and is necessary for the next assessment question

Assessment questions	Subquestions	
welfare consequences), for the listed Specific ToRs	***13.** Identify the welfare consequences influenced by each exposure variable identified in subquestion 11*	***14.** Describe the welfare consequences influenced by the exposure variables*
	Aim: For Specific ToRs 1, 2, 3 and 4, identify the welfare consequences that are correlated with the exposure variable(s) identified in subquestion 11 Approach: literature review and expert opinion via group discussion Relationship with assessment question: This subquestion is necessary for the overall assessment of each of the Specific ToRs	Aim: Description of the welfare consequences that are influenced by the exposure variable(s) identified in subquestion 11 Approach: literature review Relationship with assessment question: This subquestion corresponds to the assessment question of Specific ToRs and is necessary for the next assessment question
	***15.** Identify the 'reference' ABM(s) for addressing the subquestion qualitatively or quantitatively (all five Specific ToRs)*	***16.** Describe or quantify the reference ABM(s)*
	Aim: For Specific ToRs 1, 2, 3 and 4, identify the reference ABMs for measuring the welfare consequences identified in subquestion 13. In the case of Specific ToR 5, identify the ABMs that can be collected at slaughter to monitor the level of animal welfare on the farm Approach: literature review and expert opinion via group discussion Relationship with assessment question: This subquestion is necessary for the overall assessment question requiring qualitative or quantitative criteria	Aim: The ABMs are described or quantified Approach: literature review and/or expert opinion via group discussion (for more details, see Section 2.2.2.3) Relationship with assessment question: this corresponds to the assessment question of Specific ToRs and is necessary for the next assessment question
	***17.** Identify qualitative or quantitative preventive, corrective or mitigation measures*	***18.** Describe the preventive, corrective and mitigation measures*
	Aim: For Specific ToRs 1, 2, 3 and 4, identify measures to prevent and correct hazards leading to the welfare consequences identified in subquestion 13/or to mitigate the welfare consequences identified in subquestion 13 Approach: expert opinion via group discussion Relationship with assessment question: this corresponds to the assessment question and is related to subquestion 13 in which preventive, corrective and mitigation measures are identified in relation the welfare consequences of subsection 13	Aim: preventive, corrective and mitigation measures are described Approach: literature review Relationship with assessment question: related to subquestion 17

2.2.1. Literature search

As described in Table 3, literature searches were carried out for the subquestions requiring the description of husbandry systems, welfare consequences, ABMs, hazards, preventive and corrective or mitigation measures and exposure variables. Scientific review papers, where available, were used to avoid the necessity of an extensive repetition of information.

All publications relevant for this SO were included in an EndNote x7 Library.

2.2.1.1. General ToRs

Background information for description of pig categories and husbandry systems (General ToR-1), welfare consequences (ToR-2), ABMs (ToR-3), hazards (ToR-4) and preventive, corrective and mitigation measures (ToR-5) is reported in previous EFSA's Scientific outputs and External reports prepared for EFSA with updated literature assessing diverse aspects of pig welfare (SVC, 1997; EFSA, 2004, 2005, 2007a,b,c, 2014; EFSA AHAW Panel, 2012, 2014; Spoolder et al., 2011a,b).

This information was complemented by the results of broad literature searches that were carried out to retrieve additional information on the elements requested by the General ToRs, and by any additional relevant publication in the reference list of relevant review articles and key reports or proposed by EFSA experts.

2.2.1.2. Specific ToRs

Extensive Literature Searches (ELSs) were carried out to identify scientific evidence reporting welfare implications and associated ABM(s) with strong relationship to the exposure variables identified in subquestion 11. Restrictions were applied in relation to the date of publication, considering only those records published after a previous EFSA Scientific outputs on the topic (SVC, 1997; EFSA, 2004, 2005, 2007a,b,c, 2014; EFSA AHAW Panel, 2012, 2014).

The searches were saved in Web of Science and relevant results (records) appearing at a later stage were screened and added to the pool of papers available to the experts. In addition, relevant review articles and key reports were checked for further relevant articles, and EFSA experts were invited to propose any additional relevant publications they were aware of, until the information of the exposure variable was considered sufficient to undertake the assessment. If needed, relevant publications published before previous EFSA's scientific outputs were also considered.

Scientific data from relevant publications were extracted and analysed to address the scientific questions listed in the mandate Specific ToRs (see Chapters 4–9).

Details of the literature search strategies and number of the records that underpin the process are provided in Appendix A.

2.2.2. Expert opinion

The data obtained from the literature and the public consultation were complemented by the EFSA experts' opinion in order to address General and Specific ToRs. In particular, as described in Table 3.

For the General ToRs: Expert opinion was mainly used for the subquestions requiring the identification of the husbandry systems and selection of the most relevant ones to be fully assessed (General ToR 1); identification of the welfare consequences and selection of the highly relevant ones (ToR 2); identification of ABMs and qualitative assessment of their sensitivity and specificity (ToR 3); and identification of hazards, and preventive, corrective and mitigation measures (ToRs 4 and 5).

For the Specific ToRs: Expert opinion was mainly used for the subquestions requiring the identification of the relevant exposure variables for each Specific ToR; identification of the welfare consequences influenced by the exposure variable(s); identification and quantification (if any) of the ABMs; and identification of preventive, corrective and mitigation measures (for details on the approach to the diverse exposure variables of Specific ToRs, see Section 2.2.2.3).

Expert opinion was mainly elicited via group discussion; in some cases, specific exercises were carried out on the basis of the expert opinion:

1) selection of the highly relevant welfare consequences to address General ToR 2 (see Section 2.2.2.1),
2) development of outcome tables to address General ToRs 4 and 5 (see Section 2.2.2.2) and
3) quantitative, semiquantitative and qualitative assessments to address the Specific ToRs (for further details, see Section 2.2.2.3).

2.2.2.1. General ToR-2: Selection of the highly relevant welfare consequences for pigs

As explained in Table 3 (Subquestion 4), to identify the highly relevant welfare consequences, a structured Expert Knowledge Elicitation (EKE) was carried out.

The mandate requested the identification of the highly relevant welfare consequences for each of the identified most relevant husbandry systems.

The starting point was the list of 33 welfare consequences previously identified by EFSA (see Table 3, Subquestion 3; for further details, see EFSA AHAW Panel, 2022). These welfare consequences were screened for relevance to the topic of this SO (protection of pigs on farm) by EFSA experts. Thirty specific welfare consequences applicable to pigs on farm (any pig category in any husbandry system) were identified as pertinent for further assessment (see Table 4).

The EKE exercise was carried out separately for each husbandry system per pig category resulting from subquestion 1 (Table 3) and consisted in selecting the highly relevant welfare consequences out of these 30 per each of these combinations (pig category × husbandry system; e.g. weaners in indoor group housing, see Section 3.3.1).

For each combination, EFSA experts were asked to classify, based on an estimate of their magnitude, the 30 welfare consequences into four categories of relevance: (i) non-applicable, (ii) less relevant, (iii) moderately relevant and (iv) highly relevant. The magnitude was defined as the combination of severity, duration and frequency of occurrence (EFSA AHAW Panel, 2012). 'Duration' refers to the time an animal spends within a production stage, and 'frequency of occurrence' was defined as the prevalence of animals experiencing the welfare consequence in that stage. Owing to the lack of published data on these three parameters, no attempt was made to quantify the magnitude, and the experts expressed their opinion on the magnitude of the welfare consequences qualitatively.

Because a common criterion for relevance was used across systems, not all systems had welfare consequences in each of the four categories.

Expert opinion was elicited in three phases:

- First phase: Eight EFSA experts individually went through the list of welfare consequences and identified those that fell in the 'non-applicable' or 'less relevant' categories. Their individual judgements were then collated, and those welfare consequences unanimously identified as belonging to these two categories were removed and not considered for further assessment. Those welfare consequences for which there was no consensus as to whether they were 'non-applicable' or 'less relevant' remained for further assessment.
- Second phase: The experts went individually through the list of remaining welfare consequences and identified those that fell in the category of 'highly relevant'. These were kept for further assessment. Similarly, as during the first phase, in case discrepant opinions emerged, consensus was sought through group discussion.
- Third phase: The experts were asked to individually rank all of the remaining welfare consequences in the list that were not already identified as highly relevant (and thus kept) or non-applicable or less relevant (and thus removed) from most to least relevant. Their individual rankings were then discussed again in an open group discussion with the aim to reassign if appropriate any of the remaining welfare consequences into the categories 'highly relevant' or 'less relevant', or maintain them in the category 'moderately relevant'.

General ToRs of the present SO focus mainly on the welfare consequences that were selected as highly relevant from this exercise (see Section 3.4).

It needs to be noted that the description of each welfare consequence reported in the list refers to either one or more negative affective states (e.g. pain, fear, fatigue, etc.). These are the high-level states that derive from the occurrence of the welfare consequence and that can lead to animal suffering. A draft list and description of the negative affective states as derived from literature is reported in Table 5 (from EFSA AHAW Panel, 2022).

Table 4: List of specific welfare consequences applicable to pigs on farm (adapted from EFSA AHAW Panel, 2022)

#	Welfare consequence	Description
1	Restriction of movement	The animal experiences stress and/or negative affective states such as pain, fear discomfort and/or frustration due to the fact that it is unable to move freely, or is unable to walk comfortably (e.g. due to overcrowding, unsuitable floors, gates, barriers).
2	Resting problems	The animal experiences stress and/or negative affective states such as discomfort, fatigue and/or frustration due to the inability to lie, rest comfortably or sleep (e.g. due to hard flooring).
3	Group stress	The animal experiences stress and/or negative affective states such as pain, fear and/or frustration resulting from a high incidence of aggressive and other types of negative social interactions, often due to hierarchy formation or competition for resources.
4	Sensory under and/or overstimulation	The animal experiences stress and/or negative affective states such as fear and/or discomfort due to visual, auditory or olfactory under/overstimulation by the physical environment.
5	Handling stress	The animal experiences stress and/or negative affective states such as pain and/or fear resulting from human or mechanical handling (e.g. sorting and vaccination).
6	Isolation stress	The animal experiences stress and/or negative affective states such as frustration and/or fear resulting from the absence of social contact with conspecifics.
7	Separation stress	The animal experiences stress and/or negative affective states such as fear and/or frustration resulting from separation from conspecifics.
8	Inability to perform comfort behaviour	The animal experiences stress and/or negative affective states such as discomfort and/or frustration resulting from the thwarting of the motivation to maintain the function and integrity of the integument (e.g. cannot keep clean, scratch).
9	Inability to perform sexual behaviour	The animal experiences negative affective states such as frustration resulting from the thwarting of the motivation to engage in sexual activities.
10	Inability to avoid unwanted sexual behaviour	The animal experiences stress and/or negative affective states such as pain and/or fear resulting from inability to avoid forced mating.
11	Inability to perform exploratory or foraging behaviour	The animal experiences stress and/or negative affective states such as frustration and/or boredom resulting from the thwarting of the motivation to investigate the environment or to seek for food (i.e. extrinsically and intrinsically motivated exploration).
12	Inability to express maternal behaviour	The animal experiences stress/or and negative affective states such frustration resulting from the thwarting of the motivation to care for offspring, including during the prepartum phase (e.g. nest-building).
13	Inability to perform sucking behaviour	The animal experiences negative affective states such as frustration resulting from the thwarting of the motivation to suck from an udder.
14	Inability to perform play behaviour	The animal experiences negative affective states such as frustration resulting from the thwarting of the motivation to engage in social/locomotory or object play.
15	Predation stress	The animal experiences negative affective states such as fear resulting from being attacked or perceiving a high predation risk
16	Prolonged hunger	The animal experiences craving or urgent need for food or a specific nutrient, accompanied by a negative affective state, and eventually leading to a weakened condition as metabolic requirements are not met.
17	Prolonged thirst	The animal experiences craving or urgent need for water, accompanied by a negative affective state and eventually leading to dehydration as metabolic requirements are not met.
18	Heat stress	The animal experiences stress and/or negative affective states such as discomfort and/or distress when exposed to a high effective temperature.
19	Cold stress	The animal experiences stress and/or negative affective states such as discomfort and/or distress when exposed to low effective temperature.

#	Welfare consequence	Description
20	Locomotory disorders (including lameness)	The animal experiences negative affective states such as pain or discomfort due to impaired locomotory behaviour induced by e.g. bone, joint, skin or muscle damage.
21	Soft tissue lesions and integument damage	The animal experiences negative affective states such as pain, discomfort and/or distress due to physical damage to the integument or underlying tissues e.g. multiple scratches, open or scabbed wounds, ulcers and abscesses. This welfare consequence may result from negative social interactions such as aggression, tail biting, from handling or from damaging environmental features, or from mutilation practices (e.g. tail docking).
22	Bone lesions (incl. fractures and dislocations)	The animal experiences negative affective states such as pain, discomfort and/or distress due to fractures or dislocations of the bones (excluding those fractures leading to locomotory disorders).
23	Skin disorders (other than soft tissue lesions and wounds integument damages)	The animal experiences negative affective states such as pain, discomfort and/or distress due to e.g. infections, ectoparasites or sunburn.
24	Respiratory disorders	The animal experiences negative affective states such as discomfort, pain, air hunger and/or distress due to impaired function or lesion of the lungs or airways.
25	Eye disorders	The animal experiences negative affective states such as discomfort, pain and/or distress due to irritation or lesion or lack of function of at least one eye.
26	Gastro-enteric disorders	The animal experiences negative affective states such as discomfort, pain and/or distress due to impaired function of the gastro-intestinal tract resulting from, e.g. nutritional deficiency, infectious, parasitic or toxigenic agents.
27	Reproductive disorders	The animal experiences negative affective states such as pain and/or discomfort due to a disorder of the reproductive system resulting from physical injury or infection (including dystocia and metritis).
28	Mastitis	The animal experiences negative affective states such as pain and/or discomfort due to the inflammation of at least one of the mammary glands.
29	Metabolic disorders	The animal experiences negative affective states such as inappetence, weakness, fatigue, discomfort, pain and/or distress due to disturbed metabolism (e.g. acidosis and ketosis), deficiencies in specific nutrients (e.g. anaemia) or induced by ectoparasites affecting metabolism or poisoning.
30	Umbilical disorders and hernias	The animal experiences negative affective states such as discomfort and/or pain due to inflammation of the navel or any type of hernias.

Table 5: List and description of negative affective states (EFSA AHAW Panel, 2022)

#	Negative affective state	Description
1	**Boredom**	Boredom is an unpleasant emotion including suboptimal arousal levels and a thwarted motivation to experience almost anything different or more arousing than the behaviours and sensations currently possible (adapted from Mason and Burn, 2011).
2	**Discomfort**	Discomfort can be physical or psychological and is characterised by an unpleasant feeling resulting in a natural response of avoidance or reduction of the source of the discomfort. Pain is one of the causes for discomfort, but not every discomfort can be attributed to pain. Discomfort in non-communicative patients is assessed and measured via behavioural expression, also used to describe pain and agitation, leading to discomfort being interpreted as pain in some conditions (Ashkenazy and DeKeyser Ganz, 2019).
3	**Stress[(1)] and Distress**	**Stress**[(1)]: Stressors are events, internal or external to the body involving real or potential threats to the maintenance of homeostasis. When stressors are present, the body will show stress responses (biological defence to re-establish homoeostasis – e.g. behavioural, physiological, immunological, cognitive and emotional). Stress is a state of the body when stress responses are present (Sapolsky, 2002).

#	Negative affective state	Description
		Distress: Distress is a conscious, negatively valenced, intensified affective motivational state that occurs in response to a perception that current coping mechanisms (involving physiological stress responses) are at risk of failing to alleviate the aversiveness of the current situation in a sufficient and timely manner (McMillan, 2020).
4	**Fatigue**	Physiological state representing extreme tiredness and exhaustion of an animal (EFSA AHAW Panel, 2020).
5	**Fear**	The animal experiences an unpleasant emotional affective state induced by the perception of a danger or a potential danger that threaten the integrity of the animal (Boissy, 1995).
6	**Frustration**	Negatively valenced emotional state consecutive to the impossibility to obtain what is expected or needed. Frustration is very often triggered by restriction of natural behaviours thus resulting in thwarted motivation to perform these behaviours.
7	**Pain**	An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage (Raja et al., 2020).

(1): The term stress does not describe a negative affective state in itself, but it is mentioned and defined in the table as it is a prerequisite of distress.

2.2.2.2. General ToRs-4 and -5: Development of outcome tables

The main results of the assessment of General ToRs are summarised in outcome tables, linking all the mentioned elements requested by the mandate (husbandry systems, highly relevant welfare consequences, ABMs, hazards, preventive, corrective and mitigation measures) and provide an overall outcome in which all retrieved information is presented concisely (see description of the structure below, in Table 6).

The outcome tables have the following structure and terminology:

- OUTCOME TABLE: Each table represents the summarised information for a pig category.
- WELFARE CONSEQUENCE: This column lists the welfare consequences considered highly relevant in a given husbandry system.
- HUSBANDRY SYSTEM: This column lists the husbandry system(s) where each welfare consequence was identified as highly relevant.
- HAZARD: This column lists the factors with the potential to cause and/or impair welfare consequences
- PREVENTIVE MEASURE(S) FOR THE HAZARD: Several measures to prevent the hazard are proposed in this column.
- CORRECTIVE MEASURE(S) FOR THE HAZARD: If measures to correct the hazard exist, they are proposed in this column.
- MITIGATION MEASURE(S) FOR THE WELFARE CONSEQUENCE: In this column, practical actions/measures for mitigating the welfare consequence are presented.
- ANIMAL-BASED MEASURE(S): The column lists the feasible measures to be measured on the animals to assess the identified highly relevant welfare consequences.

Table 6: Example of the structure of an outcome table

Welfare consequence	Husbandry system(s) for which the welfare consequence has been scored as highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM (s)

2.2.2.3. Assessment of the Specific ToRs

The methodology to address the Specific ToRs followed the guidance protocol of EFSA AHAW Panel (2022) to the mandates in the context of the F2F Strategy revision.

Decision on how to assess the diverse exposure variables was taken on the basis of the availability of data in the literature. Quantitative assessment was carried out where a clear and unconfounded question could be identified and where sufficient quantitative data were sourced from literature to address this question. However, in cases where insufficient quantitative data exist, or where the inter-relationship of many different factors makes it impossible to set up an acceptable model which can address an unconfounded question, a qualitative (narrative) or semiquantitative approach was taken (for an overview of the approaches, see Table 7).

As explained in Section 2.2.1.2, published information was considered to assess the quantitative data on different ABMs relevant to each exposure variable. In four cases, one ABM could be chosen on the basis of relevance and availability of information, and was used for detailed analysis through a structured Expert Knowledge Elicitation (EKE) process with the aim of quantifying welfare implications (for details on the risk assessment model of the structured EKEs, see EFSA AHAW Panel, 2022). Seven to nine EFSA experts (depending on the availability) participated in the EKE exercises. Other ABMs for which insufficient quantitative data were available were considered in brief narrative text to include additional elements characterising animal welfare. This narrative approach was also used when insufficient quantitative evidence was available to conduct a structured EKE.

When, in case of lack of standardisation of the extracted ABMs between the studies reported in different papers, it was not possible to identify specific 'reference' ABM(s) to assess the scenarios with the structured EKE model, depending on the availability of information, the adopted approach was semiquantitative or qualitative (yes/no) or narrative (for more details on the methodology to quantitatively approach Specific ToRs, see EFSA AHAW Panel, 2022).

Table 7 shows an overview of the approaches that have been adopted to assess the diverse exposure variables of the five Specific ToRs.

Table 7: Overview of the approaches followed by EFSA experts to assess the mandate Specific ToRs

Specific ToR #		Exposure variable	Approach/type of assessment	Section in this Scientific opinion/source
1	The welfare of gilts and dry sows, from entering the service area until the end of the fourth week of pregnancy	Grouping time	Qualitative (yes/no) assessment	Section 2.2.1 and Section 4.4.3
2	The welfare of gilts and dry sows, from the time they are transferred into the farrowing facilities up to the completion of farrowing in housing systems offering different degrees of behavioural freedom	Space allowance	Quantitative assessment (EKE)	Section 2.2.1 and EFSA AHAW Panel, 2022
	Nesting/enrichment material	Semi-quantitative assessment	Section 2.2.1 and Section 5.7.14.	
	The period the sow is confined in a crate (relative to farrowing)	Narrative assessment	Section 2.2.1	
3	The welfare of sows and piglets from farrowing to weaning in different housing systems offering different degrees of behavioural freedom	Space allowance	Quantitative assessment (EKE) (sows and piglets)	Section 2.2.1 and EFSA AHAW Panel, 2022
		Enrichment material	Narrative assessment (sows and piglets)	Section 2.2.1
		The period the sow is confined in a crate	Narrative assessment (sows) and Quantitative assessment (EKE) (piglets)	Section 2.2.1 and EFSA AHAW Panel, 2022
4	The welfare of weaners and rearing pigs, in particular with the risks associated with weaning, space allowance including competition for space, types of flooring, including poor cleanliness and comfort, air quality, health status, diet including competition for food, practice of mutilations (tail docking, tooth clipping, castration)	Weaning age	Semi-quantitative assessment	Section 2.2.1.2 and Section 7.7.1.2
		Space allowance	Semi-quantitative assessment	Section 2.2.1 and Section 7.7.2.2
		Types of flooring	Narrative assessment	Section 2.2.1
		Enrichment material	Narrative assessment	Section 2.2.1
		Air quality	Narrative assessment	Section 2.2.1

Specific ToR #		Exposure variable	Approach/type of assessment	Section in this Scientific opinion/source
		Health status	Narrative assessment	Section 2.2.1
		Diet composition	Narrative assessment	Section 2.2.1
		Tail docking	Narrative assessment	Section 2.2.1
		Tooth clipping	Narrative assessment	Section 2.2.1
		Castration	Narrative assessment	Section 2.2.1
5	Assessment of ABMs collected in slaughterhouses to monitor the level of welfare on pig farms	---	Semi-quantitative assessment	Section 2.2.1 and Section 9.2

2.2.3. Uncertainty analysis

The AHAW Panel agreed to tackle the uncertainty related to the data inputs and the methodology employed to identify welfare consequences, ABMs and related hazards by first describing the potential sources of uncertainty affecting the assessment. A table describing the sources of uncertainty is presented in Chapter 10.

The impact of these uncertainties in the assessment of the General ToRs of this SO was assessed collectively following the procedure described in the EFSA guidance on uncertainty analysis in scientific assessments (EFSA Scientific Committee, 2018a,b) for case-specific assessments with some modifications. The outcome of the assessment of the General ToRs is the identification and description of the highly relevant welfare consequences, the related ABMs and the hazards causing these welfare consequences per each pig category and in the most relevant husbandry systems. Measures to prevent and correct the hazards and/or to mitigate the welfare consequences are also identified and described. Conclusions and recommendations are formulated on the basis of these elements.

For the General ToRs, EFSA experts agreed to limit the assessment to the quantification of the overall impact of the sources of uncertainty on the summary conclusions developed in chapters from 4 to 9. Experts were asked to provide their individual judgement on the certainty for each conclusion according to three predefined agreed certainty ranges (see Table 8), which are derived from the approximate probability scale from the guidance on uncertainty (EFSA, 2019).

Experts were asked to identify the probability range best reflecting their degree of certainty for each conclusion. Individual answers were then subjected to group discussion during which experts had the chance to explain the rationale behind their judgement, and a consensus on which category better reflected the overall certainty was reached. A qualitative translation of the outcome of the uncertainty assessment was also derived (e.g. 'more likely than not' for a certainty range of > 50–100%) (see Table 8).

For the Specific ToRs, a more quantitative approach was used where possible (see Table 7); in the case of EKEs, the certainty range was assessed as part of the exercise (as described in EFSA AHAW Panel, 2022). For some of the exposure variables assessed, where EKEs were not possible or not considered relevant, the uncertainty was assessed following the procedure used for the General ToRs.

For further details and the results of the uncertainty analysis on the summary conclusions, please see Chapter 11.

Table 8: Three ranges used to express agreed (consensus) certainty around conclusions (adapted from EFSA, 2019)

	Certainty range		
Quantitative assessment	**> 50–100%**	**66–100%**	**90–100%**
Qualitative translation	More likely than not	From likely to almost certain	From very likely to almost certain

3. Assessment of General ToRs 1, 2 and 3

3.1. Pig production in the EU

In December 2020, there were 146 million pigs in the EU[18]. However, there are no data on the proportion of these pigs which are produced in the different production systems.

3.2. Pig categories

In the following sections, information on the definition, biology and production cycle of pigs is provided per pig category. The main sources for this information include the report of the Scientific Veterinary Committee (SVC, 1997) on the welfare of intensively kept pigs and EFSA's scientific outputs on the welfare of pigs (e.g. EFSA, 2007a,b,c). Specific reference to these sources is made where relevant, and other references were added if appropriate.

3.2.1. General characteristics of pigs

The SVC, 1997 report contains an extensive overview of general characteristics of pigs, presented below (with some additional references). The main finding is that the behavioural and physiological biology of modern commercial pigs is still very similar to that of wild boars. Knowing how the latter behave will help to understand motivations and behaviours of domestic animals.

Pigs are social animals with the maternal group as the basic social unit. For wild boars and (semi) wild pigs, the most common group sizes are two to six individuals. The group usually consists of sows and their female offspring (family group). Sows only separate from this group to farrow and during the first few weeks of the suckling period. Males (adults and subadults) are normally solitary, but may also form groups of all males. These seem to be more instable than the family groups. Domesticated pigs also show gregariousness and within groups they form stable near linear hierarchies, which are based on age and size.

Pigs have a good social memory and will recognise other individuals after weeks of separation (Spoolder et al., 1996). SVC (1997) states: 'Individual recognition is largely based on smell, whereas sight is relatively unimportant once the social order is established. Although pigs possess a repertoire of different vocalizations, only the function and/or signal content of a few of them are known. This includes the warning call, sow lactation grunts which transfer information concerning the milk ejection during a suckling episode, "begging calls" of piglets, contact grunts and boar courtship vocalisations (chanting)'.

Pigs are omnivores. They adapt their diets to what is available. The diet of wild boars and (semi) wild pigs consists primarily of plants (e.g. seeds, grass, fruit, roots). However, animal material may be a relatively large part of it. Much food searching is performed by rooting; but grazing and browsing are also prominent foraging behaviours. This behaviour is intrinsically motivated. Even when fed full rations of commercial feed, domestic pigs have been noted to spend 6–8 h searching for food in a semi-natural enclosure.

Exploration takes place over a substantial part of the day, and develops already in young animals. Even if the stimuli which would normally trigger exploration are missing, pigs are motivated to explore and show this behaviour.

Wild boars and (semi) wild pigs have daily activity patterns that are described by SVC (1997) as 'highly variable and depends to a large degree on hunting pressure, where heavily hunted populations tend to be more nocturnal in their activity rhythms'. The weather also affects this activity patterns, and pigs tend to be less active with high temperature. Wood-Gush et al. (1990) reported a study in Edinburgh showing that domestic pigs in semi-natural conditions have concentrated activity to some hours: in the morning and in the late afternoon and early evening.

In domestic pigs, resting periods were reported in the middle of the day and during nights. However, the diurnal activity pattern of domestic pigs in conventional husbandry systems is mainly governed by feeding times.

Pigs keep the area that they occupy clean and dry as much as possible. They do this by regular addition and removal of bedding material. Pigs also separate the lying and a excretion areas when

[18] European Commission (EC). Directorate-General for Agriculture and Rural Development G3. Animal Products. Available online (https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/pig-population-survey_en.pdf). Last accessed on 20/05/2022.

possible. They choose to lie in the area of the pen which is undisturbed and thermally the most comfortable. They excrete in areas which are close enough for only a short walk, and may be too cold, wet or draughty for comfortable lying.

Although domestic pigs are known to wallow in their own excreta, this usually only occurs at high ambient temperatures. Since pigs have very limited sweating and panting abilities, they rely on wallowing for cooling in hot weather. Changes in the physiology of modern pigs make them more sensitive to heat stress as discussed below (see Section 3.2.6).

3.2.2. Gilts

3.2.2.1. Definition, biology and background information on the production cycle

According to Council Directive 2008/120/EC[19], a gilt is defined as a female pig after puberty and before farrowing. In the context of this opinion, a gilt is a young female pig that has started her reproductive life but has not yet farrowed a litter. Most commonly, gilts replace sows culled/removed from the breeding herd because of e.g. reproductive failure, injury, illness or death/euthanasia. Gilts can be selected as replacements any time after weaning and until they reach market/slaughter weight. Until the time of selection for service, they are normally housed in the same way as rearing pigs and so are covered by discussion of this category in Section 3.2.6.

SVC (1997) states that 'The age at puberty is influenced by genetic, social and environmental factors and is lower when animals are in a group, are in contact with boars and are not spatially restricted.' In female pigs, the age of puberty is usually between 160 and 265 with an average of 190 days (e.g. Calderón Díaz et al., 2015a). Puberty is defined as when the expression of behavioural oestrus coincides with ovulation (Knox et al., 2013). However, sexual maturity is different to puberty, as often gilts can express oestrus but do not ovulate or can ovulate and not express oestrus. Therefore, sexual maturity happens after puberty. Since sexual maturity is difficult to measure, other factors are considered such as symptoms of oestrus and also the weight, age and body condition of the gilt (Patterson and Foxcroft, 2019). The ideal gilt weight at breeding is from 135 to 150 kg at around 200 days of age (Williams et al., 2005; Kim et al., 2016). When a gilt is ready for breeding at sexual maturity, she will have an oestrus cycle (a recurring period of sexual receptivity and fertility, also known as 'heat'), and she should show normal oestrus expression; this involves a standing heat over 2 days, cycled in a regular 3-week interval though it can range from 18 to 24 days. The precise length of the 'standing heat' is variable and may last only 12 h in gilts. Gilts are normally served for the first time at their second or third oestrus after puberty when they are ~ 6–8 months of age. These maturation conditions in gilts must be accompanied by the physiological conditions of an ovulation and a uterus capable of holding piglets. This is to ensure exposure of the uterus and neuroendocrine tissues to progesterone before actual service, typically at the second oestrus. Elevated ambient temperature can cause infertility in replacement gilts, due to heat stress and Flowers et al. (1989) found that chronic heat stress in replacement gilts from 150 to 230 days of age at 32°C caused 80% of gilts not to cycle. The ideal photoperiod for developing gilts is 10–12 h per day of broad-spectrum light (270–500 lux) (Levis, 2000). Exposure to a boar is a well-known method of stimulating puberty in gilts; it includes sight, sound, smell and physical contact between the replacement gilts and the mature boar (Levis, 2000). Gilts that are naturally cyclic within a defined number of days after boar exposure (35–40 in a commercial situation) are the premium gilts for selection as replacements (Patterson and Foxcroft, 2019).

Selection for increased growth rate has resulted in pigs which are larger and heavier at any age (SVC, 1997; McGlone et al., 2004; Mousten et al., 2011). Gilts therefore begin their reproductive life when they are physiologically younger (Whittemore, 1994; Kummer et al., 2009). Paterson (1989) reported that in pigs which are still growing relatively fast whilst pregnant, there may be a redirection of nutrients towards the dams tissue instead of the developing fetus. This may reduce the weight at birth of the piglets. In support of this, recent studies illustrate how additional feed in late gestation confers birthweight increases to piglets born to gilts but not to piglets born to older sows (e.g. Gourley et al., 2020). Fast-growing pigs are more susceptible to osteochondrosis (Busch and Wachmann, 2011), which is likely to be painful and which may impair movement (Faba et al., 2019). Indeed, Quinn et al. (2015) reported improved locomotion scores arising from reduced weight gain and lower daily feed intakes in terminal line gilts fed a restricted diet formulated for fat rather than lean deposition.

[19] Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs. OJ L 47, 18.2.2009, p. 5–13.

The lifetime potential productivity of a sow is highly dependent upon her own birthweight and other litter characteristics and her early growth and development, as this determines ability to reach puberty, lifetime reproductive performance and structural soundness (Patterson and Foxcroft, 2019; Vallet et al., 2016). Skeletal soundness plays a major role in determining a sow's lifetime performance in the breeding herd (Serenius and Stalder, 2007; Stalder et al., 2008). Terminal lines of commercial pig breeds are selectively bred for fast growth rates and lean meat deposition, while maternal line pigs are bred for larger litter sizes with slightly less emphasis on leanness (Arey and Brooke, 2006; Prunier et al., 2010). Breeding for large litters has a negative impact on sow welfare and longevity due to higher production pressures (Rutherford et al., 2013). Moreover, selection for fast growth rates and larger more prolific sows makes modern pigs more sensitive to heat stress. Finisher pig diets are formulated to maximise the genetic potential of terminal line pigs by optimising growth-rate and lean meat deposition (Harper et al., 2002). Such diets are not designed to meet the needs of growing maternal line replacement gilts which require a diet formulated for fat deposition and fortified with specific minerals to establish strong bones and legs, and consequently ensure longevity. Specifically formulated gilt 'developer' diets achieved by adjusting the energy: lysine ratio, as well as the inclusion of supplementary minerals result in a more gradual weight gain, and reduced lameness incidence, osteochondrosis and claw lesions (Quinn et al., 2015; Hartnett et al., 2019, 2020).

3.2.3. Sows

3.2.3.1. Definitions, biology and background information on the production cycle

In the case of sows, Council Directive 2008/120/EC, provides the following definitions: (i) Sow: a female pig after the first farrowing; (ii) Farrowing sow: a female pig between the perinatal period and the weaning of the piglets; (iii) Dry pregnant sow: a sow between weaning her piglets and the perinatal period.

In the context of this opinion, 'dry sows' are intended from weaning to farrowing and 'farrowing and lactating sows', from farrowing to weaning.

The SVC (1997) report describes the biological background of sows, mainly based on observations of (semi) wild conspecifics. They are presented below as a relevant starting point for understanding sow biology. However, there are also important differences between domestic and wild sows, notably that wild boars and (semi) wild pigs have pronounced seasonal reproductive periods, but domestic pigs breed more or less the year around. This is partly due to management aspects such as early weaning, which shorten the reproductive cycle of domestic sows. Lactation or nursing inhibits the oestrous cycle and sows will not, as a rule, return to oestrous or 'heat' until 4–7 days after the litter is weaned. The period from weaning to oestrus (expressed in number of days) is influenced by e.g. the length of lactation, the parity number, the time of the year and the nutritional status. The oestrous period lasts about 3 days (72 h) and it is characterised by the sow seeking contacts with boars and staying in close proximity to them. Boar sexual behaviour and the associated stimuli enhance the receptive behaviour and subsequent fertility of the female pig. Sows are typically served at their first standing heat post-weaning. Service is either natural (by the boar) or by artificial insemination (AI). Natural service generally takes place in a mating pen but occasionally it is conducted in the sow or gilt group. If the boar is allowed to stay with the group of the females, he serves them as they come on heat. AI is generally conducted while sows or gilts are in stalls in the service house.

Sows which are not pregnant return to oestrus approximately 3 weeks later. If sows do not return to oestrus, they are usually pregnancy checked from 4 weeks after service by an ultrasonic method. The stage at which pregnant sows are introduced to the main gestation housing system depends on the EU Member State (MS). Pregnancy lasts on average about 115–117 days. Towards the end of pregnancy, wild boars and (semi) wild sows show a remarkable change in behaviour: they move away from the group for long periods of the day. In domestic pigs in semi-natural enclosures, sows leave the herd about 24–48 h before farrowing and wander long distances outside the normal home range, apparently in search of a suitable nest site.

Domestic sows and gilts are usually moved into the farrowing accommodation in the week prior to their expected farrowing date. So pregnant gilts spend this final period in a crate or pen depending on the farrowing system in operation. Approximately 16–20 h before farrowing nest-building behaviour will commence, in both wild boar and in domestic pigs. This behaviour is sensitive to environmental cues and triggered by hormonal changes. It is performed largely intact also in complete absence of relevant stimuli. The nest-building behaviour generally stops 2–4 h before parturition and from that point, the sow usually remains lying in the 'nest'.

During farrowing the sows lie in the nest and (in contrast to many other mammals) do not aid their young by e.g. tearing the umbilical cord or licking them. Within approximately 16 hours nursing starts. It consists of typical cyclical pattern, with suckling intervals of 40–60 minutes.

Under free-range conditions sows remain in their nest and neighbouring area for approximately 10 days. After this period, they return to the family group where the gradual process ofweaning process starts. Weaning finishes when the piglets are about 13–17 weeks of age.

3.2.4. Piglets

3.2.4.1. Definition, biology and background information on the production cycle

According to Council Directive 2008/120/EC, 'piglet' means a pig from birth to weaning. The definition of piglets in the context of this opinion is from birth to weaning from the mother. A special case is artificial rearing where piglets are weaned from the sow when they are very young and given artificial milk. These systems are described and analysed in the animal category of piglet (see Section 3.3.4.1). Typically, weaning from milk coincides with the piglets being separated from the mother when they are three or more weeks old. However, selection for hyper-prolific sows has increased the frequency of situations in which the number of piglets in a litter exceeds the number of functional teats, even after cross-fostering is applied. Cross-fostering involves removing some of the piglets from a sow which has a large litter to another sow with a smaller litter, to balance for litter size across sows. With hyper-prolific sows, surplus piglets may be removed from the sow within a few days after birth, after colostrum intake, and raised in artificial piglet rearing systems where they are fed artificial milk (Baxter et al., 2013; Rzezniczek et al., 2015).

On the day prior to farrowing, a sow in a semi-natural enclosure will separate herself from the social group and seek a suitable nest site (Stolba and Wood-Gush, 1984; Jensen, 1986). About 10 days later, she will return to the other sows from her group and their litters (Jensen and Recén, 1989). The piglets' social contacts are thus limited to the sow and the littermates during that period. Thereafter, piglets from different litters may mix during daily activities but typically separate during suckling bouts initiated simultaneously by the sows.

As outlined in SVC (1997), new-born piglets typically find the teats within less than 30 min post-partum. Over the next few hours, they sample different teats and ingest colostrum. If piglets fail to ingest colostrum within the first 20 h post-partum, they are very likely to die. The typical cyclical pattern of nursing and resting, with nursing intervals of 40–60 min, develops in the first about 16 h.

Over the first few days after farrowing, unused teats dry up and a teat order is formed (Jensen et al., 1991, Stangel and Jensen, 1991). Consequently, a given piglet will usually suckle on a specific teat, or teat pair, and piglets will fight for access to their teat, which may result in facial injuries (Weary and Fraser, 1999; Pedersen et al., 2011a). According to SVC (1997), the sow typically lies down for suckling, particularly in the early lactation. Suckling bouts are characterised by a series of distinctive phases, i.e. pre-massage (about 40–60 s), milk ejection (about 20 s) and final massage (30 s to 10 min). To indicate milk delivery, the sow grunts rhythmically with an increasing grunt rate, reaching a peak about 20 s before milk ejection. As a result of friction between their legs and the floor during suckling, piglets are likely to develop abrasion injuries on the legs.

Piglets are very sensitive to cold and shiver to maintain their body heat (Herpin et al., 2002). Moreover, they seek for a warm place (e.g. near the sow's udder, in the heated creep area) and huddle to conserve warmth (Vasdal et al., 2009; Pedersen et al., 2013a).

Piglets are exposed to the risk of being trampled or crushed by the sow (Weary et al., 1998). This risk is much higher for underweight piglets and piglets affected by undernutrition (Pedersen et al., 2011b; Hales et al., 2013). Genetic selection for large litters increased variation in birth weight and the number of underweight piglets in a given litter (Quesnel et al., 2008).

Piglets are playful and highly motivated to perform exploratory behaviour. The level and expression of both play behaviour and exploration vary between different farrowing systems (Vanheukelom et al., 2012; Martin et al., 2015).

3.2.5. Weaners

3.2.5.1. Definition, biology and background information on the production cycle

Council Directive 2008/120/EC defines a weaner as a pig from the time of weaning until 10 weeks of age. However, there is no official definition of 'weaning'. Some people consider that this term relates to separation from the mother, whereas others consider that is a nutritional event describing the time of milk withdrawal. Whilst these events frequently coincide in practice, this is not always the case. In this opinion, the former definition is generally used: a weaned piglet is a piglet after separation from the mother. However, the special case of piglets which are removed from the mother and placed in artificial rearing accommodation within the first few days after birth is considered under the 'Piglet' rather than 'Weaner' category.

In wild boars and (semi) wild pigs, weaning is a gradual process rather than an abrupt event (Jensen and Recén, 1989). It is characterised by progressive changes in the behaviour of the sow and piglets which include a gradual decrease of suckling frequency, an increase in the proportion of sucklings initiated by the piglets rather than the sow, an increase in the proportion of sucklings terminated by the sow rather than the piglets, increased pre-massage time and shortened post-massage time and an increased frequency of sucklings performed with the sow standing. These changes begin as early as the first week of life and cessation of suckling occurs by, on average, 13–17 weeks of age with different timing for different individuals within the litter (Jensen, 1995; Newberry and Wood-Gush, 1988). Other weaning-related changes in social and foraging behaviour occur over the same period. From the end of the first week piglets show increasing foraging behaviour away from the nest, including searching, rooting and food sampling behaviours, and these behaviours increase in free-ranging groups of juvenile pigs after the litter leaves the nest site and integrates with the other members of the family group at 10–14 days after birth (see Section 3.2.4). Their intake of solid food increases until, by 6–8 weeks of age, it makes up a major part of the diet (Petersen, 1994) and they cease to suckle as milk is no longer required.

In contrast to the natural behaviour of the pig, weaning in farm conditions is usually an abrupt event involving removal from the sow and transfer to specialist nursery accommodation. Although on some farms piglets are kept in their litter groups at this time, it is more common for piglets to be regrouped across litters according e.g. to the size of pen available and to their weight. They thus experience the simultaneous challenges of nutritional change from a predominantly milk diet to one of cereal-based dry feed, exposure to a novel environment for the first time and social disruption. The ability to deal with these stressors depends on the age of the piglet at weaning. Economic pressure to maximise the annual reproductive output of the sow promotes earlier weaning, so that the sow is released from the suckling-induced suppression of oestrus and can commence her next breeding cycle. Within the EU, Directive 2008/120/EC stipulates that 'No piglets shall be weaned from the sow at less than 28 days of age unless the welfare or health of the dam or the piglet would otherwise be adversely affected. However, piglets may be weaned up to seven days earlier if they are moved into specialised housings which are emptied and thoroughly cleaned and disinfected before the introduction of a new group and which are separated from housings where sows are kept, in order to minimise the transmission of diseases to the piglets'. In consequence, the average weaning age in EU countries currently varies from 23 to 34 days, with individual litters showing an age variation from 3 to 8 weeks (Edwards et al., 2020).

Piglets weaned at 3 weeks of age have little previous experience of finding and consuming solid food; solid food intake only starts to become significant in the fourth week of life, though there is great variation within and between litters. As a result, energy and nutrient intake shows a dramatic decrease immediately after weaning, and it may take several days before some piglets again achieve energy balance and establish a stable eating pattern (Pluske et al., 2003). During this period, the production of enzymes necessary for digestion of plant-based feed requires time for substrate induction, detrimental changes are seen in the intestinal morphology which impair nutrient absorption and dysbiosis of the gut microflora occurs. These consequences of immaturity of the digestive system, together with the withdrawal of local protective effects of immune proteins present in maternal milk, result in high susceptibility to enteric disease during this period (Pluske et al., 2018). Furthermore, due to the reduction in energy intake from feed at the time of weaning, the piglet becomes more sensitive to cold stress and temperature fluctuations which can increase susceptibility to infection (Le Dividitch and Herpin, 1994). The ability of the piglet to resist infection after weaning is impaired by immaturity of its immune system. Passive immunity obtained from ingestion of colostrum wanes progressively from the first to the sixth week of life, while the piglet's own ability to mount an active immune response develops only gradually during and after this time. The abrupt cessation of maternal contact and suckling at an early age also has consequences for the behavioural development of the piglets (Fraser et al., 1998). The massaging and sucking behaviours normally directed towards the udder during nursing bouts can become redirected towards other piglets and can develop into stereotyped belly nosing, occurring for long periods of time and disturbing resting within the group. The weaner phase is therefore a period of high risk for adverse welfare outcomes.

3.2.6. Rearing pigs

3.2.6.1. Definition, biology and background information on the production cycle

According to Council Directive 2008/120/EC, a rearing pig is defined as a pig from 10 weeks to slaughter or service. Similarly, for the purposes of this document, a rearing pig is defined as a pig that is between 10 weeks of age and either slaughter or retention for breeding (typically between 5 and 6.5 months of age). The choice of 10 weeks of age as a starting point for this life stage is arbitrary, and it is sometimes described as starting earlier or later. It is assumed, however, that by 10 weeks of age the challenges associated with weaning will have largely passed. For pigs destined for slaughter rather than breeding, this is often referred to as the growing/finishing period. The weight at which pigs are slaughtered will differ between countries. This will be between 110 and 123 kg in many cases but may also be higher (e.g. 170 kg) in countries such as Italy where specialty hams are produced (AHDB, 2021a).

Genetic selection strategies have contributed to continued increases in growth rate, feed efficiency and leanness in rearing pigs. For example, the average growth rate and feed conversion ratio of finishing pigs in the EU were reported to be 760 g/day and 2.94, respectively, in 2010 (BPEX, 2013), and 829 g/d and 2.83 in 2018 (AHDB, 2021a). It is suggested that these selection practices have contributed to altered hormone profiles and increased stress susceptibility (Prunier et al., 2010), and to increased leg health problems (Rauw et al., 1998; Prunier et al., 2010). Heat production is also increased in modern genotypes (Brown-Brandl et al., 2001), potentially making them more susceptible to heat stress (Forcada and Abecia, 2019).

3.2.7. Boars

3.2.7.1. Biology and some background information on production cycle

In the context of this opinion and according to Council Directive 2008/120/EC, 'boars' are male pigs after puberty, retained for breeding.

Boars come into puberty at around 5–7 months (Reiland, 1978); at this age, young male wild boars leave their family group and form smaller bachelor groups. Older boars may live in pairs or solitary and commonly join the female groups only during the breeding season (Briedermann, 1990). Their sexual behaviour is stimulated by various internal and external factors, including genetic, seasonal, social, sexual and psychological conditions (Hemsworth and Tilbrook, 2007): as an example, rearing with restricted physical contact leads to reduced sexual behaviour and also high temperatures have an adverse effect. Boar sexual behaviour involves sniffing, urine sampling, massaging and pressing with the snout against the body of the sow, specific courting vocalisations and producing foam from the mouth. They may also urinate rhythmically. If the female stands stationary, the boar may vigorously nudge or nose the flanks, sniff the anogenital region or head of the female and mount her (Signoret, 1970).

Boars can influence the sexual behaviour of female pigs: the presence of a mature boar, especially their visual, auditory, tactile and olfactory clues, including pheromones, stimulate the onset of puberty in gilts and the ovulation in sows (Hemsworth and Tilbrook, 2007).

Breeding boars are commonly kept in (partly) slatted and unenriched individual pens, located close to the sows in the service area. Boars can be kept as teaser boars in order to induce oestrus in sows. In this case, they are moved commonly in the alley in front of the sows prior and during AI. However, the rest of the time they are isolated with little physical contact to other pigs. Breeding boars, which are kept in dedicated breeding stations, are moved from their individual pens only for semen collection (EFSA, 2007a,b). For more detailed information on the housing systems, see Section 3.3.5.

3.2.8. Animals in need of treatment or separation

This category includes pigs of any category reported above (Sections from 3.2.2 to 3.2.7) that are obviously sick, weak, injured (e.g. lame or tail bitten) and/or have problems coping with social aspects of the husbandry system, such as being bullied which may result in impaired access to resources leading to e.g. poor body condition. It also includes pigs that are not injured and appear well but are affected by conditions which cause health risks, (e.g. hernias) or pigs which damage other pigs in the group (e.g. through tail biting). Apart from obvious clinical signs such as a severe tail injury or ataxia (a lack of motor coordination), there are a number of behavioural indications for which a pig is in need of treatment or separation from the group. They may include a reduction in activity, exploratory behaviour and in food/water consumption (Miller et al., 2019). Such pigs may also, less obviously, seek heat and/or show an increase in pain sensitivity (Nalon et al., 2013).

If the welfare of a pig is compromised to the extent that access to food, water or lying area is impaired, firstly it has to be decided if the likelihood for recovery in a hospital pen justifies that the animal is not euthanised promptly. If so, a separate (hospital/recovery) pen is crucial to ensure adequate access to nutrients and water. Furthermore, these compromised animals may have higher demands regarding temperature, which cannot be fulfilled in a normal pen. They may also be more susceptible to bullying (Munsterhjelm et al., 2017). Additionally, these pigs should be separated from pen mates to avoid further deterioration in their condition (illness, injury, hernia, lameness), and to reduce the risk of spreading disease to other animals in the group (e.g. diarrhoea).

As pigs are highly social animals, the decision to remove individual pigs from a group and to isolate them must be taken carefully: separation is highly stressful and may impair pig welfare (Tuchscherer et al., 2004; Kanitz et al., 2009). Reintroduction of the pig back into its home pen when recovered might be impossible, although Chou et al. (2019) successfully re-introduced tail biting and victim pigs back into their home pen 14 days after removal. It can also be considered to house pairs of pigs with similar conditions in hospital pens or allow at least some visual contact between pens, to reduce separation stress. Nevertheless, in less severe cases pigs may be left in the home pen after treatment, as long as they are closely monitored to determine the effectiveness of treatment.

On welfare grounds, euthanasia is the best option for animals that show no improvement in their situation.

3.3. Describing pig husbandry systems (General ToR 1)

3.3.1. Overview of pig husbandry systems per animal category

The main husbandry systems that will be assessed in this SO are reported in the following Table 9 subdivided for the pig animal category they pertain to. EFSA does not have data on the prevalence of these systems in Europe.

All systems will be described below. The systems that have been considered most relevant have been fully assessed in the General ToRs, following the methodology described above (see Section 2.2.2.1).

Table 9: Pig husbandry systems

Pig category	Pig husbandry systems*	
	Full assessment in the General ToRs	**Narrative description in the General ToRs**
Gilts and dry sows	Individual housing in stalls Indoor group housing Outdoor paddock** systems	Indoor systems with access to an outdoor concrete area
Farrowing and lactating sows and piglets	Individual housing in crates Individual housing in pens Outdoor paddock systems	Individual housing in temporary crates* Individual farrowing in pen + group suckling in pens* Indoor systems with access to an outdoor concrete area
Piglets	Artificial rearing systems	
Weaners	Indoor group housing Indoor systems with access to an outdoor area Outdoor paddock systems	
Rearing pigs	Indoor group housing Indoor systems with access to an outdoor area Outdoor paddock systems	
Boars	Indoor individual housing in pens	Indoor systems with access to an outdoor concrete area Outdoor paddock systems

Pig category	Pig husbandry systems*	
	Full assessment in the General ToRs	Narrative description in the General ToRs
Animals in need of treatment or separation: all categories		Hospital/recovery or separation pens

*: All systems are indoor systems unless specified otherwise; for all categories, 'indoor' means 'without any outdoor access'.
**: For all pig categories, 'outdoor paddocks' means 'with access to soil'.

3.3.2. Gilt and dry sow systems

3.3.2.1. General management

Gilts destined to replace sows in the breeding herd come from maternal genetic lines bred for large litter sizes (Arey and Brooke, 2006; Prunier et al., 2010). Replacement gilts can be bred in the same production herds or purchased from specialist breeders as weaners (at about 30 kg liveweight).

In herds producing their own replacement gilts, animals are transferred to the breeding herd at the weight that their finisher pig counterparts are sent for slaughter while in some herds, gilts destined for the breeding herd are separated from finisher stock at an earlier age/weight and moved to specialised gilt rearing accommodation (Quinn, 2014). Replacement gilts are thereafter kept together; they may be fed in a similar way as when in the finisher accommodation, switched to a gestating sow diet or more commonly nowadays, transferred to a specially formulated gilt diet. Gilts usually have visual and olfactory contact with a boar in the gilt pens. They are typically served for the first time by AI at their second or third oestrus after puberty, when they are ~ 6–8 months old.

Sows are usually served at their first oestrus, approximately at 4–7 days after weaning. and while they are in stalls in the service house. However, on some farms, a boar is housed with a group of sows, and can serve them as they come on heat (for further details, see Section 3.2.2).

Once sows and gilts are served, the way in which they are housed depends on the herd size, the gestation housing system in use and the EU MS (see Section 3.3.2). In some very large herds, gilts are completely separated from the older sows for the entire pregnancy and may not join them in the breeding herd until they complete their first lactation. On smaller farms, with static groups and smaller group sizes, while pregnant gilts may share the same air space as older pregnant sows, they are usually kept in groups together and not mixed with them. On farms with large dynamic groups, pregnant gilts may be mixed into such groups with older sows. The way in which gilts are fed during pregnancy varies depending on the housing system.

3.3.2.2. Individual housing in stalls

Under EU legislation, gilts and sows can be kept in this system only for a limited period of time, i.e. gilts from service up to maximum 4 weeks after service, and sows from weaning up to maximum 4 weeks after service.

Individual or gestation stalls are the main housing system for pregnant sows and gilts from service up to farrowing worldwide (Ryan et al., 2015). In the EU, they are not permitted for use beyond 28 days post-service (Commission Regulation (EC) 889/2008[20]). Some MSs have stricter legislative restrictions on their use. For example, in the Netherlands, gilts and dry sows can only be held in stalls for a maximum of 4 days post-service, in Austria for a maximum of 10 days and Sweden not at all except for the actual insemination. In Denmark, in 2020 legislation has been passed that sows housed in buildings built after 2015 must be loose housed from weaning to farrowing; from 2035 this requirement applies to all sows. Similarly, Germany passed a legislation in 2020 introducing a ban on sow stalls, but it will not become mandatory until 2030. Stalls are a metal enclosure with a trough at the front and a gate at the rear. They have concrete flooring which is either fully slatted or with slats towards the rear and with solid concrete flooring in the anterior two thirds of the stall. They are seldom bedded. A long feeding trough runs the length of rows of individual stalls and the EU legislation requires for each stall to have water provision. Dimensions vary but stalls are typically ~ 2 m long and 0.7 m wide irrespective of whether they are used for sows or gilts. Facilities with older installations may have stalls of narrower widths (0.6 m).

These systems are further analysed in the General ToRs (see Sections 3.4 and 4.1) and in the section on Specific ToR 1 (Section 4.4).

[20] Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. OJ L 250, 18.9.2008, p. 1–84.

3.3.2.3. Indoor group housing

Indoor group systems for pregnant sows and gilts represent the main housing system in the EU since 2013 (Commission Regulation (EC) 889/2008). They are generally characterised in terms of the feeding and grouping system (static/stable or dynamic/changing) employed. The choice between the two grouping 'systems' was traditionally based on herd size with smaller herds usually adopting static groups and dynamic groups being more common in larger herds. Nowadays however, it is possible to find both grouping systems in any herd size. In static groups, the group composition does not change once sows are introduced. That is no new animals enter the group and none of the group members leave (unless they are injured or return to service) until the entire group is moved to the farrowing unit (Bos et al., 2016). This is beneficial in that the dominance hierarchy remains stable once it is established and sows are only exposed to the stress of re-mixing once. In the past, static groups generally consisted of relatively small group sizes (between 4 and 12 sows). In groups of between 5 and 40 sows, the space allowance required by legislation (2.25 m^2/sow) is such that the amount of shared space is minimal, and that levels of social stress can be high. However, much larger static groups are an increasingly common feature of larger herds, and involve more shared space. One of the disadvantages to the farmer of static groups is that sows that are lost (i.e. die or are culled) from the system cannot be replaced, meaning that a sow space lies empty. Management of sows that return to service ('repeats') can also be difficult: repeats generally remain in the group and are either moved into stalls or allowed to remain on their own in the otherwise empty pen when their pen mates are moved to the farrowing house. The latter option means that the pen is in-use longer than it should be, which can put pressure on the rest of the system. In dynamic groups, the group composition changes weekly with served sows entering the group and sows due to farrow exiting. Sows in large dynamic groups are therefore continuously exposed to the stresses of re-mixing (Durrell et al., 2002). However, as dynamic groups are almost always associated with large group sizes, there are benefits associated with large amounts of shared space such as more room to exercise (Durrell et al., 2002). Furthermore, in such systems, there is more space for subordinate and otherwise vulnerable sows to avoid the aggressive encounters arising at the introduction of new sows each week. As the composition of a dynamic group is in a continual state of change it is well suited to handling repeats.

The design of group housing systems is generally focused around the choice of feeding system and this can also influence the flooring used. Dump feeding is whereby feed is automatically dropped onto a solid area of floor. Competition for access to feed is usually intense in this system. With spin feeding, the feed is spread over a larger area than with dump feeding, ranging from 6 to 24 m. Theoretically, this gives all sows in the group better access to feed (Spoolder et al., 2009). This system is used for groups of up to 25 sows suiting herds of 350–600 sows but like dump feeding, it results in intense competition for access to feed and variable body condition within groups. More than half the floor is solid with such a system. Free access stall systems are where sows were fed from a long trough but separated from one another during feeding by full length divisions or stalls. Traditionally, sows in this system were kept in small groups of four to six sows where the small amount of shared space was more than compensated for by the presence of full-length stalls in which the sows could escape from aggression/hide, etc. (Andersen et al., 1999). The feeding stalls were dual purpose in that they were also wide enough for sows to use them for lying. Pens are often fully slatted. Similarly, sows in larger static groups (10–20 sows) are also kept in, often fully slatted, pens in which they feed from a long stainless steel communal trough without any partitions along one side of the pen. A modification of such a system involves 'trickle feeding' whereby an auger slowly drops feed, usually at a rate of 100–120g/min, from calibrated hoppers into the troughs simultaneously to accommodate the slower feeding sows (Hulbert and McGlone, 2006). While such a system should remove the need for trough divisions, in practice at least shoulder length partitions 0.45 m apart (one per sow) are used. Electronic sow feeding (ESF) stations are the only way that automated individual rationing of sows can be achieved with group housing (Chapinal et al., 2008). Obviously, sows cannot feed simultaneously in ESF and the sight and sounds of a sow feeding in the station stimulates the motivation to feed in the animals waiting outside. Sows fed by ESF are identified by an ear transponder, enter the feed station through a rear gate and are fed a preset amount of feed, depending on the stage of pregnancy and body condition. Feed allocation is computer controlled and with individual feed scales being entered into the computer. While very large herds may keep sows in large static groups each with an ESF, this feeding system is often synonymous with dynamic grouping systems. Pens may be split into separate solid floored lying 'bays' or can be large/open undifferentiated fully slatted spaces.

These systems are further analysed in the General ToRs (see Sections 3.4 and 4.1) and in the section on Specific ToR 1 (Section 4.4).

3.3.2.4. Indoor systems with access to an outdoor concrete area

The keeping of gilts and dry sows in housing which combines an indoor area and an outdoor concrete area is seen mainly in small-scale traditional farms or in farms certified for organic production in many European countries (Früh et al., 2013). The proportion of sows in the EU which are kept in this system is consequently small. The indoor area provides for resting and commonly has a solid or part-slatted floor with bedding. It may incorporate any of the feeding systems described in Section 3.3.2.3. The outdoor area is designed for exercise and excretion and may be used additionally for roughage feeding. It may be completely open or partially roofed, and typically has an unbedded solid concrete floor with a drainage slope, but may sometimes also have some bedding or rooting material. The group size and space allowance can vary widely, although if on a certified organic farm, the pen must provide a minimum space per pig of 2.5 m^2 indoors plus 1.9 m^2 outdoors (Commission Regulation (EC) 889/2008).

These systems have not been further analysed in the General and Specific ToRs because they comprise only a few small farms. In these systems, the welfare consequences experienced by pigs are likely to be similar to the ones identified in the case of indoor group housing.

3.3.2.5. Outdoor paddock systems

In most European countries this system is used to a very limited extent, mainly on farms which are certified for organic production (Früh et al., 2013) or other niche label schemes. However, there are notable exceptions where large commercial herds for conventional production house their breeding sows in outdoor paddocks, as is the case for 40% of sows in the UK and a smaller number of herds in France and other countries in regions with suitable climate and soil type (Edwards, 1994). The animals are typically enclosed by electrified fences and provided with bedded wooden or metal shelters. The group size and space allowance within a paddock are highly variable, depending on farm size and soil type. Sows are most commonly fed as a group with large nuts scattered on the ground and provided with water in automatically supplied troughs. Specialised genotypes with greater robustness are normally used in such systems and the sows may be fitted with nose-rings to prevent rooting and rapid destruction of vegetation. Detailed description of typical production conditions and practices can be found in Thornton (1988).

Another important type of outdoor system in Europe is the traditional Mediterranean silvopastoral system. This system involves indigenous breeds that are allowed to forage extensively in natural forests and produce progeny for the production of high-value dry-cured hams (Dobao et al., 1988; Edwards and Casabianca, 1996; García-Gudiño et al., 2020). In 2017, there were 4370 registered Iberian pig farms operating in this way, with 375,500 breeding sows (Nieto et al., 2019a,b).

These systems are further analysed in the General ToRs (see Sections 3.4 and 4).

3.3.3. Farrowing and lactation systems

Farrowing and lactating sows are kept together with piglets until weaning in the same farrowing facilities (systems) and, therefore, in the following sections a single description of the systems is provided. The general management of sows and piglets differs substantially, and they are therefore described separately.

Welfare consequences may be different for sows and piglets, and therefore in this SO, they will be also described separately (see Sections 5.1 and 5.4).

3.3.3.1. General management of farrowing and lactating sows

During lactation, sows are typically fed restrictedly (two or more meals per day) with a feed ration that is adjusted to the stage of lactation and the litter size. Water is provided ad libitum, usually through nipple drinkers.

On most farms, farrowing houses are divided into units such that sows farrowing simultaneously are introduced into and removed from the pens (with or without crates) of a given unit at the same time (all-in all-out management). These units are equipped with a ventilation system to control room temperature.

Where farms have very prolific sows some individuals may be kept as nurse sows which raise two litters in succession in order to provide enough suckling possibilities for piglets in excess of the capacity of their mother (Sorensen et al., 2016).

3.3.3.2. General management of piglets

Attending sows at farrowing is time-consuming, as the last piglet is typically born several hours after the first. Therefore, supervision of farrowing sows varies greatly between farms. To enhance piglet survival, staff may free piglets from membranes, move weak piglets to the udder to promote colostrum intake or put piglets under a lamp to heat them up. To prevent stillbirths, manual assistance is provided with difficult births.

As the temperature requirements of the piglets are considerably higher than those of the sows, additional heat is provided in the creep area (e.g. heating lamp, floor heating). Water is offered ad libitum to the piglets, through nipple drinkers or drinking cups.

To encourage foraging behaviours and reduce the impact of nutritional challenges once milk production starts to decline, piglets usually have access to supplementary food starting at 1–2 weeks of age. According to SVC (1997), some enterprises operating early weaning (at 3 weeks) may not offer 'creep' feed.

3.3.3.3. Individual farrowing crates

Individual crates are the main housing system for farrowing and lactating sows. The sows are normally moved to the farrowing crates in the week before expected time of farrowing and removed after the weaning of the piglets. A farrowing crate consists of metal bars running along the length of the sow. Sometimes, additional metal bars are placed on the top of the cage to prevent the sow from jumping or climbing in the attempt to escape. The length of the crate is about 2 m with a width between 0.45 and 0.65 m. To allow assisted farrowing, an unobstructed area behind the sow or gilt must be present. The space provided in the crates allows the sow to stand up and lie down, but not turn around or walk. Nowadays, sows are substantially larger than 40 years ago (Moustsen et al., 2011; Nielsen et al., 2018) and they rear a larger litter for a longer lactation length than before. Therefore, physical and behavioural restriction have increased over this period, especially in crates which cannot be adapted to the length and width of the sows.

The floor is usually part or fully slatted (made of plastic or metal slats) to allow the excreta to fall through into the slurry pits placed below. A sufficient quantity of nesting material should be present Generally, when the floor is slatted, a loose substrate to help fulfill behavioural needs such as nest-building, is not provided (Baxter and Edwards, 2021) as the material will block the slots of the slatted floor and hinder drainage. That is therefore impeding the expression of nest-building behaviour, which has high motivation in the sow (Wischner et al., 2009). Total floor area in pens with a farrowing crate typically ranges from 3.7 to 5.2 m^2 (Andersen et al., 2014; Martin et al., 2015; Swan et al., 2018; Lohmeier et al., 2020).

Farrowing crates were introduced with the aim to prevent crushing piglets by the sow and thus reduce piglet mortality (Edwards, 2002). However, aggressive behaviour towards the piglets has been shown to increase when the sows are crated as compared to sows in loose housing system (Jarvis et al., 2006). Sows in crated system showed also higher restlessness, which further increases the risk of overlying when the piglets try to access the udder (Ocepek and Andersen, 2017).

The piglets must have sufficient space to be able to be suckled without difficulty. A part of the total floor, sufficient to allow the piglets to rest together at the same time, must be solid or covered with a mat or be littered with straw or any other suitable material. Many current farrowing crate designs are not providing sufficient space for very large litters (Pedersen et al., 2013b) for resting together in a thermally comfortable area. They may also hinder the piglets trying to reach the udder. An example of a standard farrowing crate is presented in Figure 1.

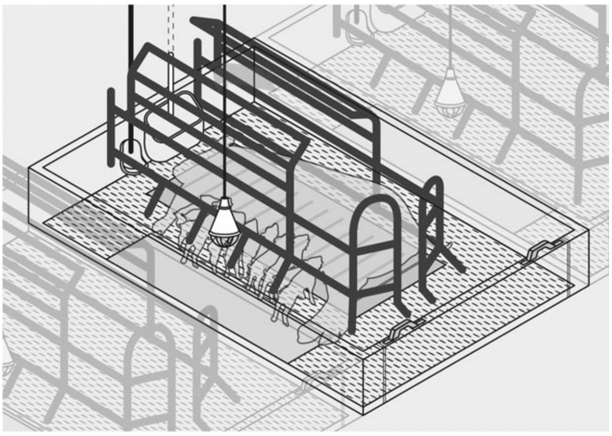

Figure 1: Drawing of a farrowing crate (based on Baumgartner et al., 2005)

These systems are further analysed in the General ToRs (see Sections 3.4 and 5.1) and in the section on Specific ToRs 2 and 3 (Section 5.7).

3.3.3.4. Individual housing in temporary farrowing crates

Farrowing pens with temporary confinement have been developed as a compromise between conventional farrowing crates and loose farrowing pens. The aim of temporary crating is to reduce piglet mortality due to crushing in the first days after birth and to increase the sow's mobility during the rest of the lactation. The system is similar to conventional farrowing crates and includes a heated creep area for the piglets. However, the design of the crate is such that one or both sides of the crate can be opened (or be removed) in different ways, allowing the sow to turn around. To minimise the risk of crushing of piglets once the crate is in the open position, the system may contain farrowing rails (horizontal anti-crush bars) and/or sloping walls along the sides of the pen. The time of closing the crate is typically between day 5 and 2 before the expected parturition date and the opening is between day 3 and 7 of lactation. As the sow is able to turn around when the crate is open, pen size for systems with temporary crating is larger than that for conventional farrowing crates, ranging from 5.5 to 7.5 m^2 (Chidgey et al., 2015; Hales et al., 2016; Goumon et al., 2018; Oczak et al., 2019; Lohmeier et al., 2020) (see features of temporary crates in Figure 2A and B).

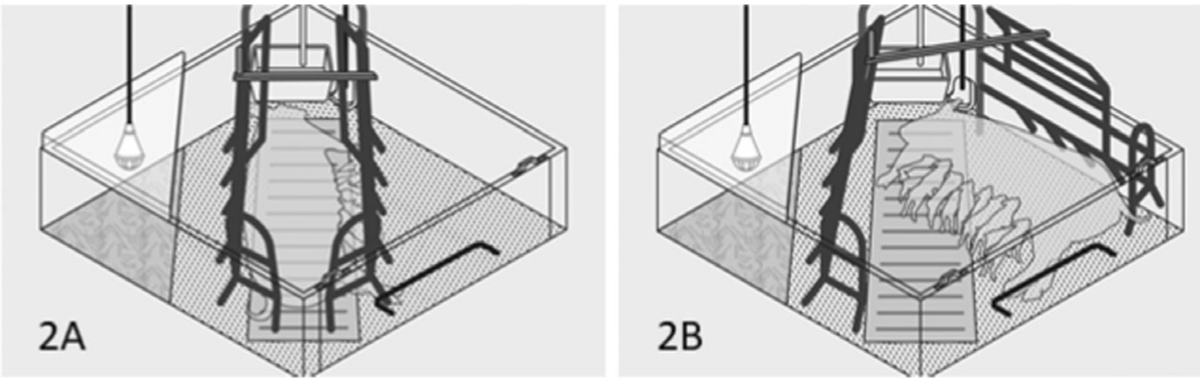

Figure 2: Drawings of farrowing system with temporary crating. (A) crate closed, (B) crate open (based on Heidinger et al., 2022)

Temporary farrowing crates are discussed in more detail in Specific ToRs 2 and 3 (Section 5.7). In these systems, the welfare consequences experienced by sows are likely to be similar to the ones identified in the case of individual farrowing crates, during the first part of lactation, and to the ones experienced in pens, during the second phase of lactation up to weaning.

3.3.3.5. Individual farrowing pens

This system is most common in countries where crating of sows is prohibited (Norway, Sweden, Switzerland). Also, according to organic standards in Europe (Regulation (EU) 2018/848[21]), loose farrowing is obligatory. EFSA experts estimate that < 1% of all pigs are kept according to organic standards. Loose farrowing systems do not allow for temporary crating of the sow during farrowing; however, confinement might be possible for short periods at the feeding area. The pen includes an area for movement of the sow and a heated creep area for the piglets that is not accessible to the sow. The pen may be divided into a bedded nesting area and an activity/dunging area. Floor quality (solid or slatted) may differ accordingly between these areas. To reduce the risk of crushing of piglets, the system may contain farrowing rails (horizontal anti-crush bars) and/or sloping walls along the sides of the pen (see Figures 3A and B). The feed trough for the sow may be positioned in the nesting, the activity area or as a separate area. Sow and piglet drinkers are preferably provided in the activity area. The sow is usually introduced to the pen 5 to 2 days before the expected parturition date. To stimulate nest-building behaviour, long-cut straw or similar material may be provided on the floor or in a rack. The size of such pens typically ranges from 6.5 to 8.0 m^2 (Burri et al., 2009; Bøe et al., 2019; Nicolaisen et al., 2019; Portele et al., 2019; Rosvold and Andersen, 2019).

[21] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007. OJ L 150, 14.6.2018, p. 1–92.

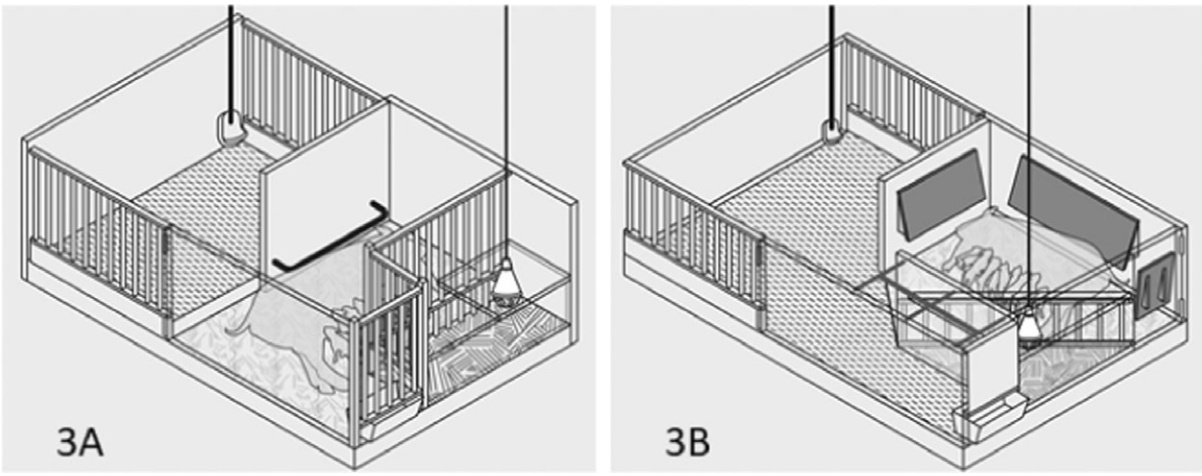

Figure 3: Examples of farrowing pens ((A) is based on Weber and Schick, 1996 and (B) is based on Baxter and Edwards, 2021)

These systems are further analysed in the common ToRs (see Sections 3.4 and 5.6) and in the section on Specific ToRs 2 and 3 (Section 5.7).

3.3.3.6. Individual farrowing pen with group suckling in pens

These systems allow sows and litters to mix before weaning.

The most common system consists in utilising two separate pen types for different stages (often referred to as a multisuckling system). Sows and litters are initially housed in standard farrowing pens, with or without crates, and then moved from these individual pens after approx. 2 weeks and mixed together in a group suckling area, so that the individual pens are available for the next batch of farrowing sows (see Figure 4).

Another form of the system (communal farrowing), a group of sows is moved together before farrowing into a large pen which contains individual nest areas. During the nest-building period and in the first days (up to 2 weeks) after farrowing, the sows may be temporarily confined in these individual nest areas or may be freely able to leave these nest areas to visit an activity area that they share with other sows. The piglets, however, are prevented from leaving their farrowing area for about 10 days after birth to avoid cross-suckling. Hence, they are retained in the farrowing area by means of a barrier (e.g. a 40-cm high threshold with a 15-cm wide roller on top), allowing them to become attached to the mother sow and to establish a teat order. Each farrowing area contains a heated creep area. Sow feeders, an area for creep feeding of piglets and drinkers may initially be provided in the farrowing area if the sows are confined but are later provided in the communal activity area. The floor in the communal area may be solid or partly slatted or be covered with deep litter.

Group suckling systems of these different types are usually designed for four to eight sows and their litters (Wattanakul et al., 1997; Grimberg-Henrici et al., 2019; Nicolaisen et al., 2019; Verdon et al., 2019).

These systems have not been further analysed in the General and Specific ToRs because of their diversity in detail and the fact that they are currently not widely used in commercial practice (< 1% of sows lactate in such systems). Their lack of commercial uptake is due to the higher cost of providing the space necessary for a true communal farrowing system, and the additional labour demand and management challenges of operating a two-stage system. Mixing of sows and litters during lactation can result in aggression between sows and disruption of nursing. This can lead to a growth check, increased cross-suckling and mortality of piglets, and the occurrence of lactational oestrus in some sows which disrupts batch management. However, piglets from group suckling systems generally show less aggression and growth check after weaning.

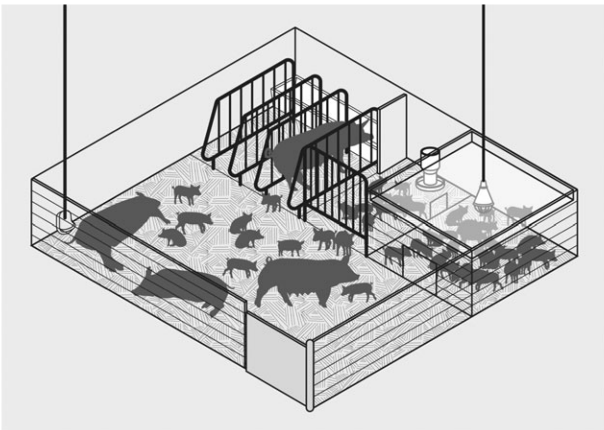

Figure 4: An example of group housing system for lactating sows and their litters (based on Hagmüller et al., 2017)

3.3.3.7. Indoor farrowing pen with access to an outdoor concrete area

This system is similar to the system described in Section 3.3.3.5, with an indoor area of 7.5 m^2, but also includes an additional outdoor concrete area of at least 2.5 m^2 that is accessible to the sow and the piglets, as required by organic standards (Commission Regulation (EC) 889/2008). Similarly, this type of accommodation is used in welfare label systems, although with varying space requirements (e.g. Swiss label IP-SUISSE (IP-SUISSE, 2020)). The floor in the outdoor area may be partly slatted, and part of this area may be (partly) covered by a roof. In non-organic systems, access to the outdoor area may be limited during the nest-building period and in the first few days after farrowing. The feed trough for the sow as well as the sow and piglet drinkers can be provided indoors or outdoors (when roofed).

These systems have not been further analysed in the General and Specific ToRs because they are currently not widely used in commercial practice, unless in the case of organic or niche productions. In these systems, the welfare consequences experienced by sows are likely to be similar to the ones identified in the case of individual housing in pens.

3.3.3.8. Outdoor farrowing paddocks

In Europe, lactating sows are kept on outdoor paddocks but to a limited extent, possibly even less than pregnant sows (Section 3.3.2.5). The UK is an exception with ~ 40% of conventional sows being kept in these systems (data from AHDB website[22]). In other EU countries, e.g. France, Denmark, Italy, this system can be mainly found on organic farms. However, across the EU, an estimated maximum of 5–10% of all organic sows farrow in outdoor paddocks (Früh et al., 2013). Also, in some niche (welfare) label schemes, and on the Iberian pig farms, sows are kept on paddocks during farrowing and lactation.

Sows are usually moved to individual paddocks approx. 1 week before expected farrowing and remain there for the whole lactation (4 weeks conventional, 6–8 weeks organic), or are grouped with a few other sows after 1–2 weeks (group suckling). In some cases, sows are not separated for farrowing but remain as a group throughout the whole period (so-called batch paddocks).

The paddock is fenced with electric wire, however, piglets are able to walk underneath, so that they mix with neighbouring litters from early on. Each paddock is equipped with a farrowing hut (of different materials and designs, sometimes insulated) of ~ 5–7 m^2, which is bedded with straw. It has commonly a 'veranda' (130 × 130 cm) in front of the exit for the first week of piglets' life to prevent them from getting lost. Furthermore, in the paddock, a drinker is provided (which can also be combined with a shower facility), and a feeding trough may be present, or the sow may be fed using large nuts placed directly on the ground. Piglets in conventional outdoor farms are not usually offered creep feed but can access the sow feed when older, and this is also the case on many organic farms (Prunier et al. 2014). However, on some farms with later weaning, a creep feeder may be provided for piglets, which is outside the paddock, or protected so that the sow is not able to reach it (Prunier et al., 2014).

[22] AHDB (Agriculture and Horticulture Development Board) https://ahdb.org.uk

These systems are further analysed in the General ToRs (see Sections 3.4 and 5.4) and in the Specific ToRs 2 and 3 (Section 5.7).

3.3.4. Piglet systems

As described in Section 3.3.3, piglets that depend on milk are normally housed with their mother. However, under some circumstances piglets are moved away from the mother to a different husbandry system.

3.3.4.1. Artificial rearing systems

Over the last 20 years, genetic selection has resulted in a significant increase in litter size. According to Nielsen et al. (2018), e.g. litter size of Danish crossbred sows increased from 14.6 piglets per litter in 2004 to 18.0 in 2016, representing an increase of 0.28 piglets per litter per year. In the Netherlands, a breeding company increased litter size by 0.16 piglets per year from 2001 to 2009 (Merks et al., 2012) and in Sweden, litter size in second parity sows increased from 11.2 in 1997 to 13.9 in 2009, corresponding to an increase of 0.22 piglets per litter per year (Andersson et al., 2016). Consequently, the number of live-born piglets may outnumber the number of functional teats. A common method used to balance litter size between sows is cross-fostering. Piglets are relocated from their biological mother sow to another lactating sow with fewer piglets. On units where the average litter size is very high, however, this will not be feasible. To resolve this problem, surplus piglets can be removed from the sow within a few days after birth, after colostrum intake (range 3–6 days), and raised in artificial piglet rearing systems (Baxter et al., 2013; Rzezniczek et al., 2015; Schmitt et al., 2019). In these husbandry systems, they are first fed artificial milk, which is later replaced by solid feed.

In a commercially available artificial piglet rearing system, e.g. 7–12 piglets (up to 21 days of age) are kept in a plastic box (1.34 × 0.82 m; height: 0.54 m) with a transparent viewing window in the front (Rzezniczek et al. 2015) (see Figure 5A). The system is structured into a feeding/dunging area and a lying area. The lying area is covered by a plastic lid that contains a hole for an infrared heat lamp. The fully slatted floor is made of plastic-coated, rhombic expanded metal, and has a maximum slot width of 9 mm. The milk system consists of a storage bin, a ring line composed of plastic tubes, and two cups with a diameter of 11 cm per Rescue Deck. The cups are attached on the slatted floor in the front part of the feeding/dunging area. Each cup has a nipple in the middle, which can be operated by the piglets by pushing it slightly to one side. Artificial milk is available ad libitum to the piglets. In addition, water is provided ad libitum in the feeding/dunging area in a third cup. The system can be placed above the farrowing crates.

In another system, a maximum of 26 piglets (up to 28 days of age) are kept in a pen (2.60 × 1.65 m, plus a dunging area 0.70 × 0.60 m) (Weber et al., 2015) (see Figure 5B). The lying area is covered by a lid, heated and separated from the feeding/dunging area by a transparent curtain made of plastic stripes. The floor in the lying area is covered with litter. The floor in the feeding/dunging area is partly slatted, and the metal floor has a slot width of 9 mm. After introduction to the system, artificial milk is available ad libitum to the piglets. During the rearing period, the artificial milk is first mixed with and later replaced by solid feed.

These systems are further analysed in the General ToRs and Specific ToR 4, (see Sections 3.4, 5.4 and 7.7.1 under the description of the exposure variable 'weaning age'). In addition, the effect of litter size on the welfare of piglets is assessed in Section 5.7.18.

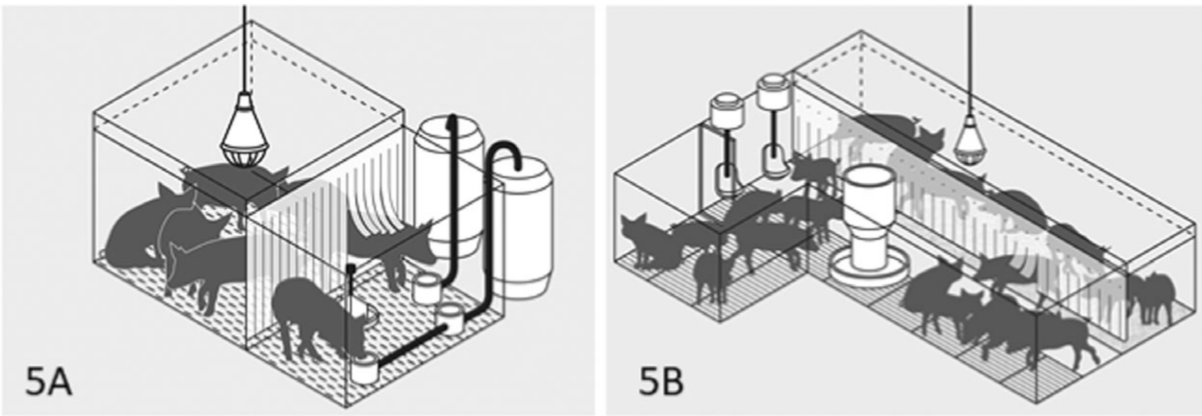

Figure 5: Artificial piglet rearing systems: (A); based on Rzezniczek et al. (2015) and (B) based on Weber et al. (2015)

3.3.5. Weaner systems

3.3.5.1. General management

After weaning as described in Section 3.2.5, the piglets are either left for a period in the farrowing pen after removal of the sow (not very common) or, more commonly, moved immediately to specialised weaner accommodation. This may be located on the same farm or may involve transportation to a different farm if a 2- or 3-site production system is used. Segregated early weaning (SEW) was developed mainly in large pig farms in North America. SEW is characterised by very early weaning of piglets (between 7–21 days of age, and usually between 12 and 16 days), and isolated housing in nurseries. It generally involves growing/finishing units with all-in all-out pig flows on multiple-site systems. The goal of SEW is to break infections by using passive maternal immunity, before the litter develops its own active immunity through contact with the pathogens of the environment (van Borell et al., 2020). Whilst it is not legal to routinely wean at less than 21 days in the EU, this approach may sometimes be utilised for health improvement (Council Directive 2008/120/EC).

Because of their high susceptibility to disease in the immediate post-weaning period, it is common to manage weaned piglets according to a batch system, in which animals of similar age are weaned at the same time and housed together, with all-in all-out occupation of the accommodation and thorough cleaning between batches. Weaner pigs are typically fed initially on a high-quality diet, often incorporating milk products in the first phase. As their feed intake increases and their digestive system matures, they are changed after some days to cheaper and less sophisticated diets. The diets may be fed wet or dry and offered ad libitum or at a restricted level.

3.3.5.2. Indoor group housing

A variety of indoor housing systems are used for weaned piglets. Illustrations can be found in the IPPCBAT Reference Documents on the Intensive Rearing of Poultry and Pigs (IPPC, 2000, 2003). Usually, piglets are housed in partly or fully slatted pens with climate control, and equipped with supplementary heating. They can also be raised as groups of 10–40 animals in flat decks. There are also systems in which after about 2–4 weeks, the piglets are moved from the 'first stage weaner' system to a 'second stage' (larger) accommodation. Nevertheless, they may also remain in the same pen until they reach a weigh of 30–40 kg (at about 10 weeks of age) or, in a few farms, until slaughter. According to the EU legislation, the minimum space allowance per animal varies from 0.2 m^2 (for pigs weighting up to 20 kg) to 0.3 m^2 (for animal below 30 kg of weight), as specified in the European legislation. Recently, balcony systems, incorporating elevated platforms over a part of the pen which can be accessed by a ramp, are becoming more widely used in some countries to provide more space per animal within the pen (Fels et al., 2018) (see Figure 6).

A European survey carried out in 1996–1998 (Hendriks and van de Weerdhof, 1999) reported that 67% of weaners were housed in pens with fully-slatted floors, 20% with part-slatted floors and 8% on solid floors with straw. Slatted/perforated flooring is most commonly of plastic or metal material, although concrete is also used. A small amount of straw, wood shavings or sawdust may be used in part slatted pens, but hanging toys are more commonly used to provide enrichment. Some weaners, especially the progeny from outdoor breeding herds, may be housed in systems with deep bedding in naturally ventilated barns. Group size in this system is typically greater, up to several hundred pigs from a contemporary weaning batch. Where pigs are kept on deep-litter, space allowance per pig is typically greater, often 0.7–1.5 m^2/pig depending on the planned weight before removal, in order to maintain hygiene.

Within nursery accommodation, the ambient temperature recommended, by e.g. Close and Le Dividich (1984) and Madec et al. (2003), and generally used (non-bedded, perforated floors) is in the range 26–30°C e.g. a temperature of 28°C for piglets weaned at 26–28 days of age. Temporary roofing over the lying area may be used for an initial period of 1–2 weeks to aid heat retention, or in more sophisticated two-climate pens use of the roof over the solid-floor lying area may be regulated

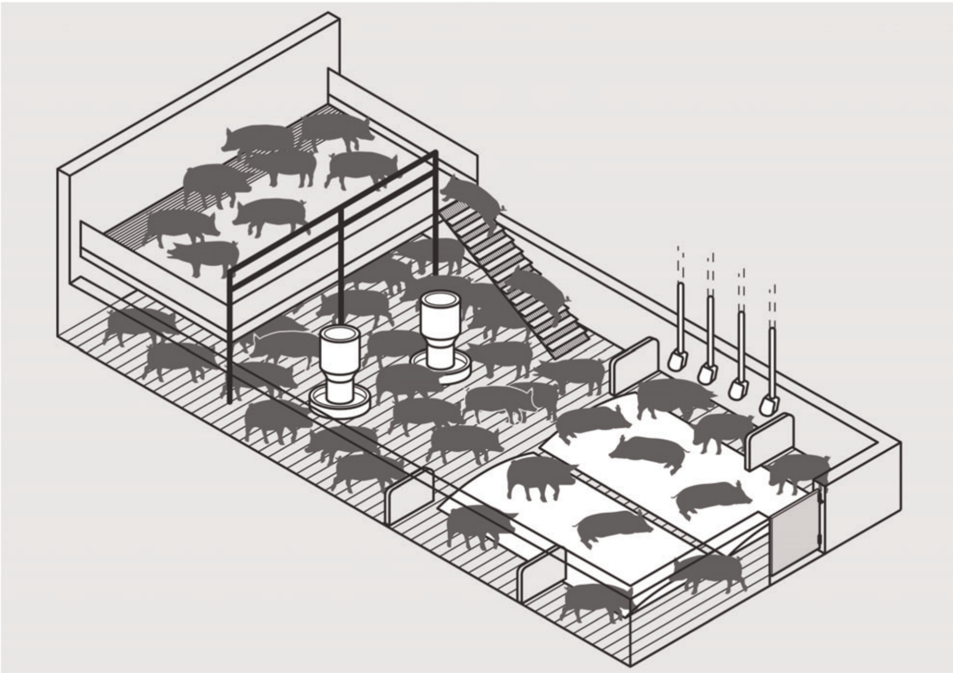

Figure 6: Example of an indoor group housing of weaners with a balcony (based on Vermeer et al., 2012)

according to the pigs' lying behaviour during the whole weaner period.

These systems are further analysed in the General ToRs (see Sections 3.4 and 7.1).

3.3.5.3. Indoor systems with access to an outdoor area

These systems include 'bungalows', which are raised housing units with enclosed lying areas and outdoor, slatted dunging areas (see Figures 3.9b and c in SVC, 1997). Artificial heat is not usually provided in these systems, which rely on the body temperature of the pigs to heat the limited airspace in the lying compartment. Bedding is usually minimal or absent. Feed and water provision are as described for indoor systems. Organic production systems commonly use pens with an indoor enclosed lying area, where bedding is provided on a solid or part-slatted concrete floor, and a solid-floored outdoor run which may be partially roofed (Früh et al., 2013). These typically incorporates a drainage slope and may be cleaned by hand or automated scraping system. Minimum space allowances, both indoor and outdoor, are greater than required in conventional systems – 0.8 m^2/pig indoors plus 0.6 m^2/pig outdoors are specified in the Regulation (EC) 889/2008. An example of indoor system with access to an outdoor area is visualised in Figure 7.

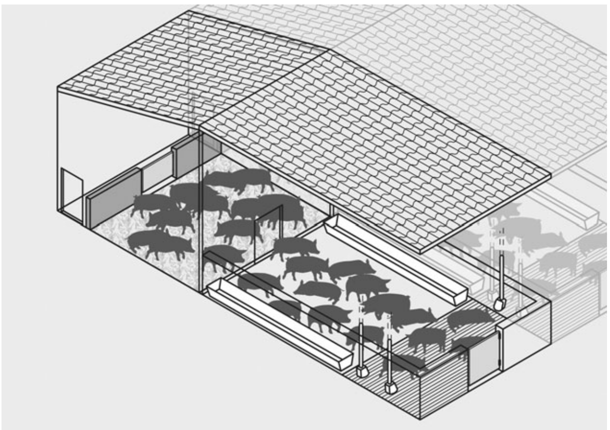

Figure 7: Example of an indoor group housing of weaners with access to an outdoor area (based on Auinger et al., 2015)

These systems are further analysed in the General ToRs (see Sections 3.4 and 7.1).

3.3.5.4. Outdoor paddock systems

Paddock systems for weaners are relatively uncommon in conventional production, although some outdoor herds use 'hut-and-run' systems where groups of typically 20–50 pigs are housed in a simple wooden structure (see Figure 7.7 in EFSA, 2005) or a canvas tent, with a fenced outdoor run. Deep straw is usually provided on the ground in the indoor section, and sometimes also the outdoor section. These units may be placed directly on soil and moved to fresh ground between each batch of pigs, or they may be placed permanently on a concrete pad and dismantled for cleaning between batches. Only a small number of farms, usually organic farms or those selling into specialised niche markets, operate a true paddock system for weaners in which the pigs have free run of a fenced field and are provided with a bedded hut for shelter.

Another system in which weaners may be kept outdoors in paddocks is the traditional Mediterranean silvopastoral system. Progeny of indigenous breeds for the production of high-value dry-cured hams are allowed to forage over large areas in natural forests of oak and chestnut (Dobao et al., 1988; Edwards and Casabianca, 1996). In the traditional production system, Iberian piglets are weaned at 2 months old, and then, they are usually mixed in large pastures, where they are given concentrate at the same time as getting natural resources. However, some Iberian farms wean piglets at an earlier age and keep their pigs inside during the post-weaning period, feeding them only with concentrate (Martinez-Macipe et al., 2020).

These systems are further analysed in the General ToRs (see Sections 3.4 and 7.1).

3.3.6. Rearing pig systems

3.3.6.1. General management

Grouping rearing pigs by sex may facilitate more precise nutritional and slaughter management, particularly when entire male pigs are used, however mixed sex groups are commonly used. Group size varies between farms but large group systems (e.g. of 40 pigs or more) are becoming increasingly common (Santonja et al., 2017). Although other systems are used, the majority of rearing pigs are housed in pens, where the floor is either fully or partially slatted (EFSA, 2007a). Hendriks and van de Weerdhof (1999) indicate that at that time, 47% and 44% of growing-finishing pigs in Europe were housed on partly-slatted or fully-slatted floors, respectively, with no/limited bedding. This can create challenges in meeting the requirements of Council Directive 2008/120/EC to provide pigs with access to a sufficient quantity of material to enable proper investigation and manipulation activities. Pigs are highly motivated to perform these activities, and insufficient appropriate material in the pens of rearing pigs has been linked to increased oral manipulation (including biting and chewing) of penmates (Pedersen et al., 2014). Rearing pigs are offered liquid or concentrate (pelleted or meal) diets from feeders or troughs. Feed is often offered on an ad libitum basis to rearing pigs but restricted feeding practices are also applied to improve feed use efficiency or to prevent excessive fat deposition. Dietary ingredients used will vary depending on cost, availability and feeding system. The nutritional specification of the diet may be altered during the rearing period to reflect changing requirements of pigs. In particular, this may lead to reduced levels of crude protein and lysine in diets offered to older pigs.

Pigs may be moved to new accommodation at the start of or during the rearing period, and this can include movement within or between farms (e.g. moving at about 30 kg to specialist 'finishing' farms). This typically involves mixing unfamiliar animals and leads to increased aggression as new social relationships are established. Problems with aggression may be exacerbated at high stocking densities, or where there is competition for access to resources such as feeders or drinkers. In some countries, such as the UK and Ireland, entire males rather than castrated pigs are typically used, and this can also lead to increased levels of aggressive and mounting behaviours in the rearing stage (Boyle and Björklund, 2007). These problems, together with an increased risk of boar taint with age, mean that lower slaughter weights tend to be adopted in systems that use entire male pigs (von Borell et al., 2020).

Groups of pigs may be sent for slaughter on an 'all-out' basis, or 'split-marketing' approaches may also be applied whereby larger pigs in a pen are sent for slaughter earlier than others (Conte et al., 2012). Although split marketing practices could potentially stimulate aggression by destabilising social relationships, the magnitude of these effects will likely depend on the group size and percentage of pigs removed. Split marketing may have also led to benefits for pigs that remain in the pen in terms of increasing space and access to resources such as feeders and drinkers.

3.3.6.2. Indoor group housing

This is the most common method of keeping rearing pigs in the European Union. As mentioned in Section 3.3.6.1, pigs may be moved to new accommodation at the start of and during the rearing period. This may involve mixing unfamiliar pigs, which can stimulate aggressive behaviour and compromise welfare. If mixing cannot be avoided at this stage, Council Directive 2008/120/EC indicates that pigs should be provided with opportunities to escape and hide from other pigs. Provision of plentiful straw or other materials for investigation is also suggested in cases where severe fighting is evident.

A variety of floor types are used for rearing pigs that can be broadly categorised as (1) fully slatted, (2) partly slatted, (3) solid floored with little or no bedding (and a scraped dunging area) and (4) solid floored with deep litter (see EFSA, 2005, 2007a. Bedding is typically straw or sawdust, and it accumulates over the rearing cycle in deep litter systems (Santonja et al., 2017). As mentioned in Section 3.3.6.1 most rearing pigs in Europe are housed in slatted pens (fully or partly). Slats are typically constructed from concrete, and appropriate slat and slot dimensions for fully slatted floors for rearing pigs are stipulated in the above EU legislation (80 and 18 mm, respectively). Solid floor areas in part-slatted pens may be located at the side or centre of the pen as illustrated in Santonja et al. (2017). The minimum space allowance that can be provided to rearing pigs is also included in EU legislation and ranges from 0.4 m^2 per pig (> 30–50 kg) to 1 m^2 per pig (> 110 kg). Additional space is normally provided in systems that are not fully slatted to enable pigs to maintain separate areas for resting and eliminative behaviours. The layout of pens will vary between farms and may include structures such as kennels (or temporary kennel covers) and/or balconies (see Figure 6).

Factors such as level of building insulation, ventilation type and provision of supplementary heating to rearing pigs will differ depending on climate and system. In colder climates, well-insulated buildings with forced ventilation systems and supplementary heating may be used (Santonja et al., 2017). Natural ventilation or automatically controlled natural ventilation is also used in rearing pig houses. Research in partially slatted pens (with a lying area space allowance of 0.67 m^2/pig) indicated that temperature ranges within the thermal comfort zone of pigs were 10–17°C for pigs of between 50 and 70 kg, and 5–17°C for pigs of more than 85 kg (Hillmann et al., 2004). Misting or other cooling systems are sometimes provided to assist pigs with temperature regulation in warmer climates. Alternatively, thermal properties associated with deep bedding can protect pigs in uninsulated buildings from colder weather.

Group sizes used for rearing pigs are increasing (e.g. from 10/15 to > 40 pigs per pen), largely to facilitate more efficient use of space and equipment. The ratio of pigs to feeder space will vary between different feeding systems and may reach 12:1 (EFSA, 2007a). As mentioned in Section 3.3.6.1, feed can be offered in wet (including liquid) or dry form. It is often offered on an ad libitum basis to rearing pigs, but restricted feeding practices are also applied to improve feed use efficiency or to prevent excessive fat deposition.

These systems are further analysed in the General ToRs (see Sections 3.4 and 7.4).

3.3.6.3. Indoor systems with access to an outdoor area

Outdoor run areas are typically constructed from concrete and can have solid or slatted floors. The runs may also be partially or fully covered by a roof. Feed and water are generally provided in the indoor section, and illustrations of some of these systems (with slatted external area, or solid external area with litter) are provided in Santonja et al. (2017). This type of accommodation may be used in organic production systems, and in this case, minimum space allowances are stipulated in Commission Regulation (EC) 889/2008. This provides a greater total space allowance than in conventional indoor systems. For example, pigs from > 50 to 85 kg must be provided with 1.1 m^2/pig in indoor areas and 0.8 m^2/pig in outdoor areas in organic systems. An example is visualised in Figure 7.

These systems are further analysed in the General ToRs (see Sections 3.4 and 7.4).

3.3.6.4. Outdoor paddock systems

This system involves access to paddocks (grass or soil) with either temporary or permanent buildings for shelter. As indicated in EFSA (2007a), this may involve providing simple shelter in the form of corrugated iron arcs, wooden sheds or tents, and access to a large fenced off paddock area at a stocking rate of 40–50 pigs per hectare. Pigs may also be housed in specially designed huts containing ventilation flaps and integral feed and water supplies (a common example is illustrated in EFSA, 2007a) with access to smaller run areas. In both cases, accommodation can be moved to a new site for each batch of pigs. Lindgren et al. (2014) also describe permanent barn structures where pigs have access to outdoor areas, possibly including rotated paddocks. EU Regulations on organic farming (Council Regulation (EC) 834/2007[23] and Commission Regulation (EC) 889/2008) also indicate a maximum stocking rate of 14 fattening pigs per hectare. As indicated in EFSA (2007a), resting areas for pigs within accommodation are typically insulated or bedded to protect them from adverse climatic conditions. To further protect pigs, paddock-based systems may only be used at certain times of year in some countries (Früh et al., 2013). A Mediterranean silvopastoral system used to produce dry-cured ham from pigs of indigenous breeds finished in oak or chestnut forests has also been described (EFSA, 2007a).

These systems are further analysed in the General ToRs (see Sections 3.4 and 7.4).

3.3.7. Boar systems

3.3.7.1. General management

Boars are commonly bred at specialised 'nucleus' herds which are at the top of the breeding pyramid and practise very intense genetic selection. Boars are typically purchased at 5–6 months of age by piglet producing farms and begin their productive life about 1–2 months later. On most farms, they are culled after 2–3 years when they have become too large, due to health problems (e.g. lameness, infertility), and are superseded by the next generation of genetically more improved animals. In some countries, natural mating is most common, whereas in other countries, artificial insemination (AI) predominates. In European countries, the proportion of pigs mated by AI is between 25% and 98% (Khalifa et al., 2014). Semen is bought in on a regular basis from breeding stations or collected from the farms' own boar. Most farms, even those using only AI, will keep at least one boar to assist with oestrus stimulation and detection, which is commonly a boar of lesser genetic merit ('teaser boar'). Breeding boars are trained to mount a dummy sow for semen collection which typically occurs once or twice weekly (EFSA, 2007b). In order to handle boars and collect semen, a good human–animal relation is important (Hemsworth et al., 1986). In order to prevent locomotory problems (due to high pressure during mounting) and penile injuries and, in turn, a reduction in the risk of depressing sexual behaviour, attention to the design and maintenance of the accommodation and mating or semen collection areas is necessary (Hemsworth and Tilbrook, 2007). Furthermore, regular claw trimming might be necessary to prevent injuries.

Boar tusks might need reduction in length (allowed procedure, according to Council Directive 2008/120/EC); this may avoid injuries of their own head (when teeth are growing into the maxilla) and protect staff safety.

[23] Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91 OJ L 189, 20.7.2007, p. 1–23.

Mature boars are normally housed individually in pens, with a minimum space allowance of 6 m^2, to facilitate staff safety and service management. However, in these pens, social and exploratory behaviours are restricted due to isolation and limited amount of enrichment materials (EFSA, 2007a).

Service typically takes place in the boar pen, or in a specially designed mating area. Sometimes, however, the boar is allowed to remain with a group of sows and serve them as they come on heat.

Group housing is more normal in outdoor systems, where service is carried out by one boar or a team of boars living with a group of sows after weaning, but also sometimes remaining with the pregnant sows, to detect any sows coming back to service. These 'catch boars' may also be used in large group systems indoors, such as with electronic sow feeding.

3.3.7.2. Indoor individual housing in pens

Information on husbandry and management of boars is scarce; however, according to a survey in seven European countries (EFSA, 2007a), boars are kept either for semen collection in AI centres (approx. 20–30%) or on piglet-producing farms (70–80%) for semen collection, natural mating or as teaser boars, to stimulate oestrus in sows. They are housed in individual pens, with a minimum area of 6 m^2, when not used for natural service or 10 m^2, when also service takes place there (Council Directive 2008/120/EC). It is required that boars are able to turn round and to hear, smell and see other pigs. These are either other boars in adjacent pens or sows in the vicinity, as the boar pen is usually located in the service area, so that boar–sow contact is ensured. Commonly, boar pens have partly slatted floor, sometimes including rubber mats or some bedding as well as some provision of exploratory material.

These systems are further analysed in the General ToRs (see Section 3.4 and Chapter 8).

3.3.7.3. Indoor systems with access to an outdoor concrete area

Sometimes, indoor pens for boars (Section 3.3.7.2) provide access to a concrete outside run, which is obligatory (8 m^2) for organic farms. It can be (partly) roofed, equipped with partly slatted flooring and serves as excretory and exercise area. The drinker can be located outdoors, as well as a sprinkler device for thermoregulation, devices for comfort behaviour (brushes) or exploration (hay/silage racks).

These systems have not been further analysed in the General ToRs because they are very rare in the EU and linked to organic or niche productions. In these systems, the welfare consequences experienced by boars are likely to be similar to the ones identified in the case of individual housing in pens.

3.3.7.4. Outdoor paddock systems

Boars kept on outdoor paddocks are (as individuals or in small groups) commonly grouped with sows in 'service paddocks', which include access to bedded, group huts, drinkers, wallowing areas and fenced with electric wires.

These systems have not been further analysed in the General ToRs because they exist only in few EU MSs and are linked to organic or niche productions. In these systems, the welfare consequences experienced by boars are likely to be similar to the ones identified in the case of individual housing in pens.

3.3.8. Hospital and separation pens

Hospital pens for the care of sick animals should facilitate care and recovery of the animal appropriate to its physical condition, age and illness/injury. Hence, for lame animals, the pen should have an area of solid flooring to allow provision of bedding and easy access to water and food. Additional heat might be a feature in hospital pens for younger/smaller pigs, and good lighting is essential for ease of inspection. Close monitoring of pigs and effectiveness of treatment is essential to ensure that, if there is no improvement, pigs are euthanised promptly.

Separation pens (for e.g. tail biters or surplus pigs) on many farms are typically similar in construction and design to the pens employed in the main production stages. They are generally smaller and in a smaller airspace but are often fully slatted and relatively devoid of differentiated areas. As pigs will generally remain there for the remains of the production period, they should allow social contact and appropriate access to resources.

On most farms, several pens are available, so that they can be filled and emptied on an all-in, all-out basis in order to reduce the build-up of disease-causing organisms.

These systems have not been further analysed in the Common ToRs because there are many different ways in which one can keep animals which are sick or in need of isolation and there is no possibility to assess the highly relevant welfare consequences in systems with such variety.

3.4. Describing pig welfare: most relevant welfare consequences for pigs and related ABMs (General ToRs 2 and 3)

Following the exercise described in Section 2.2.2.1, the magnitude (based on a qualitative estimation of severity, duration and frequency of occurrence) of 30 welfare consequences was assessed by group consensus based on the outcomes of an individual qualitative ranking exercise, for the selected husbandry systems (see Table 9, Section 3.2.1).

The exercise resulted in 16 welfare consequences identified as having high relevance across pig systems (see Table 10). This categorisation was applied to facilitate discussions on the most relevant welfare issues. No attempt was made to individually rank these welfare consequences, even though it is acknowledged that they are not all equally relevant.

A detailed description of these 16 welfare consequences and the ABMs that can be used under on-farm conditions to assess each of them is reported after the table. Regarding these ABMs, the opinion suggests a definition, an interpretation and considerations regarding sensitivity and specificity. The method used to apply the ABM plays an important role regarding sensitivity, specificity and feasibility of the ABM. However, these could not be described in detail in this opinion.

It is worthwhile to highlight that the ABMs reported in this SO represent a number of the possible ones that can be used to assess a certain welfare consequence. They were included as they are reported in the literature and they are commonly used in practice, even if the EFSA experts considered them not specific nor sensitive to the welfare consequence.

It needs to be noted that other welfare consequences may negatively affect the welfare of pigs, but in the opinion of the WG experts they were classified as of less or moderate relevance compared to the highly relevant ones (see Section 2.2.2.1). An overview of the expert judgement on the welfare consequences that may affect the welfare of pigs is visualised in Appendix B.

Table 10: Pig categories and husbandry systems that have been fully assessed in the General ToRs and welfare consequences classified as highly relevant through WG expert opinion (for details, see Section 2.2.2.1)

Welfare consequences	Pig husbandry systems																
	Gilts + dry sows			Farrowing and lactating sows			Piglets				Weaners			Rearing pigs			Boars
	Individual stalls	Indoor group	Outdoor paddock	Individual crates	Individual pens	Outdoor paddock	Individual crates	Individual pens	Artificial rearing systems	Outdoor paddock	Indoor group	Indoor with access to outdoor area	Outdoor paddock	Indoor group	Indoor with access to outdoor area	Outdoor paddock	Indoor individual pens
Restriction of movement	x			x					x					x			x
Resting problems	x			x										x			
Group stress	x	x	x	x			x	x	x	x	x	x		x	x		
Isolation stress																	x
Separation stress									x								
Inability to perform exploratory or foraging behaviour	x	x		x			x		x		x	x		x	x		x
Inability to express maternal behaviour				x													
Inability to perform sucking behaviour									x								
Prolonged hunger	x	x	x				x	x	x	x							x
Prolonged thirst							x	x		x							
Heat stress				x													
Cold stress										x			x				
Locomotory disorders (including lameness)		x												x	x		x
Soft tissue lesions and integument damage		x		x			x	x		x	x	x		x	x		
Respiratory disorders														x	x		
Gastro-enteric disorders											x	x	x				

3.4.1. Restriction of movement and related ABMs

Description: The animal experiences stress and/or negative affective states such as pain, fear discomfort and/or frustration due to the fact that it is unable to move freely (including getting up and lying down) or is unable to walk comfortably (e.g. due to overcrowding, unsuitable (e.g. slippery) floors, gates, barriers).

Classified as highly relevant: The pig categories and the husbandry systems for which 'restriction of movement' was identified as highly relevant are listed in Table 11; the specific relevance for each pig category is described in the following text.

The ABMs that can be used for assessing the welfare consequences, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 12.

Table 11: Pig categories and husbandry systems for which 'restriction of movement' was identified by experts as a highly relevant welfare consequence

Pig category	Husbandry system
Gilts and dry sows	Individual housing in stalls
Farrowing and lactating sows	Individual farrowing crates
Piglets	Artificial rearing systems
Rearing pigs	Indoor group housing
Boars	Indoor individual housing in pens

Relevance for dry sows and gilts: Stolba and Wood-Gush (1989) observed the behaviour of pigs in a semi-natural environment. They reported that adult female pigs spent about 12% of their daylight activity in locomotion. Gestation stalls are typically between 2–2.5 m long and 0.5–0.7 m wide (McGlone, 2013). This space, not much larger than the size of the sow prevents her from walking and turning around. Such restriction induces an acute behavioural response from gilts introduced to stalls for the first time and this behavioural response can result in injury to the skin of the limbs (Boyle et al., 2002a). Gestation stalls also limit the movement of getting up and lying down (Marchant and Broom, 1996a) which is exacerbated as pregnancy progresses (Boyle, 2008). This results in gilts in gestation stalls progressively lying down more and for longer periods and changing their lying position more frequently compared to gilts in loose individual pens (Taylor et al., 1988). Inactivity due to restriction of movement reduces cardiovascular fitness (Marchant et al., 1997) and bone and muscle strength (Marchant and Broom, 1996b) Combined with claw lesions, particularly to the white line, this can result in lameness (Barnett et al., 2001; Calderón Díaz et al., 2014). Inactivity due to restriction combined with manoeuvring difficulties in stalls also increases the incidence of callosities and injuries to the limbs (Leeb et al., 2001; Calderón Díaz et al., 2014). Boyle et al. (1999) reported that the most commonly injured location in stall housed sows is the lateral/outer accessory digit (or dew claw) of the hind limb with 6.2% of pregnant animals affected. Furthermore, Calderón Díaz et al. (2014) found more dewclaw injuries in stall compared to loose-housed sows at the end of pregnancy. The most severe injuries in this region include partial or whole amputation of the dewclaws /accessory digits or much less frequently of the weight bearing claws (Boyle, 1996). These commonly occur when the claw is caught in the gap in the slats as the sow lies or attempts to lie down.

The motivation to move may increase due to feed restriction. Sows experience from prolonged hunger during gestation resulting in an increased motivation to move around and forage for food, even after feeding (SVC, 1997). Restriction of movement in conjunction with feed restriction is involved in the development of oral stereotypies (Lawrence and Rushen, 1993).

During oestrus, sows become highly active and motivated for social contact (Pedersen et al., 1993; Pedersen, 2007). This may include mounting other sows and standing in front of the boar if present. If kept in groups during this time social stress can be high and subordinate sows are particularly affected. Indeed, Rault et al. (2014) concluded that sows housed in groups at weaning and regrouped after insemination experienced higher stress than sows housed in individual stalls at weaning and mixed in groups after insemination.

On the day before farrowing, sows kept in a semi natural environment become very active (Stolba and Wood-Gush, 1989). They gathered twigs and grass tufts to build a nest. To do so, they made about 83 trips in 90 min and covered 1,500 m. During nest-building, sows turn around at the nest-site and show pawing and rooting behaviour over several hours (Arey et al., 1991). In a study using operant conditioning methods, Arey (1992) showed that sows in conventional husbandry systems are still highly motivated to get access to nest-building material on the day before farrowing. They are thus likely to experience frustration if they are unable to move around and collect nest-building material. Even in the absence of nest-building material or room to turn around, sows will rub their nose against the floor, and make pawing movements similar to those performed when nest-building (Damm et al., 2003).

Relevance for farrowing and lactating sows: In the first 8 days after farrowing, sows in a semi-natural environment spend increasing amounts of time over 10 m away from the nest-site (Csermely, 1994). Meanwhile, she is still regularly engaged in maintaining the nest. Confined sows cannot express these behaviours.

Confinement in a farrowing crate may also impair the sow's getting up and lying down behaviour, resulting in atypical lying down movements. Andersen et al. (2014) reported that sows in crates, observed from day 110 in pregnancy to 4 days after farrowing, spent more time sitting and made fewer posture changes after farrowing compared to sows kept loose in a pen. Similarly, Hales et al. (2016) observed that the frequencies of lying down and getting up were lower in sows confined in farrowing crates either from gestation day 114 to day 4 after farrowing or from the end of farrowing to day 4 after farrowing compared to loose-housed sows. After farrowing, sows often lie for long periods in the same posture, which leads to the compression of blood vessels, insufficient blood circulation, necrosis and subsequent ulceration of the shoulders (Rioja-Lang et al., 2018). When lying down or standing up, sows confined in crates may knock parts of their body against the crates (Troxler and Weber, 1988). In a study including 10 herds with sows housed in conventional farrowing crates, Bonde et al. (2004) found that 41% of the sows showed difficulties in lying down, indicated by interruptions in the behaviour sequence, slipping on one or both hind legs or uncontrolled movements. Calderón Díaz et al. (2015b) reported that sows in farrowing crates during ten minutes prior to feed delivery made on average two attempts per minute to rise before standing successfully. Following feeding they also made on average approximately two attempts per minute to lie down before lying down successfully. This suggests increased difficulties in getting up and lying down behaviour. These challenges are unsurprisingly associated with injuries to the limbs. Both Edwards and Lightfoot (1986) and Boyle et al. (1999) reported the most commonly observed injury in sows on all farrowing house floors was abrasion of the skin of the hind foot at the base of the accessory digit. The latter authors reported 20.5% of sows affected by lesions to this location. As lactation progresses and piglets grow and become more demanding, the sow will more often want to move away from them (Csermely, 1994). Crated sows cannot perform this 'escape behaviour' and will increase sternal lying behaviour as opposed to lateral lying, in order to reduce piglet access to the udder (Götz, 1991; Valrosa et al., 2002).

Relevance for piglets: Space allowance in artificial piglet rearing systems is usually low (Schmitt et al., 2019). In the Rescue Deck system, e.g. the total floor area is 1.1 m^2, of which 0.55 m^2 are provided in the heated lying area. When 7 or 12 piglets are raised in this system, space allowance per animal is only about 0.15 or 0.1 m^2, respectively. Moreover, there is little opportunity to walk around, as part of the floor area is used by lying or standing piglets, and the maximum distance that can be covered is 1.34 m, the length of the system. Rzezniczek et al. (2015) reported that piglets raised by the sow in a pen displayed play-fighting longer than piglets reared in the Rescue Deck, probably because the lower space allowance in the artificial rearing system did not facilitate such behaviour. Moreover, piglets' lying behaviour was increasingly affected by space allowance in that study. The time they spent resting decreased over the first 18 days after introduction to the artificial rearing system, whereas duration of resting increased during the same period in piglets that were reared by the sow in a control treatment.

Relevance for rearing pigs: Inadequate floor space allowance is the main factor restricting movement in rearing pigs. This can lead to an inability or unwillingness to navigate other pigs in order to walk freely and access resources in the pen, and these crowding problems are exacerbated as pigs grow. Research shows that increasing floor space allowance above the EU legal minimum requirements leads to increased locomotion (Cornale et al., 2015) and feed intake (Carpenter et al., 2018) in rearing pigs. Bulens et al. (2017) also found that providing additional space to finishing pigs housed at the EU legal minimum by giving access to a balcony led to less manipulation of penmates, increased lying behaviour and reduced headknocks. This corresponds with recent findings by Camp Montoro et al. (2021) that reductions in space allowance (within those permitted under current EU legislation) led to increased aggression-related injury in slaughter weight pigs. This might reflect a reduced ability of pigs to escape aggressive interactions when movement is restricted. Reduced space allowance is associated with increased tail lesions indicative of tail biting behaviour in fattening pigs (Munsterhjelm et al., 2015), but this is not always shown (see D'Eath et al., 2014). Restriction of movement in rearing pigs due to low space allowances also makes it more difficult for them to maintain separate dunging and resting areas. This may lead to increased fouling of lying areas (Larsen et al., 2017), which is associated with reduced health and welfare (Nannoni et al., 2020). The ability of the pigs to maintain a physical distance from each other, and also to lie in a lateral position is also adversely affected by low space allowances, and this can make thermoregulation more difficult. Perhaps due to a combination of effects, reduced space allowance is associated with increased levels of faecal corticosteroids in fattening pigs (Cornale et al., 2015).

Relevance for boars: Breeding (or teaser) boars are commonly kept in pens of 6 m^2 of space and partly slatted floor for most of the time. For mating or oestrus stimulation of sows, they are taken out of the pen to another accommodation (the mating or semen collection area with solid flooring (EFSA, 2007b)). For mating, at least 10 m^2 are required, as otherwise expression of courtship behaviour is reduced (Petchey and Hunt, 1990; SVC, 1997).

In semi-natural conditions, boars behave similarly to adult sows, and spend 10% of their daylight time in locomotion (Stolba and Wood-Gush, 1989). In wild boars and (semi) wild pigs, this behaviour increases in the breeding season, when they are motivated to search for sows as well as during courtship and mating behaviour (Briedermann, 1986). Breeding boars are therefore highly motivated to move around. Furthermore, also health aspects, such as the cardiovascular as well as the locomotory system (Marchant and Broom, 1996b) and fertility (Flowers, 2015) are influenced by movement. Flooring conditions (cleanliness, slipperiness, abrasiveness, slat width) are important features influencing locomotory behaviour. The condition of the floor is particularly relevant, during semen collection or natural mating. The floor needs to be safe to avoid claw and leg injuries, as the whole weight of boars is shifted to the two back legs.

Table 12: ABMs for assessing 'restriction of movement', definition, interpretation, qualitative assessment of their sensitivity and specificity and indication to which pig categories they apply. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Nest-building behaviours (dry sows and gilts, immediately before farrowing)	**Definition:** Nest-building is a highly active, intrinsically motivated pattern of behaviours expressed by sows from 24 hours prior to parturition (Jensen, 1989), and aims to prepare a dedicated place for farrowing. It is characterised by rooting with the snout (movements of the snout on the floor or arranging of straw), digging/pawing, turning and carrying substrates (Andersen et al., 2014). Elements of nest-building behaviour are performed even in the absence of relevant stimuli. **Interpretation:** The ability to perform nest-building behaviour facilitates parturition (Cronin et al., 1993; Yun and Valros, 2015) such that frustration of the behaviour disrupts parturition resulting in prolonged farrowing times. There is a correlation between the duration of prepartum nest-building behaviour and carefulness of sows towards their offspring during early lactation (Yun et al., 2014). **Sensitivity/specificity:** The ABM is sensitive: if movement is restricted, no sow in the nest-building phase will show the full repertoire of nest-building behaviours. The ABM is not specific: if movement is not restricted, there may be other reasons why sows do not show the full repertoire of nest-building behaviours, e.g. absence of nest-building materials or for health reasons.
Locomotory behaviour (all pigs)	**Definition:** Average proportion of time an animal spends changing location/position by moving (e.g. walking, running, turning). This includes locomotion that occurs when foraging, exploring and does not include 'Standing'.

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Interpretation: when the movements of an animal are restricted, the locomotory behaviour decreases or is absent (Cornale et al., 2015). **Sensitivity/specificity:** The ABM is sensitive: if movement is restricted, pigs will not show normal locomotory behaviours. The ABM is not specific: if movement is not restricted, locomotion may still be impeded by e.g. lack of stimuli, leg health issues.
Play-fighting (mainly in piglets)	**Definition:** Play fighting, or rough-and-tumble play, is a commonly reported form of play that occurs in a wide range of species (Pellis and Pellis, 2017). It is seen as a form of non-serious fighting, as the same body areas that are bitten or struck during serious fighting are also the ones that are targeted during play fighting. **Interpretation:** A low incidence of play fighting appears to be associated with physical restriction (insufficient space) (Rzezniczek et al., 2015) **Sensitivity/specificity:** The ABM is sensitive: if movement is restricted, there will be very limited play fighting. The ABM is not specific: if movement is not restricted, play fighting may still not occur for other reasons, e.g. poor health.
Lying behaviour (all pigs)	**Definition:** Lying behaviour generally includes 'Lying in sternal position' (when most of the ventral part of the body contacting the floor) and 'Lying laterally' (when most of one side of the body contacting the floor and with most of the udder accessible to piglets) (Muns et al., 2016). **Interpretation:** Pigs are lying more if the space available for locomotion is restricted (Bulens et al., 2017). Pigs may increase their sternal:lateral lying ratio if there is insufficient space for all pigs to lie down laterally. **Sensitivity/specificity:** The ABM is sensitive: if movement is restricted, lying behaviour is likely to increase at the expense of standing and walking. The ABM is not specific: if movement is not restricted, lying behaviour may still be high if the environment is barren or if there are health problems.
Posture changes (all pigs)	**Definition:** Changing posture from e.g. lying to sitting or standing, or from lying in lateral recumbency to lying on all four legs (sternal), or from standing to lying. **Interpretation:** A low frequency of posture changes may indicate a restrictive environment (e.g. in farrowing crate, Hales et al., 2016). **Sensitivity/specificity:** The ABM is not sensitive: if movement is restricted, not all pigs will show reduced posture changes because some animals may increase posture changes due to uncomfortable flooring. The ABM is not specific: if movement is not restricted, there may be other reasons why animals show a low frequency of posture changes, e.g. health disorders.
Atypical lying down movements (mainly in sows)	**Definition:** Atypical lying down movements include those that require the support of pen or crate elements to prevent a sudden drop on the floor. They may also include sudden lying (or 'flopping down') caused by slipping/falling or inability to control lowering of the hindquarters when lying down. Atypical lying can also include lowering the hindquarters before the forequarters. **Interpretation:** These behaviours potentially reflect poor leg quality or unsuitable floors (Bonde et al., 2004). They may also relate to overgrown claws and close confinement.

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is not sensitive: if movement is restricted, there may not always be atypical lying down movements. The ABM is not specific: if movement is not restricted, there may still be atypical lying down movements due to other reasons (e.g. lameness).
Pressure injuries: shoulder ulcers (mainly sows), calluses and bursitis (sows, rearing pigs, boars)	**Definition:** Decubital shoulder ulcers are lesions in post-farrowing sows caused by pressure inflicted by the flooring, leading to oxygen deficiency in the skin and the underlying tissue. They are thought to be comparable with human pressure sores (Herskin et al., 2011). Scoring systems can be based on the diameter (on live animals) or on layers affected (post-mortem only): ulcers restricted to the superficial skin layers, to all skin layers and sometimes even the underlying bone (Meyer et al., 2019). Callosities are a build-up of hard, thick areas of skin. Bursitis is referred to as 'a common condition that arises from constant pressure and trauma to the skin overlying any bony prominence. The membrane or periosteum covering the bone reacts by creating more bone, a swelling develops, and the skin becomes thicker until there is a prominent soft lump. Bursitis may cause the skin to become broken and secondary infection can develop' (The Pig Site[(a)]). **Interpretation:** In sows, shoulder ulcers are caused by oxygen deficiency in the skin and the underlying tissue caused by prolonged lying on hard flooring usually in combination with poor body condition (Herskin et al., 2011; Rioja-Lang et al., 2018). Callosities develop on e.g. legs as a consequence of prolonged lying on (hard) floor. The main causes of bursitis are poor solid floor surfaces or poor slats, lack of bedding, high stocking densities. Bursitis develops due to prolonged pressure on the affected area (KilBride et al., 2009a). **Sensitivity/specificity:** The ABM is not sensitive: if movement is restricted, pressure injuries may not occur (e.g. if the lying surface is soft). The ABM is not specific: if movement is not restricted, pressure injuries may still occur e.g. due to poor quality flooring.
Dewclaw injuries (gilts and sows)	**Definition:** Wounds to the skin at the base of the outer/lateral accessory digit or partial or complete amputation of the dewclaw itself, particularly on the hind limbs. **Interpretation:** Where sows have to change posture under close confinement in gestation stalls or farrowing crates, and on floors without bedding the skin at the base of the dewclaw is easily abraded. The dewclaws can also get stuck/caught in the slats and torn off (amputated) as sows try to lie down. **Sensitivity/specificity:** The ABM is not sensitive: if movement is restricted, dewclaw injuries may not always occur (e.g. if the flooring is of good quality). The ABM is not specific: if movement is not restricted, dewclaw injuries may still occur.

(a): https://www.thepigsite.com/disease-guide/bursitis-joint-inflammation

3.4.2. Resting problems and related ABMs

Description: The animal experiences stress and/or negative affective states such as discomfort, fatigue and/or frustration due to difficulties in lying down, inability to rest in a comfortable lying posture and/or to sleep properly (e.g. due to hard, uncomfortable flooring or inadequate space).

Classified as highly relevant: The pig categories and the husbandry systems for which 'resting problems' was scored as highly relevant are listed in Table 13; the specific relevance for each pig category is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 14.

Table 13: Pig categories and husbandry systems and for which 'resting problems' was identified by experts as a highly relevant welfare consequence

Pig categories	Husbandry systems
Gilts and dry sows	Individual housing in stalls
Farrowing and lactating sows	Individual farrowing crates
Rearing pigs	Indoor group housing

General considerations: Comfort while lying is an important component of animal welfare. Pigs show two resting/sleeping postures, ventral or sternal lying involves resting on the belly with at least two legs folded under the body and lateral lying, where pigs lie on the side with all four legs stretched out i.e. in lateral recumbency (Ekkel et al., 2003). Lying laterally is the predominant form of resting behaviour observed in pigs (Ekkel et al., 2003).

When lying sternally, only 10–20% of the animals' total body surface is in contact with the flooring, putting an increased strain on these areas of the body (Baxter, 1984, Arey, 1993). Therefore, lateral lying is considered more comfortable for pigs. However, temperature influences the posture adopted by pigs while lying (Olsen et al., 2001). For example, lateral lying is a frequent response to high effective temperature as an attempt to increase the body area in contact with the floor.

Relevance for dry sows and gilts: Pregnant sows and gilts spend ~ 80% of their time lying (Buckner et al., 1998; Tuyttens et al., 2008). Hence, adequate rest and sleep requires that they adopt a sleeping posture on a suitable surface for a period during which there is not too much disturbance. Lying in lateral recumbency increases as pregnancy progresses in both sows and gilts (Calderón Díaz and Boyle, 2014) and is adopted more by sows on rubber flooring (Elmore et al., 2010) reflecting the association of this posture with increased comfort. Nevertheless, the latter finding could arguably reflect the difficulty sows have in losing heat to a rubber floor, compared to concrete (Tuyttens et al., 2008). In stalls, sows and gilts rest in a limited space that impairs getting up and down movements (Taylor et al., 1988; Marchant and Broom, 1996b) and the ability to adopt comfortable lying positions i.e. lateral lying (McGlone et al., 2004). This may be reflected in deviations from the normal standing up and lying down sequence (Mumm et al., 2020), prolonged ventral lying (Marchant, 1994), standing or dog-sitting. Such restrictions also likely disrupt the quantity and quality of sleep.

Space restrictions while lying in gestation stalls (or in farrowing crates) are exacerbated by the progressive increase in body size due to genetic selection (Edwards, 1998; Moustsen et al., 2011) which further reduces the space allowance for resting comfortably. O'Connell et al. (2007) suggest that on the basis of 'body depth' on day 110 of gestation, 95% of sows can lie unrestricted in stalls that are 67.4 cm wide. Curtis et al. (1989) estimated that in order to get up and lie down comfortably, a sow weighing 300 kg uses 220 cm in length and 86 cm in width. Thus, a stall measuring less than 220 × 86 cm will impede natural lying down and getting up behaviour (Arndt et al., 2020).

The floor of the gestation stall is typically concrete either with a solid concrete area on the front part and a slatted floor in the rear or fully slatted. In gestation stalls, such flooring causes injuries to the limbs as sows stand up and lie down, with severity progressing with advancing pregnancy (and thereby body size) (Boyle et al., 1999). Furthermore, sustained pressure on the bony prominences of the limbs while sows lie on concrete flooring causes bursitis (Bonde et al., 2004). Rubber lying mats ameliorate this lesion (Calderón Díaz et al., 2013) but bedding is rarely provided to sows in gestation stalls.

Close confinement of pigs disrupts their naturally clean excretory behaviour whereby they choose a specific dunging site (Stolba and Wood-Gush, 1989). Hence, sows may experience discomfort while lying in gestation stalls where they are unable to distance themselves from their urine and faeces.

Relevance for farrowing and lactating sows: Many of the issues surrounding resting which apply to sows in gestation stalls also apply to sows in farrowing crates. However, farrowing crates typically offer even closer confinement then gestation stalls. Boyle et al. (2002b) showed that even when sows had previous experience of farrowing crates they showed lying difficulties during the first two hours on re-introduction to crates, making on average three attempts before lying down successfully. Similarly, Bonde et al. (2004) found that 41% of sows in farrowing crates in 10 commercial herds showed lying difficulties. An additional issue for lactating sows in farrowing crates is heat stress caused by the poor ability to thermoregulate (Parois et al., 2018) potentially exacerbated by certain floor types such as plastic. Other typical farrowing house floors in the EU, include plastic coated woven wire or expanded metal, steel or cast-iron slats (Lewis et al., 2005a) and concrete, usually partially or fully slatted. Combined with close confinement such floors are injurious to the limbs and claws (KilBride et al., 2009b, Calderón Díaz and Boyle, 2014) and also influence sow lying ability (O'Connell et al., 1996). Shoulder lesions are related to a combination of sow body condition, flooring quality and prolonged resting (Rioja-Lang et al., 2018; Holmgren and Lundeheim, 2010). Provision of bedding material can ameliorate many of the problems outlined above. Comparing pens with different floor types, Edwards and Lightfoot (1986) found that lactating sows in farrowing crates had more leg and teat injuries on slatted floors than on solid floors with bedding. Lying behaviour of sows with rubber mats in the farrowing crate indicates that they provide a cushioning effect for the knees while lying as well as reducing slipping while getting up and lying down (Boyle et al., 2000).

When confined in farrowing crates, sows are forced to excrete at the nest site, whereas lactating sows kept in pens typically leave the nest area to urinate and defaecate (Schmid 1992; Pajor et al., 2000).

Relevance for rearing pigs: Rearing pigs may experience resting problems due to inadequate space and/or uncomfortable flooring. Research with weaned pigs shows that, in general, pigs occupy more floor space when lying than standing, and that this is particularly the case with lateral lying (Fels et al., 2018). Insufficient space can physically restrict lying behaviour, particularly when many pigs want to perform it simultaneously, and can also lead to increased disturbance of resting animals by active pigs. This is supported by research showing increased lying behaviour (Bulens et al., 2017) and increased lateral lying (Nannoni et al., 2019) when finishing pigs are provided with additional space. A reduced ability to perform lateral lying can adversely affect the ability of pigs to thermoregulate, and EFSA (2005) indicates that at temperatures above 21°C ~ 60% of pigs between 75 and 100 kg lie in a lateral position on fully or partly slatted floors. In fact, EFSA (2005) recommended that the space provided to finishing pigs should be greater than the current legal minimum in the EU in order to enable all pigs to lie separately and in a lateral position. The quality of rest may also be affected by the comfort of the flooring, and this, in turn may be affected by both floor type and cleanliness. Fully slatted flooring precludes the use of bedding, and finishing pigs prefer to spend time in bedded rather than unbedded pens when not thermally challenged (Beattie et al., 1998). This may reflect increased recreational value associated with bedding substrates, but also increased comfort. Indeed, numerous studies report associations between bursitis and the absence of, or sparse bedding (Mouttotou et al., 1998, 1999, Gillman et al., 2008, Temple et al., 2012). Furthermore, age is a risk factor for bursitis attributable to increased pressure on the joints in contact with the floor due to higher body weight (Gillman et al., 2008, Temple et al., 2012, van Staaveren et al., 2018). As mentioned previously, reduced space allowances also reduce the ability of pigs to maintain separate lying and dunging areas, and wet and dirty lying areas may also reduce quality of rest.

Table 14: ABMs for assessing 'Resting problems', definition, interpretation, qualitative assessment of their sensitivity and specificity and indication to which pig categories they apply. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Lying behaviour (all pigs)	**Definition:** Lying behaviour generally includes 'Lying in sternal position' (when most of the ventral part of the body contacting the floor) and 'Lying laterally' (when most of one side of the body contacting the floor and with most of the udder accessible to piglets) (Muns et al., 2016). **Interpretation:** If pigs spend too little time lying in general and specifically in the preferred lateral position it can indicate that they are uncomfortable/have problems with resting. Nevertheless, prolonged lateral lying reflected in long lying bouts may indicate a different welfare problem such as illness or lameness. Additionally, lateral lying is used by pigs to increase contact between the skin surface and the floor to lose heat. **Sensitivity/specificity:** The ABM is sensitive: resting problems are always associated with reduced lateral lying. The ABM is specific: if there are no resting problems, pigs will exhibit normal lateral lying behaviour.
Pressure injuries: shoulder ulcers (mainly sows), calluses and bursitis (sows, rearing pigs, boars)	**Definition:** Decubital shoulder ulcers are lesions in post-farrowing sows caused by pressure inflicted by the flooring, leading to oxygen deficiency in the skin and the underlying tissue. They are thought to be comparable with human pressure sores (Herskin et al., 2011). Scoring systems can be based on the diameter (on live animals) or on layers affected (*post-mortem* only): ulcers restricted to the superficial skin layers, to all skin layers and sometimes even the underlying bone (Meyer et al., 2019). Callosities are a build-up of hard, thick areas of skin. The Pig Site refers to bursitis as 'a common condition that arises from constant pressure and trauma to the skin overlying any bony prominence. The membrane or periosteum covering the bone reacts by creating more bone, a swelling develops and the skin becomes thicker until there is a prominent soft lump. Bursitis may cause the skin to become broken and secondary infection can develop'. **Interpretation:** In sows, shoulder ulcers are caused by oxygen deficiency in the skin and the underlying tissue caused by prolonged lying on hard flooring usually in combination with poor body condition (Herskin et al., 2011; Rioja-Lang et al., 2018). Callosities develop on e.g. legs as a consequence of prolonged lying on (hard) floor and due to prolonged rubbing of the affected area. The main causes of bursitis are poor solid floor surfaces or poor slats, lack of bedding. **Sensitivity/specificity:** The ABM is not sensitive: resting problems in pigs may not always be associated with pressure injuries if the floor surface is soft. The ABM is specific: if there are no resting problems, pigs will not have pressure injuries.
Pig cleanliness (all pigs)	**Definition:** The level of soiling of the skin with excrement. **Interpretation:** Pigs that cannot lie down comfortably due to e.g. lack of space or because the ambient temperature is too high will lie down in areas of

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	the pen which are also used for defecation. An increased level of resting problems may be thus associated with increased soiling of pigs. **Sensitivity/specificity:** The ABM is not sensitive: if there are resting problems, this may not always be associated with dirty pigs. Pigs in clean pens can also have resting problems. The ABM is not specific: if there are no resting problems, pigs may still be soiled by manure in case of problems of health or thermoregulation.
Teat lesions (lactating sows)	**Definition:** Broken skin of teats and udder. **Interpretation:** Traumatic teat lesions can be the consequence of injuries induced by piglets or other sows, or by slipping on slatted floors (Boyer and Almond, 2014). **Sensitivity/specificity:** The ABM is not sensitive: if resting problems are present, these may not always be associated with teat lesions. The ABM is not specific: if resting problems are truly absent, lactating sows may still have teat lesions due to e.g. poor floor quality.

3.4.3. Group stress and related ABMs

Description: The animal experiences stress and/or negative affective states such as pain, fear and/or frustration resulting from a high incidence of aggression and often due to hierarchy formation or competition for resources or mates. This includes the inability to avoid unwanted social interactions, e.g. from piglets for lactating sows, or from other sows in forced close proximity in stalls.

Classified as highly relevant: The pig categories and the husbandry systems for which 'group stress' was identified as highly relevant are listed in Table 15; the specific for each pig category is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 16.

Table 15: Pig categories and husbandry systems and for which 'group stress' was scored by experts as a highly relevant welfare consequence

Pig categories	Husbandry systems
Gilts and dry sows	Individual housing in stalls
	Indoor group housing
	Outdoor paddock systems
Farrowing and lactating sows	Individual farrowing crates
Piglets	Individual farrowing crates
	Individual farrowing pens
	Artificial rearing systems
	Outdoor farrowing paddock systems
Weaners	Indoor group housing
	Indoor systems with access to an outdoor area
Rearing pigs	Indoor group housing
	Indoor systems with access to an outdoor area

Relevance for dry sows and gilts: The stall protects subordinate sows from aggression injuries. However, sows and gilts in crates can also experience social aggression between neighbours (SVC, 1997), due to their inability to reconcile the dominance hierarchy. This is such that there can be intense aggression between neighbouring sows in the initial days following introduction to the stalls particularly if the bars are horizontal (Barnett et al., 1987, 1991). The average duration of conflicts in stalled sows is longer compared to group housed animals (Dolf, 1986). When housed in groups, sows diminish rapidly the aggression, whereas stalled sows continue their aggressive interactions at least for

3 days. It is likely that these responses are persistently high as the aggression cannot be resolved satisfactorily. Broom et al. (1995) found that the aggression was escalated to a higher level and more often compared to group housed sows (Broom et al. 1995). Furthermore, in stalls, sows use an incomplete behavioural repertoire. Dynamic grouping systems and competitive feeding environments can increase aggression in sows (Durrell et al., 2002; Verdon et al., 2015). Norring et al. (2019) found that social status was linked to live weight gain in pregnant sows, likely reflecting differences in ability to compete for food. This suggests that within-group variability in body weight increases in competitive feeding situations.

Relevance for farrowing and lactating sows: For sows during lactation, group stress can be caused by the inability to avoid unwanted social interactions, such as the piglets annoying their mother to get access to the teats.

In free-ranging domestic pigs, natural weaning is a gradual process that finishes when the piglets are about 12–17 weeks old (Jensen and Recen, 1989). If the sow is able to leave her litter by stepping over a barrier that the piglets cannot cross, the time she spends with her offspring decreases gradually with increasing age of the piglets (Bøe, 1991; Pajor et al., 2000). In parallel, the proportion of sucklings terminated by the sows increases over the lactation period (Valrosa et al., 2002). Puppe and Tuchscherer (2000) recorded the development of the daily suckling frequency in sows loose-housed in pens over a 35-day lactation period. The number of suckling bouts increased in the first days after birth, and after reaching a maximum on day 8 (with 31 sucklings), they slowly decreased up to the weaning day. Singh et al. (2017) observed differences due to litter age (observations made on day 4, 11 and 18 of lactation) with the frequency and duration of nursing bouts declining over time, but not affected by housing (crated vs. loose pens). Similar effects were found by Verdon et al. (2017) studying the differences between group lactation pens and crates in Australia.

To terminate a suckling bout, the sow hides her teats by changing her lying posture (rolling on belly) or gets up and moves away from the piglets. In loose-housed sows, Valrosa et al. (2002) observed that lying in sternal recumbency increased and the duration of sow-terminated nursings decreased over the first 5 weeks of lactation. Similarly, Götz (1991) reported that sows kept in farrowing crates lay progressively more in sternal recumbency during the first 4 weeks post-partum. In a comparison of sows housed in temporary and permanent crates, Illmann et al. (2019) found no effect of crate opening from day 3 postpartum to weaning on the proportion of piglets attending and fighting during pre- and post-massages (but see Pedersen et al. 2011a). Similarly, suckling behaviour of piglets did not differ between housing conditions in the study of Oostindjer et al. (2011), with farrowing crates either being removed or remaining in place on day 5 after farrowing. Probably, sows loose housed in pens do not have more control over the weaning process than sows confined in crates, as they cannot increase the distance to their litter sufficiently during the lactation period. In a study including an outdoor farrowing system, teat-directed activity was more common in piglets kept indoors in farrowing crates than outdoor piglets (Cox and Cooper 2001).

Relevance for piglets: At the beginning of a suckling bout, piglets not only show udder massaging behaviour but also fight for access to the teats (Fraser and Thompson, 1991). This competition is likely to cause considerable group stress, because some piglets may be prevented from sucking on a teat once milk flow starts. Moreover, teat fighting leads to facial injuries, as piglets are born with fully erupted 'needle teeth' that are used to defend a teat (Weary and Fraser, 1999). Milligan et al. (2001) reported that piglets in larger litters (11 or 12 piglets) showed more teat disputes before milk ejection and missed more nursings compared to piglets in smaller litters (8 or 9 piglets). Accordingly, Hansson and Lundeheim (2012) observed that the proportion of piglets with facial lesions was higher in larger litters. Moreover, Kobek-Kjeldager et al. (2000a) found that piglets in litters from hyper-prolific sows and of low birth weight experienced increased competition for access to teats. Piglets are often moved between sows to balance litter sizes on commercial farms ('cross-fostering'). Repeated cross-fostering disrupts teat suckling relationships and leads to increased fighting and skin lesions in piglets (Robert and Martineau, 2001).

Group stress caused by teat fighting is also likely to be provoked when several sows are housed together in a group sucking pen and piglets show cross-suckling behaviour, fighting for access to the udder of a sow other than the mother (Pedersen et al., 1998). By doing so, cross-suckling piglets seek to improve milk intake. Olsen et al. (1998) showed that cross-suckling piglets compensated for the low milk yield of her mother by cross-suckling a sow with a higher milk yield. Also, Maletinska and Špinka (2001) reported that piglets, who were observed suckling only alien sows, belonged to larger litters than piglets suckling only their own mother.

In artificial piglet rearing systems, group stress may arise from piglets that redirect massaging behaviour (belly nosing) to their pen mates. This abnormal behaviour increases both in frequency and duration over the rearing period, whereas piglets reared by the sow hardly ever perform belly nosing (Rzezniczek et al., 2015; Schmitt et al., 2019). Possibly, belly nosing disturbs the lying behaviour of the piglets. Rzezniczek et al. (2015) observed that the average resting bout length was shorter in artificially raised piglets compared to piglets reared by the sow. Also, in that study, piglets kept in the artificial piglet rearing system showed more frequent aggressive behaviour than piglets reared by the sow. In the discussion of their results, Rzezniczek et al. (2015) mentioned that aggressive interactions were possibly induced by the lack of space at the milk cups in the artificial piglet rearing system or could be linked to high levels of belly nosing. In line with this interpretation, Fraser (1978) reported that piglets occasionally bite at pen mates in response to being belly nosed.

Relevance for weaners: Group stress in the weaned pig can arise from a number of different situations. The first is that it is very common to mix pigs from different litters at the time of weaning. This is done to ensure efficient use of the available pen space and to form groups with animals of similar size to allow better organisation of pig flow and targeted nutritional inputs. When mixed with unfamiliar pigs, the newly weaned pigs will fight to establish a new dominance hierarchy. This process normally continues for ~ 72 h after weaning, with the most violent fights occurring in the first 8 h and a decreasing overall prevalence of fights from 48 h (Fels et al., 2014; Tong et al., 2019). Fighting is greater when the piglets are of similar size (Rushen, 1987), which occurs when piglets are mixed into size-sorted groups according to normal commercial practice. A second source of group stress in weaned pigs arises from competition within the group for limited resources. Prior to weaning, synchronous suckling behaviour occurs, and so weaned piglets are not accustomed to time sharing of resources and social facilitation may impair feeding behaviour. Several studies and meta-analyses have reported a reduction in feed intake and growth rate as group size increases in the weaner stage (Turner et al., 2003), although this does not seem to be expressed more in lower weight (less competitive) individuals. There have been relatively few scientific studies on the group feeding behaviour and extent of competition for feed in weaned pigs. Increasing feeding space has often shown no effect on performance in the early post weaning period, though may become more important in the later period as pig grow and feed intake increases (Weber et al. 2015). A third source of group stress in weaned pigs is the occurrence of abnormal pig-directed behaviours, particularly belly nosing and belly sucking, as also described in relevance for piglets. The behaviour, which appears to result from frustrated feeding/drinking motivation, usually commences 3–5 days after weaning, peaks ~ 2 weeks later, and then gradually declines (Widowski et al., 2008). The prevalence of this behaviour can be high, especially when piglets are weaned at a young age (Widowski et al., 2003), and this results in stress for the recipient and disrupted group behaviour.

All of the described causes of group stress in weaned pigs occur to a greater extent in indoor and semi-outdoor systems, where space is more limited, and enrichment is usually basic. For example, Beattie et al. (1996) found that aggression was higher when piglets were weaned into barren compared to enriched pens, and that belly nosing behaviour was also more frequent in the barren environment. Aggression and piglet directed behaviours have been reported to be very low when piglets are reared and weaned outdoors (Hötzel et al., 2004).

Relevance for rearing pigs: Group stress in rearing pigs is often associated with aggressive behaviour that occurs when unfamiliar pigs are mixed together. This may happen at the start of and during the rearing period, and often coincides with a move to new accommodation. The level of aggression shown at regrouping may be exacerbated by limitations in floor space and by uniformity in pig size (and thus in competitive ability) (Andersen et al., 2000a,b; Peden et al., 2018), however this latter effect is not always apparent (O'Connell et al., 2005). Removal of some pigs from the group (e.g. in split-marketing slaughter practices) may also affect social dynamics and lead to increased aggression (Rydhmer et al., 2006; Carpenter et al., 2018). In addition, pigs may be regrouped as they are transported for slaughter and held at lairage, and this can also stimulate aggression. Fighting associated with establishment of social relationships in pigs is normally most severe in the first 24 h after group formation (Turner et al., 2017). However chronic aggression may also be observed, particularly when access to resources is restricted. For example, persistent increases in aggressive behaviour are shown when access to feed (Turner et al., 2013) or floor space (Camp Montoro et al., 2021) is reduced. Increased competition for feed also leads to greater differences in feed intake between small and large pigs in the group (Georgsson and Svendsen, 2002), and this can contribute to more variable growth rates and body condition. Levels of aggressive and mounting behaviour in finishing pigs are also increased when entire male rather than castrated pigs are used (Rydhmer et al., 2006; Bünger et al., 2015), and this can contribute to group stress. Disruption to social groups and associated aggressive behaviour have been linked with increased injury, and with reduced feed intake and growth performance in finishing pigs (Camp Montoro et al., 2021). Aggression-related injuries at slaughter are also associated with increased cortisol levels (Warriss et al., 1998). Immunosuppressive effects of stress hormones in pigs (Reiske et al., 2019) suggest that health status is also likely to be affected by group stress.

Table 16: ABMs for assessing 'group stress', definition, interpretation, qualitative assessment of their sensitivity and specificity and indication to which pig categories they apply. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Termination of a nursing bout (Lactating sows)	**Definition:** According to the behavioural classification of Singh et al. (2017), a nursing bout is where at least 75% of the litter gather at udder and massaging and/or nursing continued for at least 1.5 min. The sow terminates a nursing bout by changing her lying posture to hide her teats (e.g. changing to sternal recumbency), or by getting up and moving away from the piglets. **Interpretation:** The frequency of suckling bouts per day increases in the first days after birth, peaks at 31 bouts/day on day 8 and slowly decreases up to weaning (Puppe and Tuchscherer, 2000). A higher incidence of nursing bouts terminated by the sow indicates an increased level of discomfort from suckling piglets. **Sensitivity/specificity:** The ABM is not sensitive: group stress in lactating sows may exist without termination of a nursing bout. The ABM is specific: if there is no group stress, lactating sows will not frequently terminate a nursing bout when piglets are young.
Agonistic behaviour (all pigs)	**Definition:** Aggressive behaviour between two pigs involving physical contact (biting, knocking or lateral fighting with the opponents standing in antiparallel position, both performing bites or knocks) (Rhim, 2012). **Interpretation:** An increased incidence of agonistic behaviour in a group of pigs indicates social unrest, and reduced welfare. **Sensitivity/specificity:** The ABM is sensitive: Group stress will almost always be associated with increased agonistic behaviour. The ABM is specific: If there is no group stress, it is unlikely that there will be increased levels of agonistic behaviour
Facial injuries (mainly in piglets)	**Definition:** Skin lesions on the face of suckling piglets, associated with competition to access for teats. The fighting is part of the natural establishment of teat order and occurs soon after pigs are born (Fraser, 1990). **Interpretation:** In the first week of life, fighting may be more apparent if piglets are part of a large litter, if there is interruption in the supply of milk as a result of mastitis or agalactia (Fraser, 1990) or if there is repeated cross-fostering (Robert and Martineau, 2001). **Sensitivity/specificity:** The ABM is sensitive: Group stress among suckling piglets will almost always be associated with increased facial injuries. The ABM is specific: If there is no group stress, it is unlikely that facial injuries will be present.
Belly nosing (piglets)	**Definition:** Belly nosing involves the repetitive rooting motion on the belly of another piglet, similar to massaging the sow's udder (Fraser, 1978), and can result in the development of lesions on the recipient piglet (Fraser et al., 1998).

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Interpretation: An increased prevalence of belly nosing is associated with early weaning and may indicate frustrated suckling motivation. Belly nosing is also associated with shorter lying bouts in artificial rearing systems (Rzezniczek et al., 2015). **Sensitivity/specificity:** The ABM is not sensitive: Group stress among weaned piglets may also be present in the absence of belly nosing. The ABM is specific: If there is no group stress, it is unlikely that belly nosing will be present.
Skin lesions (all pigs)	**Definition:** Skin lesions related to aggression can be seen as broken skin causing some degree of blood loss. These are typically located at the front of the body for reciprocal aggression or at the rear for bullying (Turner et al., 2006). **Interpretation:** Increased group stress leads to more aggression-related skin lesions). **Sensitivity/specificity:** The ABM is sensitive: group stress will almost always be associated with increased level of skin lesions. The ABM is specific: if group stress is truly absent, it is unlikely that the ABM will reflect increased levels of skin lesions typical of aggression.
Body condition (all pigs)	**Definition:** The body condition reflects body reserves or fat accumulation of an animal. Body condition scoring is used to critically examine the nutritional status of a pig herd (Welfare Quality®, 2009). **Interpretation:** Variation in body condition between pen mates increases if feed is not equally distributed, and/or when energy expenditures is not even across the group (e.g. poor thermal circumstances for some but not all pigs). In principle, this ABM would be applicable to all pigs; methods for assessing body condition score are available for sows and rearing pigs (Charrette, 1996, Welfare Quality®, 2009). **Sensitivity/specificity:** The ABM is sensitive: group stress will almost always be associated with variation in body condition. The ABM is not specific: if there is no group stress, it is still possible that body condition scores are variable for other reasons e.g. poor health.
Abnormal gait (all pigs)	**Definition:** According to Pairis et al. (2011), gait scoring systems are designed to categorise the degree of lameness shown during locomotion. **Interpretation:** Lameness scores are based on gait abnormalities during movement and deviations from normal posture while standing (Sprecher et al. 1997). Poor scores indicate lameness. Lameness is indirectly related to aggression and may occur if claws slip or get caught during aggressive interactions. **Sensitivity/specificity:** The ABM is not sensitive: group stress is not always associated with abnormal gait scores. The ABM is not specific: if there is no group stress, the gait score can still be abnormal if e.g. the floor is slippery.
Claw lesions (all pigs)	**Definition:** Claw lesions are injuries to the feet of pigs, and often associated with lameness. The most frequently observed claw lesions in sows, varying in severity, are heel horn erosions, defects in the heel horn/sole junction, white line defects, horizontal and vertical wall cracks, claw and dewclaw overgrowth or amputation, ulcers and skin lesions (van Riet et al., 2019).

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	There are several claw lesions scoring systems described in scientific publications for research purposes (e.g. Calderón Díaz et al., 2013, 2014) and also in some farm advisory (grey) literature, e.g. the Dutch Klauwencheck (Lamers, 2006). Claw lesions are indirectly related to aggression and may occur if claws slip or get caught during aggressive interactions. **Interpretation:** Claw lesions and lameness are painful and can be caused by injury due to poor housing conditions, non-infectious and infectious conditions and degenerative diseases (e.g. Taylor, 1999). **Sensitivity/specificity:** The ABM is not sensitive: group stress is not always associated with claw lesions. The ABM is not specific: if there is no group stress, there may still be serious claw lesions due to poor flooring.

3.4.4. Isolation stress and related ABMs

Description: The animal experiences stress and/or negative affective states such as frustration and/or fear resulting from the absence of social contact with conspecifics.

Classified as highly relevant: 'Isolation stress' was identified as highly relevant in boars housed in indoor individual pens. The specific relevance is described in the following text.

Dog-sitting posture associated with apathy is the ABM that can be used for assessing this welfare consequence, its definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed in Table 17.

Relevance for boars: Young boars live within the social group of their mothers, they remain also in (smaller) social groups or pairs, when they have left the group (Jensen, 2002). Even when adult, when boars are reported to live solitary for most part of the year, they start to become very active when the mating season starts (October) in the search of groups of sows (Graves, 1984; Briedermann and Stöcker, 2009). During the whole mating season (until early springtime) they live as part of the group. In contrast, boars on farms or breeding studs are almost always kept in individual pens, commonly in the service area with only audio-visual contact to other boars or sows, (Council Directive 2008/120/EC). Only in few farms, mostly outdoor paddock systems, but also in the case of catch boars in large group sow systems, are boars constantly grouped with sows. In this case, also boar teams of two to three animals may be kept together (AHDB website[21]). Breeding boars on most farms are moved to the alleys in front of sows only for oestrus stimulation, however, this period of 'social contact' is relatively short. Social isolation during pubertal development was reported to decrease mounting behaviour, when adult (Zimmerman et al., 1981). However, there are no studies investigating the effect of separation and isolation of conspecifics in boars, so that it can only be concluded from (wild) boar behaviour in semi-natural conditions (as described above), that boars are likely to experience negative affective states, especially in young boars and during the mating season. Therefore, no scientific evidence is available on ABMs for boars. Consequently, suggestions for ABMs can only be derived from pig behaviour in general. An example of this is apathetic dog-sitting.

Table 17: ABM for assessing 'isolation stress' in boars: definition, interpretation and qualitative assessment of its sensitivity and specificity. This ABM is generally considered to be linked to this welfare consequence, but in the opinion of the EFSA experts, it is not considered to be sensitive nor specific; thus, it has been marked in grey

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Ref.)
Apathetic dog-sitting	**Definition:** the pig sits in a hunched posture and is unresponsive to external stimuli (Wemelsfelder et al., 2007). **Interpretation:** pigs kept in isolation may show increasing periods of apathetic behaviour.

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Ref.)
	Sensitivity/specificity: The ABM is not sensitive: isolation stress does not always induce dog sitting apathy in boars. The ABM is not specific: if isolation stress is absent, pigs may still show dog-sitting for other reasons, e.g. lameness.

3.4.5. Separation stress and related ABMs

Description: The animal experiences stress and/or negative affective states such as fear and/or frustration resulting from separation from conspecifics.

Classified as highly relevant: 'Separation stress' was classified as highly relevant in piglets in artificial rearing systems. The specific relevance is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed in Table 18.

Relevance for piglets: For a piglet separated from the sow in a natural environment in the first weeks of life, the situation is life-threatening, as it depends on milk supply as well as protection from predators provided by the sow. Separation from its sow and litter is consequently a very stressful situation for a piglet (Kanitz et al., 2009). To measure separation stress, Weary et al. (1999) recorded the vocalisations of piglets during short-term (10 min) isolation from the sow and litter mates at 1, 2, 3 and 4 weeks of age. They reported that piglets of all ages vocalised intensely during isolation, but call rate was lower with older piglets, indicating that separation-induced distress is greater at younger ages. Roelofs et al. (2019) isolated piglets at 3 weeks of age from the sow and the litter mates and transferred them to a novel environment for a human approach test. In the first minute after separation, during habituation to the test arena, they recorded on average 27 and 31 grunts as well as 7 and 6 screams in piglets with normal and low birth weight, respectively. Weary and Fraser (1995) also investigated the influence of weight on vocalisation in piglets kept singly for 13 min in a visually and acoustically isolated enclosure at 10 days of age. They concluded that vocalisation intensity provides reliable information about the piglet's needs, as piglets with the lightest weight and slowest weight gain called more and used more high-frequency and longer calls compared to piglets with the heaviest weight and most rapid weight gain.

When piglets are suddenly removed from the sow, they may show intense activity and characteristic patterns of vocalisation in the minutes and hours after separation and then disappear gradually over one or more days (Weary and Fraser, 1997). As piglets increase in age, their (vocalisation) response to isolation from the sow decreases in intensity (Weary and Fraser, 1997; Weary et al., 1999; Iacobucci et al., 2015). Piglets weaned at 2 weeks of age produced high-frequency calls $>$ 500 Hz. almost twice as often as those weaned at 4 weeks of age (Weary et al., 1999). In addition to distress vocalisations, piglet separated from their sow and litter will often show increased activity and vigorous attempts to regain proximity. These include increased locomotion and attempts to escape by running and jumping up against the walls of their enclosure (Kanitz et al., 2009). However, when separated and placed in a strange enclosure some piglets with a more passive behavioural profile may instead respond by 'freezing' (becoming immobile and silent) (Rooney et al., 2021).

Table 18: ABMs for assessing 'separation stress' in piglets: definition, interpretation and qualitative assessment of their sensitivity and specificity. The ABM which is generally considered to be linked to this welfare consequence, but in the opinion of the EFSA experts is not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Increased activity	**Definition:** increased locomotion such as by running and escape behaviour, often accompanied by vocalisation, urination and defecation (Puppe et al., 2003; Kanitz et al., 2009). **Interpretation:** Piglets show increased activity when separated from the group or the sow in an attempt to escape the new situation and return to the social group.

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is sensitive: separation stress is highly associated with increased activity, although a few piglets respond to the situation by freezing (Rooney et al., 2021). The ABM is not specific: in the absence of separation stress some piglets may still show increased activity due to other environmental stimuli.
Vocalisations	**Definition:** Vocalisations performed by piglets when separated from the sow, typically characterised by a duration of 0.34 s and a frequency in the range of 500 to 3,500 Hz (Xin et al., 1989). **Interpretation:** Piglets emit distress vocalisation because separation from the mother is life threatening, especially for young animals. Therefore, the intensity of such vocalisations decreases with increasing age of the piglets (Weary and Fraser, 1997; Weary et al., 1999; Iacobucci et al., 2015). **Sensitivity/specificity:** The ABM is not sensitive: separation stress may not always be associated with vocalisations. Some pigs cope with the situation by being very quiet. The ABM is not specific: vocalisations performed when a piglet is separated can be similar to vocalisations shown in other situations, such as reunion, huddling and surprise (Tallet et al., 2013).

3.4.6. Inability to perform exploratory or foraging behaviour and related ABMs

Description: The animal experiences stress and/or negative affective states such as frustration and/or boredom resulting from the thwarting of the motivation to investigate the environment or to seek for food (i.e. extrinsically and intrinsically motivated exploration).

Classified as highly relevant: The pig categories and the husbandry systems for which 'inability to perform exploratory or foraging behaviour' was classified as highly relevant are reported in Table 19; the relevance for these pig categories is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 20.

Table 19: Pig categories and husbandry systems and for which 'inability to perform exploratory or foraging behaviour' was classified by experts as highly relevant welfare consequence

Pig categories	Husbandry systems
Gilts and dry sows	Individual housing in stalls
	Indoor group housing
Farrowing and lactating sows	Individual farrowing crates
Piglets	Individual farrowing crates
	Artificial rearing systems
Weaners	Indoor group housing
	Indoor systems with access to an outdoor area
Boars	Indoor individual housing in pens

Relevance for dry gilts and sows: To prevent obesity, joint problems and reduced longevity, the feed of sows and gilts is typically restricted to around 60–70% of the quantity they are capable of eating *ad libitum* (Dourmad et al., 1994; Jørgensen and Sørensen, 1998). Due to feed restriction, sows suffer from prolonged hunger during gestation and therefore an increased motivation to move around for exploring and foraging for food.

The feeding motivation model (Lawrence and Terlouw, 1993) includes appetitive and consummatory phases. De Leeuw (2004) describes these motivations as two distinct aspects, with the first referring to 'behavioural satiety', and the second to 'nutritional satiety'. The appetitive feeding behaviour consists of exploring the environment, foraging, rooting and sniffing. This exploratory behaviour is linked with feeding but probably only indirectly as it is shown, to some extent, also by sows that are nutritionally satiated (Zonderland et al., 2004). Therefore, the final aim of exploratory behaviour is to gain information from the surrounding environment, in particular to 'encounter, sample and learn about new food sources in their environment, and then to continuously gather up to date information about known food sources' (Day et al., 1998; Studnitz et al., 2007).

Housing the sows in stalls restrict their movement and consequently the exploratory and foraging behaviour of the sows. As a result stall-housed sows perform redirected oral behaviour (e.g. nosing, licking and biting) towards the floor, chain and through. They may engage in manipulation of the drinker, including in some cases, polydipsia (excessive water consumption) (Terlouw et al., 1991) and 'sham' chewing with an empty mouth (Rushen, 1985). In older sows, these behaviours may become stereotypic: since they are performed in a routinised and repetitive way (Lawrence and Terlouw, 1993).

The provision of manipulable materials such as straw or other loose materials might give stalled sows the opportunity to perform appetitive feeding behaviours such as sniffing, rooting and foraging, thus stimulating 'behavioural satiety'. In the absence of these materials, this motivation may lead to reduced exploratory behaviour directed at bars and other pen fixtures (Spoolder et al., 1995). However, other studies concluded that oral behaviours such as sham chewing are not reduced by the presence of straw alone, and that the combined provision of straw with a high-fibre diet is more effective (Stewart et al., 2008; Stewart et al., 2011).

Relevance for farrowing and lactating sows: Farrowing crates are barren, as the floor is usually partly or fully slatted and no bedding material is provided to the sow. Hence, the sow has little possibilities to show investigative and manipulatory behaviour. Consequently, she may direct such behaviour to the bars of the crate, as observed by Damm et al. (2003) in the nest-building phase, specifically during the last hours preceding farrowing. In line with this, Arey and Sancha (1996) observed more pen-directed behaviour and less substrate-directed behaviour in sows in farrowing crates in the first 4 weeks postpartum compared to sows in an enriched environment, the family pen system.

Relevance for piglets: In barren farrowing housing systems, with little or no bedding material provided, piglets can hardly perform exploratory and manipulative behaviour. To investigate the effect of environmental enrichment on piglet behaviour, Oostindjer et al. (2011) compared farrowing systems, with sows either confined in a crate or loose housed, that contained only a small amount of sawdust or were enriched with wood shavings, peat, branches and straw. They found that enriched housed piglets showed more chewing and explored the floor more, while barren housed piglets explored fixtures in the pen more. In addition, barren housed piglets showed more belly nosing and manipulatory behaviour, defined as nibbling, sucking or chewing part of the body of a pen mate. Similarly, but with all sows housed in farrowing crates, Vanheukelom et al. (2011) reported that piglets with access to peat performed foraging behaviour more often than piglets without peat, and Telkänranta et al. (2014a) observed that piglets offered sisal ropes, a plastic ball, newspaper and wood shavings as enrichment materials showed a higher frequency of object-directed oral-nasal manipulation than piglets in a control group provided only with a plastic ball and wood shavings.

With piglets kept in the Rescue Deck, an artificial piglet rearing system with fully slatted flooring, Schmitt et al. (2019) found that these explored their environment less frequently than piglets reared by the sow in a farrowing crate with plastic slatted flooring and offered small amounts of shredded paper.

Relevance for weaners: Under natural or semi-natural conditions, piglets show increasing exploratory behaviour over the first 8 weeks of life, rooting, biting objects, chewing, sniffing at substrate and, from week 4, grazing (Petersen, 1994). In farm conditions, even when feed is freely available, weaned pigs show a high level of exploratory motivation, with greater interest in particulate substrates than in inanimate objects (Docking et al., 2008) and more engagement with novel and destructible objects (Trickett et al., 2009). In a barren environment, exploratory and foraging behaviours normally directed towards the physical environment can be redirected to pen mates, with undesirable consequences including aggression, belly nosing and tail and ear biting (Beattie et al., 1996; Kelly et al., 2000a,b; Zonderland et al., 2008). Ear necrosis is a potential outcome of ear biting. It is a progressive disease, starting at the site of a local wound. Colonisation of these skin lesions first by Staphylococcus, followed by invasion of Streptococci into the dermis, leads to the development and continuation of the necrosis (Richardson et al., 1984).

Inability to perform exploratory or foraging behaviour is therefore an important welfare consequence in indoor and semi-outdoor housing, when only minimal enrichment is typically provided, but not in outdoor systems where weaners can show the full range of natural exploratory and foraging behaviours.

Relevance for rearing pigs: Exploration is described as a behavioural need in pigs (see Studnitz et al., 2007), and, as with weaners, rearing pigs redirect this behaviour to pen fixtures and penmates when inadequate exploratory outlets are provided. The redirection of exploratory behaviour can manifest as nosing, manipulation and chewing of penmates. This type of behaviour is likely to disturb resting pigs, and has been associated with increases in aggressive behaviour, and ear and tail lesions in fattening pigs (Telkänranta et al., 2014b; Cornale et al., 2015). Tail lesions in pigs at slaughter have, in turn, been linked with evidence of chronic stress and reduced growth performance (Carroll et al., 2018a,b). The provision of bedding substrates such as straw leads to reduced redirected exploration in finishing pigs (Scott et al., 2007a). These substrates are not always used on commercial farms, however, due to issues such as incompatibility with flooring systems, lack of availability and cost. In this case, more localised 'point source' environmental enrichment may be provided. Evidence suggests that pigs do not engage with this type of enrichment as much as with straw bedding, but that they value point source enrichment more if it is chewable, deformable and destructible (Van de Weerd and Day, 2009). Stereotypic behaviours can also be increased in the absence of litter, as was observed in rearing pigs as 'chewing with nothing in its mouth, opening its mouth to hold or bite bars of the fence, or walking back and forth in a fixed route' (Wei et al., 2019).

Relevance for boars: During a risk assessment study mainly based on expert opinion (EFSA, 2007b), several main problems for boars were identified related to exploratory or foraging behaviour: frustration/lack of positive emotions due to lack of fibrous diet and insufficient access to foraging or exploratory material. In an EFSA report, a survey in seven European countries was presented indicating that boars are mainly provided with chains, wood or small amounts of straw as environmental enrichment. In the study of Stolba and Wood-Gush (1989), the time budget of boars in a semi-natural environment was similar to that of sows, indicating that their motivation to show exploration and foraging behaviour is high and should be satisfied in husbandry systems to a similar extent to that of sows.

Table 20: ABMs for assessing 'inability to perform exploratory or foraging behaviour', definition, interpretation, qualitative assessment of their sensitivity and specificity and indication to which pig categories they apply. ABMs which are generally considered to be linked to this welfare consequence, but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Exploratory behaviours directed at enrichment material (all pigs)	**Definition:** A behaviour performed to investigate the surroundings by rooting, sniffing, biting and chewing various food items as well as indigestible items. Rooting behaviour appears to be a high priority behaviour in pigs. **Interpretation:** Following a period of deprivation, pigs will start to root immediately when allowed (Studnitz et al., 2007), thus indicating that they are motivated to show exploratory and foraging behaviour. **Sensitivity/specificity:** The ABM is sensitive: inability to perform exploratory or foraging behaviour is a welfare consequence that is indicated by the absence of these behaviours. The ABM is specific: inability to perform exploratory or foraging behaviour is not present if pigs perform exploratory behaviours.
Exploratory behaviour directed to pen-fittings (all pigs)	**Definition:** The pig addresses oral behaviour to pen fittings. **Interpretation:** In barren environments, such as crates for sows and fully slatted floor systems for rearing pigs, the animals show redirected oral behaviour such as biting, nosing and licking pen fittings, the floor or the trough (Fraser, 1975; Petersen et al., 1995), **Sensitivity/specificity:** The ABM is sensitive: inability to perform exploratory or foraging behaviour results in exploration and manipulation of far less appropriate pen fittings.

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	The ABM is not specific: the ability to perform exploratory or foraging behaviour may not stop pigs from also investigating the pen fittings.
Re-directed exploratory behaviour, towards pen mates (all pigs)	**Definition**: The pig addresses nosing, chewing or biting behaviour to other pigs (different parts of the body, e.g. flank, tail, ear) in the group. **Interpretation**: Due to the lack of interesting stimuli to investigate and manipulate, pigs in barren environments re-direct exploratory and manipulatory behaviour towards penmates to satisfy their behavioural needs (EFSA, 2007c). **Sensitivity/specificity:** The ABM is sensitive: inability to perform exploratory or foraging behaviour results in increased levels of pen mate directed behaviours. The ABM is not specific: the ability to perform exploratory or foraging behaviour on enrichment materials may not stop pigs from also investigating pen mates, e.g. belly nosing in early-weaned pigs.
Stereotypic behaviour (gilts, sows, rearing pigs, boars)	**Definition:** Stereotypic behaviour, or stereotypy, is repetitive and apparently functionless and often develops in suboptimal environments that could cause poor welfare (Mason, 1991). **Interpretation:** Increased levels of stereotypies are associated with frustration due to e.g. hunger or lack of stimulating environment (Terlouw et al., 1991; Lawrence and Terlouw, 1993; Wei et al., 2019). This is seen at group level but not necessarily at individual level, due to individual differences in coping styles. **Sensitivity/specificity:** The ABM is sensitive: inability to perform exploratory or foraging behaviour usually results in stereotypic behaviour in a proportion of animals. The ABM is not specific: the ability to perform exploratory or foraging behaviour may not stop the development and performance of stereotypic behaviour. The level of feed is also highly relevant.
Tail lesions (piglets, weaners, rearing pigs)	**Definition:** Skin lesions to the tail, ranging from mild bite marks, with or without puncture of the skin, up to a complete tail loss (Gentz et al., 2019) **Interpretation:** Tail lesions are associated with several factors indicating a lack of environmental stimuli promoting exploratory or foraging behaviour (EFSA, 2007c). **Sensitivity/specificity:** The ABM is not sensitive: inability to perform exploratory or foraging behaviour is strongly related to tail biting risk in rearing pigs, but damaging tail biting does not always occur in barren pen situations (so where enrichment is absent). The ABM is not specific: animals with the ability to perform exploratory or foraging behaviour may still show tail lesions resulting from other causes of tail biting.
Ear lesions (mainly weaners, in some cases piglets)	**Definition:** Superficial lesions to the skin of the ears as well as ear necrosis, indicated by large erosive lesions on the ears, and potentially leading to partial or in extreme cases, total loss of the ear (Weissenbacher-Lang et al. 2012). **Interpretation:** Ear lesions can be a result of increased chewing of the ear by other pigs associated with boredom and insufficient exploratory behaviour. **Sensitivity/specificity:** The ABM is not sensitive: inability to perform exploratory or foraging behaviour may not always result in ear biting. The ABM is not specific: the ability to perform exploratory or foraging behaviour may not prevent ear lesions, which can arise from e.g. other sources of aggression.
Skin lesions on other body parts (all pigs)	**Definition:** Skin lesions on other parts of the body, else than tail and ears, e.g. on flanks and shoulders, due to re-directed exploratory behaviour (Mirt, 1999). **Interpretation:** skin lesions are often caused by pigs redirecting exploratory or foraging behaviour to the body of other pigs

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is not sensitive: inability to perform exploratory or foraging behaviour may not always result in skin lesions. The ABM is not specific: the ability to perform exploratory or foraging behaviour may not always prevent skin lesions, which can arise from e.g. other sources of aggression.

3.4.7. Inability to express maternal behaviour and related ABMs

Description: The animal experiences stress and/or negative affective states such as frustration resulting from the thwarting of the motivation to care for offspring, including nest-building during the prepartum phase.

Classified as highly relevant: 'Inability to express maternal behaviour' was classified as highly relevant in sows housed in farrowing crates. The specific relevance is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed in Table 21.

General considerations: Nest-building behaviour is part of maternal behaviour but it is performed by pregnant sows and gilts in the limited time before farrowing in farrowing facilities. Nevertheless, in the context of this opinion, we consider that the nest-building period relates to the category of farrowing and lactating sows.

In the last few hours before farrowing, sows become very active spending much of their time engaged in nest-building behaviour (Stolba and Wood-Gush, 1989). When loose-housed in a pen, sows will gather nesting material, deposit it at the nest-site, turn around and show pawing and rooting behaviour over several hours (Arey et al., 1991). Damm et al. (2003) found that sows confined in crates made similar movements to those performed when nest-building (rubbing nose against and pawing the floor) even in the absence of nest-building material or room to turn around. However, crated sows performed quantitatively less nest-building behaviour, which was less varied and more fragmented as measured by postural changes. Similarly, Verhovsek et al. (2007) suggested that a higher frequency of posture changes in combination with a higher duration of lying inactive and a lower duration of head on the floor prior to farrowing (i.e. nest-building like activities) reflect restlessness and enforced inactivity of crated sows. Cronin et al. (1998) speculated that if the nest width is narrower than the length of the sow, the ease of the sow turning around will be inhibited, discouraging sow activity in the nest-building period. Indeed, Heckt et al. (1988) reported that gilts made on average 50–180-degree turns in the 48 h preceding farrowing in turn around pens. Given that sows are highly motivated to get access to nest-building material on the day before farrowing and will perform nest-building even when a preformed nest is provided (i.e. Arey et al., 1991; Jensen, 1993; Cronin et al., 1996), it is likely that sows in confined systems experience frustration, if they are unable to move and turn around to collect nest-building material. In support of this, Damm et al. (2003) reported higher heart rates during the last hour preceding farrowing and more oral/nasal stereotypies in crated sows compared to sows loose housed in pens. Others reported elevated levels of plasma cortisol concentrations during the pre-parturient period in sows kept in crates compared to loose-housed sows (Lawrence et al., 1994; Jarvis et al., 2002). Contrary to this, however, Hansen et al. (2017) measured lower salivary cortisol concentrations during the nest-building period in confined compared to loose housed sows. Nevertheless, the findings generally indicate that restrictions in nest-building behaviour result in restlessness, frequent posture changing, stereotypies and increased stress. Several authors showed that such disruptions prolong the duration of farrowing/the interval between the birth of each piglet (e.g. Thodberg et al., 2002; Verhovsek et al., 2007). The precise mechanism for this is unclear. In spite of some reports of more stress reflected in higher cortisol levels in sows in crates than in pens (Lawrence et al., 1994; Jarvis et al., 1997, 2002), which might antagonise the effect of oxytocin on uterine contraction, Oliverio et al. (2008) found no difference in cortisol levels although sows in crates took significantly longer to farrow. These authors also reported a reduction in circulating oxytocin concentrations during parturition in the confined sows, which is unsurprising given that the duration of the birth process correlates negatively with peripheral oxytocin levels (Algers and Uvnäs-Moberg, 2007). In the study by Oliviero et al. (2008), prolonged farrowing was associated with higher cortisol levels in early lactation. Although Nowland et al. (2019) found no differences in farrowing duration between confined and non-confined sows, animals that had farrowing durations that exceeded five hours had elevated plasma cortisol concentrations of 100 nmol/l. In addition to the possible effects of restricted nest-building behaviour, many other factors affect the duration of farrowing. These include breed, age of the sow, length of gestation, number of piglets born, body condition of the sow and state of constipation (e.g. Oliviero et al., 2009, 2010).

Relevance for farrowing and lactating sows: In the first days after farrowing, the sow is active in initiating social contacts with her piglets. Petersen et al. (1990) observed the behaviour of sows and piglets during farrowing under free-range conditions and reported that the sows got up at least once during the farrowing and sniffed their piglets. In a study with free-farrowing pens, sow-to-piglet nosing occurred on average 3.6 times per 30 min observation time during the first 3 weeks after farrowing (Portele et al., 2019). When the sow is confined in a crate, she cannot show such behaviour unless piglets approach the front part of the crate. Comparing the behaviour of sows loose-housed in pens and confined in crates in the first 2 days of lactation, Cronin et al. (1996) found that the latter showed less investigation of, and vocalisation to, their piglets. Similarly, Chidgey et al. (2016) and Singh et al. (2017) reported that sows in crates investigated and touched their piglets less than sows in pens over the first 6 and 18 days of lactation, respectively.

With regard to nursing behaviour, Pedersen et al., (2011a) observed that sows in farrowing pens terminated fewer nursings than sows housed in farrowing crates, and thereby allowed the piglets to post-massage longer. Accordingly, Loftus et al. (2020) reported that sows in conventional farrowing crates spent less time nursing their piglets compared to sows in freedom farrowing crates in which they were confined only for the 5 days postpartum. In a similar study with sows confined for the first 3 days postpartum, Singh et al. (2017) compared the nursing behaviour of sows subsequently kept in crates or pens on days 4, 11 and 18 postpartum and found no effect of housing on the frequency or duration of nursing bouts, or on the inter-nursing interval. Moreover, nursing behaviour (i.e. number of nutritive nursings, proportion of non-nutritive nursings, duration of post-massages and proportion of termination of post-massages) did not differ between sows housed in temporary crates (in the first 3 days of lactation) and those housed in permanent crates on days 4 and 25 postpartum in the study of Illmann et al. (2019). In line with this, neither the total time spent nursing not the proportion of successful nursings differed on day 10 postpartum between sows kept in a farrowing crate or a get-away pen (Thodberg et al., 2002). From day 1 to day 3 of lactation, however, Hales et al. (2016) observed more nursing bouts and a shorter interval between nursings in loose-housed compared to confined sows.

As reported by Špinka et al. (2011), some pig nursing episodes end without milk transfer, the so-called non-nutritive nursings (NNNs). During NNNs, the sow does not increase her grunting rate, oxytocin is not released (Ellendorff et al., 1982), piglets do not display rapid mouth movements and there is no milk intake (Fraser, 1977; Špinka et al., 1997). The proportion of NNNs ranges between 5% and 30% for domestic pigs in intensive housing systems (Fraser, 1977; Whatson and Bertram, 1980; Illmann and Madlafousek, 1995; Illmann et al., 1999; Puppe and Tuchscherer, 2000; Valros et al., 2002) and under semi-natural conditions (Newberry and Wood-Gush, 1985; Jensen, 1988; Castrén et al., 1989) and in the wild boar (Horrell, 1997). It has been demonstrated that both the sow and her litter enter an NNN with full motivation to accomplish a normal nursing. The high variability and difficulty of measurement means that the frequency of NNN is not a useful ABM.

Piglet mortality is mainly caused by the sow crushing the piglets. However, although this may be the ultimate cause of death for piglets, the underlying problems often include complex interactions between the sow, the piglets and the environment. For example, cold stress and prolonged hunger, piglet vitality and birth weight, as well sow maternal behaviour, play an important role on piglets survival. To reduce piglet mortality, management strategies aimed at improving piglet vitality and reducing sow stress are thus considered important (Rutherford et al., 2013; Baxter et al., 2013).

As reported by Baxter and Edwards (2018), when considering the welfare implications from mortality for the piglet, least concern relates to those piglets that never develop full and rhythmic breathing and hence never gain full consciousness (i.e. those that die during labour or immediately after). A medium level of concern attaches to piglets that develop full breathing but descend quickly into hypothermia (and hence reduced awareness) over the immediate hours following birth, whilst high concern focusses around piglets that develop full breathing, are not hypothermic, but suffer slow deaths from hunger, injury or disease as they will have developed full consciousness and hence potential to suffer.

Table 21: ABMs for assessing 'inability to express maternal behaviour' in sows: definition, interpretation and qualitative assessment of their sensitivity and specificity. The ABM which is generally considered to be linked to this welfare consequence but in the opinion of the EFSA experts is not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (sow categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Nest-building behaviours (sows and gilts immediately before farrowing)	**Definition**: Nest-building is a highly active, intrinsically motivated pattern of behaviours expressed by sows from 24 h prior to parturition (Jensen, 1989), and aims to prepare a dedicated place for farrowing. It is characterised by rooting with the snout (movements of the snout on the floor or arranging of straw), digging/pawing, turning and carrying substrates (Andersen et al., 2014). Elements of nest-building behaviour are performed even in the absence of relevant stimuli. **Interpretation**: The ability to perform nest-building behaviour facilitates parturition (Cronin et al., 1993; Yun and Valros, 2015) such that frustration of the behaviour disrupts parturition resulting in prolonged farrowing times. There is a correlation between the duration of prepartum nest-building behaviour and carefulness of sows towards their offspring during early lactation (Yun et al., 2014). **Sensitivity/specificity:** The ABM is not sensitive: if the sow is unable to express maternal behaviour, this might be due to deficiency in behaviours other than nest-building, e.g. impaired nursing. The ABM is specific: If a sow is able to express the complete set of maternal behaviours this includes nest-building behaviours.
Farrowing duration (farrowing sows)	**Definition**: This is the time required for the sow to deliver the litter of piglets. It is expressed in total duration (time in minutes from birth of first to birth of last piglet) or the inter-piglet birth interval (mean time in minutes between birth of each piglet, including stillborn). Interpretation: Farrowing duration increases due to the stress resulting from the frustration of sows endogenously motivated need to build a nest for their piglets. **Sensitivity/specificity:** The ABM is sensitive: if the sow is unable to express her maternal behaviour (nest-building) the duration of farrowing increases. The ABM is not specific: if the sow is able to express maternal behaviour, there might be other reasons why the farrowing duration increases (e.g. large litter size, heat stress).
Social contact with piglets (lactating sows)	**Definition:** Sow turning towards and sniffing/touching her piglets. The behaviour may be accompanied by low frequency rhythmic grunts or suckling grunts (Cronin et al., 1996). **Interpretation:** The sow's vocalisations towards her litter are associated with maintenance of the social coherence of the litter (Lewis and Hurnik, 1986). **Sensitivity/specificity:** The ABM is sensitive: inability to express maternal behaviour is associated with decreased social contact with piglets. The ABM is specific: ability to express maternal behaviour is associated with increased social contact with piglets.

ABM (sow categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Piglet mortality (lactating sows)	**Definition:** The proportion of piglets which have died in a given period. Live-born preweaning mortality is typically of 11–13%, with a further 7–8% of piglets being. stillborn (reviewed by Kirkden, 2013). **Interpretation:** Piglet mortality can be the result of poor maternal quality. **Sensitivity/specificity:** The ABM is sensitive: inability to express maternal behaviour in lactating sows is associated with an increasing risk of piglet mortality due to malnutrition. The ABM is not specific: the ability to express maternal behaviour in lactating sows may not prevent piglet mortality due to other factors like environmental temperature or disease.
Non-nutritive nursings (NNNs) (lactating sows)	**Definition:** Nursing bouts which end without milk transfer (Špinka et al., 2011). **Interpretation:** An increased number of NNNs suggests that the sow is unable to perform normal maternal behaviour. **Sensitivity/specificity:** The ABM is not sensitive: inability to express maternal behaviour in lactating sows is not always associated with an increasing frequency of NNNs. The ABM is not specific: If the sow is able to show maternal behaviour, increased NNNs may still occur as a part of the natural weaning process.

3.4.8. Inability to perform sucking behaviour and related ABMs

Description: The animal experiences negative affective states such as frustration resulting from the thwarting of the motivation to suck from an udder.

Classified as highly relevant: 'Inability to perform sucking behaviour' was classified as highly relevant in piglets in artificial rearing systems. The specific relevance is described in the following text.

Belly nosing is the ABM that can be used for assessing this welfare consequence; its definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed are listed in Table 22.

Relevance for piglets: Once colostrum intake is finished, piglets are typically suckled about once an hour. At the start of a suckling bout, they emit so-called deep grunts (Jensen and Algers, 1984), possibly indicating their need for milk and stimulating the sow to initiate nursing (Wechsler and Brodmann, 1996). In an experimental study, reviewed by Da Silva Cordeiro et al. (2013) covered the sow's teats with a rubberised fabric to prevent piglets from sucking and identified a vocalization pattern that was different from the one observed in piglets being squeezed by an experimenter to induce pain or exposed to a lowered temperature to elicit cold distress.

In the first phase of a sucking bout, the piglets massage the sows' udder to stimulate milk let down (Fraser, 1980). Moreover, they perform massaging movements after milk ejection. Algers and Jensen (1985) suggested that the function of this final massage is to regulate the milk production of the sow according to the prevalent litter size.

Early weaned piglets typically develop an abnormal behaviour pattern termed 'belly nosing' (Fraser, 1978). They show rhythmic up-and-down movements with the snout directed to the body of a pen mate indicating that their behavioural need for massaging and sucking behaviour is not satisfied when reared without the sow. Pigs weaned at 12–14 days of age, spent 2.4% of actual time, with 81% of the pigs, belly nosing (Li and Gonyou, 2002). 5% of the pigs spent more than 8% of time belly nosing. The average duration of the nosing segment was 538 s, during which the pig spent 65.8% of the time belly nosing with a mean duration of 64 s per event (Li and Gonyou, 2002). In the study of Bench and Gonyou (2009), belly nosing bouts lasted on average 17.5 s (at 21 days) and 27.3 s (at 35 days).

Generally, belly nosing increases in both frequency and duration as weaning age decreases (Metz and Gonyou, 1990; Bøe, 1993; Worobec et al., 1999; Jarvis et al., 2008). With piglets removed from the sow at the age of 3–6 days and raised in an artificial rearing system, Rzezniczek et al. (2015) and Bench and Gonyou (2009) found that the duration as well as the frequency of belly nosing increased with increasing age of the piglets.

It is suggested that belly nosing is more closely associated with social interaction than with eating or drinking (Li and Gonyou, 2002).

Table 22: ABM for assessing 'inability to perform sucking behaviour' in piglets: definition, interpretation and qualitative assessment of its sensitivity and specificity

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Belly nosing	**Definition:** Belly nosing involves the repetitive rooting motion on the belly of another piglet, similar to massaging the sow's udder (Fraser, 1978), and can result in the development of lesions on the recipient piglet (Fraser et al., 1998). **Interpretation:** An increased prevalence of belly nosing is associated with early weaning and indicates frustrated suckling motivation. The occurrence of this behaviour increases both in frequency and duration as weaning age decreases (Metz and Gonyou, 1990; Bøe, 1993; Jarvis et al., 2008), in parallel to the reduction in the necessity to gain nutrient energy exclusively from milk intake. **Sensitivity/specificity:** The ABM is sensitive: Inability to perform sucking behaviour is strongly associated with belly nosing, although there is variation in the amount of such behaviour shown by individual piglets. The ABM is specific: The ability to express sucking behaviour will reduce belly nosing considerably.

3.4.9. Prolonged hunger and related ABMs

Description: The animal experiences craving or urgent need for food or a specific nutrient, accompanied by a negative affective state, and eventually leading to a weakened condition as metabolic requirements are not met.

Classified as highly relevant: The pig categories and the husbandry systems for which 'prolonged hunger' was classified as highly relevant are listed in Table 23; the relevance for these pig categories is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity to the welfare consequence and an indication to which pig categories they apply are reported in the following Table 24.

Table 23: Pig categories and husbandry systems and for which 'prolonged hunger' was classified by experts as a highly relevant welfare consequence

Pig categories	Husbandry systems
Gilts and dry sows	Individual housing in stalls
	Indoor group housing
	Outdoor paddock systems
Piglets	Individual farrowing crates
	Individual farrowing pens
	Artificial rearing systems
	Outdoor paddock systems
Boars	Indoor individual housing in pens

Relevance for dry sows and gilts: During pregnancy, the energy requirements of sows for maintenance and reproductive performance are much lower than intake under ad libitum feeding conditions (Meunier-Salaün et al., 2001; Read et al., 2020). Hence, they are fed a restricted diet to avoid obesity and metabolic issues leading to poor health (Dourmad et al., 1994, 1996). However, this means that sows experience hunger. D'Eath et al. (2009) emphasise the longer term aspect of hunger because research with poultry indicates that chronic restriction has a much greater influence on feeding motivation than acute food deprivation (Savory et al., 1993; Bokkers et al., 2004). Indeed, the intensity of hunger sows experience is likely to increase as pregnancy progresses (Terlouw et al., 1991; D'Eath et al., 2009). Furthermore, D'Eath et al. (2018) suggest that the on-going trend of selecting sows on the basis of larger litter size and associated practices such as the use of nurse sows could exacerbate hunger in pregnant sows. Recent work by Read et al. (2020) may support an effect of increased litter sizes. They found that a diet designed to maintain good health and performance provided < 50% (44.1%) of sows desired food intake compared to an equivalent figure of 60% in the early 90's (Terlouw et al., 1991). Schmitt et al. (2019) found no detrimental effect of different nurse sow strategies on body condition score at weaning but this does not necessarily indicate that the sows did not experience hunger during their prolonged lactation. The fact that sows are fed to support physiological but not behavioural needs is a key factor in the development of stereotypies (Lawrence and Terlouw, 1993). Stereotypies related to hunger in pregnant sows are represented as oral behaviours including sham chewing and those redirected unnaturally towards non-food items (e.g. bar biting) (Appleby and Lawrence, 1987, Terlouw et al., 1991). Inclusion of fibre in gestating sow diets, particularly fibres that are soluble and fermentable in the hindgut, reduces such oral behaviours and appears to prolong satiety, reduce activity and thereby improve welfare (D'Eath et al., 2018). Dietary fibre and access to foraging materials, such as straw, is requirement of EU legislation for pregnant sows but implementation of this law varies greatly across EU member states.

Relevance for piglets: Weak and underweight piglets are likely to have difficulties to get access to the udder and ingest sufficient amounts of milk. They thus experience hunger and may die due to starvation (Kielland et al., 2018; Marchant et al., 2000). With normal-weight and healthy piglets, this will only occur if the sow has problems to produce milk at farrowing. Olsson et al. (2019) found that piglet mortality due to prolonged hunger was higher in larger litters and that, over the whole preweaning period, the percentage of piglets with this cause of death did not differ between loose-housed and temporarily confined farrowing sows. Similarly, Pedersen et al. (2011b) reported that the risk of piglets dying of starvation did not differ between gilts farrowing in crates or in indoor pens, but the odds of dying of starvation were greater for piglets with a low birth weight. With sows loose-housed in individual pens, Andersen et al. (2011) observed that number of piglets failing to get access to a teat during milk let-down, a measure of sibling competition at the udder, increased with increasing litter size at farrowing and that the percentage of piglets that died of starvation increased with increasing litter size for sows in their first, second and third parties.

Prolonged hunger may also arise in early weaned piglets kept in artificial piglet rearing systems and fed with artificial milk, as these have to become familiar with the functionality and location of the milk cup system. To achieve this, Rzezniczek et al. (2015) trained piglets to drink from the cups by dipping their snout two to four times into the cup during their first 2 days in the Rescue Deck.

Relevance for boars: Breeding boars, like dry sows, are normally fed a restricted diet to avoid obesity, maximise reproductive vigour and minimise unproductive feed cost. Whilst no studies on the welfare consequences for this animal category have been published, it is therefore likely that they also experience prolonged hunger as a result of lack of behavioural and physiological satiety.

Table 24: ABMs for assessing 'prolonged hunger', definition, interpretation, qualitative assessment of their sensitivity and specificity and indication to which pig categories they apply. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Description, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Stereotypic behaviours (gilts, sows, boars)	**Definition:** Stereotypic behaviour, such as bar biting, tongue rolling or sham chewing is repetitive and apparently functionless and often develops in suboptimal environments where strongly motivated behaviours cannot be appropriately expressed (Mason, 1991). **Interpretation:** Increased levels of stereotypies are associated with prolonged hunger when the opportunity to express motivated foraging behaviour is

ABM (pig categories)	Description, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	thwarted by lack of environmental opportunity. (Terlouw et al., 1991; Lawrence and Terlouw, 1993). **Sensitivity/specificity:** The ABM is not sensitive: prolonged hunger is indicated by increased levels of stereotypies, but not in all animals and only when the environment does not provide opportunities for more functional expression of foraging behaviour. The ABM is specific: absence of prolonged hunger will result in much less stereotypic behaviour.
Body Condition (gilts, sows, boars)	**Definition:** The body condition reflects body reserves or fat accumulation of an animal. Body condition scoring is used to critically examine the nutritional status of a pig herd, and simple visual scales show some relationship to measured fat reserves (Maes et al., 2004). **Interpretation:** A low body condition is associated with prolonged lack of food because the animal does not have adequate nutrients to deposit body tissue or may even metabolise tissue reserves in extreme cases. **Sensitivity/specificity:** The ABM is not sensitive: prolonged hunger is indicated by a poor body condition score, although there may still be metabolic hunger for specific nutrients or gut fill when pigs have good body condition. The ABM is not specific: The absence of prolonged hunger is generally indicated by a good body condition, but poor body condition may also reflect health issues when the animal is hypophagic.
Runt pigs	**Definition:** a runt is a pig which displays a stunted growth relative to its conspecifics, combined with visible spine or sunken flank (Welfare Quality®, 2009). **Interpretation:** an increased proportion of runts reflects poor nutrition and is therefore associated with prolonged hunger. **Sensitivity/specificity:** The ABM is not sensitive: prolonged hunger is usually indicated by an increased proportion of runt pigs, although there may still be metabolic hunger for specific nutrients or gut fill when runting is not seen. The ABM is not specific: although absence of prolonged hunger is generally indicated by absence of runt pigs, runting may also reflect health issues when the animal is hypophagic.
Facial injuries (mainly piglets)	**Definition:** Skin lesions on the face of suckling piglets, associated with competition to access for teats (Fraser and Thompson, 1991). **Interpretation:** An increased prevalence of facial lesions is seen when competition for teat access is increased by a large litter size, or if there is interruption in the supply of milk as a result of mastitis or agalactia. **Sensitivity/specificity:** The ABM is not sensitive: prolonged hunger is usually indicated by a higher level of facial injuries in piglets, although this may not be the case if piglets have been subject to tooth reduction. The ABM is not specific: absence of prolonged hunger may still be associated with in facial injuries among litter mates if they have a need to re-establish the teat order as a result of cross-fostering.
Live-born mortality (piglets)	**Definition:** The proportion of animals which have died of starvation, indicated by poor body condition or lack of food in the stomach. **Interpretation:** An increased number of pigs dying from starvation would be an indicator of prolonged hunger.

ABM (pig categories)	Description, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is not sensitive: prolonged hunger is not necessarily indicated by increased mortality, as hunger does not always result in death. The ABM is not specific: absence of prolonged hunger may still be associated with high mortality due to other reasons.

3.4.10. Prolonged thirst and related ABMs

Description: The animal experiences craving or urgent need for water, accompanied by a negative affective state and eventually leading to dehydration as metabolic requirements are not met.

Classified as highly relevant: 'Prolonged thirst' was classified as highly relevant in piglets in the following systems:

- Individual farrowing crates
- Individual farrowing pens
- Outdoor farrowing paddocks

The specific relevance is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed in Table 25.

Relevance for piglets: Milk intake is not generally sufficient to satisfy the need for water in piglets. In a study of Deligeorgis et al. (2006), with sows kept in farrowing crates, the first visit of piglets to the water dispenser occurred on average 16 h after birth. In the first 2 days of life, water consumption per piglet per day varied between 15 and 35 g in different experimental conditions. Over the first 4 days after farrowing, Fraser et al. (1988) measured an average water consumption of 46 g per day per piglet. Moreover, they observed that piglets in litters with low weight gain, possibly indicating low milk intake, were particularly likely to drink water in the first 2 days. Access to water may also be crucial for piglets housed under warm environmental conditions and during episodes of diarrhoea (Prunier et al., 2014). The risk of dehydration is especially high in situations with both insufficient access to water and limited milk intake. Piglets of low birth weight and in large litters, experiencing increased competition for access to teats (Kobek-Kjeldager et al., 2020a), are then prone to suffer from prolonged thirst. With piglets raised in outdoor paddock systems, freezing of the drinkers during the cold days may also result in prolonged thirst (Andersen and Pedersen, 2014). The turgor of the skin can be used as an indicator of serious dehydration in piglets.[24]

The total water intake for a piglet is determined by three variables: the number of visits to the drinker, duration of each visit and intake per unit of time (Nielsen, 1999). Piglets that are thirsty are likely to increase their attempts to access the drinkers.[25]

Table 25: ABMs for assessing 'prolonged thirst' in piglets: definition, interpretation and qualitative assessment of their sensitivity and specificity

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Increased drinking attempts	**Definition:** Repeated unsuccessful or increased attempts to access water/milk.[24] **Interpretation:** Pigs which are suffering from prolonged thirst will increase their attempts to drink, but not succeed. **Sensitivity/specificity:** The ABM is sensitive: prolonged thirst will lead to increased drinking attempts. The ABM is specific: piglets that are not thirsty will have a normal pattern of drinking behaviour.

[24] https://www.val-co.com
[25] https://swine.extension.org

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Skin pinch test	**Definition:** to pinch the skin gently along the eye-lid and see if the skin returns quickly to normal or if it remains in folds for a few seconds, which is a sign of dehydration (Baumgartner, 2009). **Interpretation:** If the fold remains elevated for more than a few seconds, the piglet is seriously dehydrated. A positive outcome means that the animal is dehydrated. **Sensitivity/specificity:** The ABM is sensitive: prolonged thirst causing serious dehydration leads to a delay in the time for the skin to return to normal position. The ABM is not specific: if prolonged thirst is not present, the fold might remain elevated for a few seconds also in case of skin problems.

3.4.11. Heat stress and related ABMs

Description: The animal experiences stress and/or negative affective states such as discomfort and/or distress when exposed to high effective temperature.

Classified as highly relevant: 'Heat stress' was classified as highly relevant in sows housed in farrowing crates. The specific relevance is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed are listed in Table 26.

Relevance for farrowing and lactating sows: Farrowing sows exert high muscular activity while lactating sows have a high metabolic heat production associated with milk production. Quiniou and Noblet (1999) investigated the influence of high ambient temperature on performance of lactating sows. Comparing five ambient temperatures (18, 22, 25, 27 and 29°C) maintained constant over the 21-day lactation period, they found that skin temperature increased with increased ambient temperature (34.6–37.4°C between 18°C and 29°C), whereas udder temperature reached a plateau at 25°C (38.3°C). Moreover, the respiratory rate increased from 26 to 124 breaths/min between 18°C and 29°C, indicating that the evaporative critical temperature, corresponding to the upper limit of the comfort zone was below 22°C. They thus concluded that temperatures above 25°C seem to be upper critical temperature for lactating sows. In a further study, Muns et al. (2016) kept sows in the peripartum period either in a room where temperature was kept at 20°C (Control) or a room where they were exposed to 25°C (Heat) for 4 days from d 112 to 115 of gestation. They found that the time sows spent lying sternally was 11.3% in heat treatment vs. 25.2% in control treatment. The time spent lying laterally was 61.5% in heat treatment vs. 47.3% in control treatment. In addition, sows exposed to heat had higher respiration rates on the day before farrowing and on the day of farrowing and tended to have a higher rectal temperature than control sows around farrowing. A respiratory rate of more than 28 breaths per minute in sows and more than 55 breaths per minute in piglets was suggested to be panting (Welfare Quality®, 2009). Given their results, they concluded that high temperatures around farrowing (25°C) compromise crated sows' welfare. In outdoors systems, wallowing is, together with posture change, the predominant means for heat regulation. In the absence of puddles for wallowing, pigs will lie on the faeces to cool down.

Table 26: ABMs for assessing 'heat stress' in sows: definition, interpretation and qualitative assessment of their sensitivity and specificity. The ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Respiratory rate and panting	**Definition:** A respiratory rate is the number of breaths per minute (Welfare Quality®, 2009). Panting can be defined as breathing rapidly in short gasps and carried out by breathing through the mouth (Welfare Quality®, 2009). While looking at the flanks, the number of breaths per minute is counted.

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Interpretation: The respiratory rate was reported to increase linearly with ambient temperature and contribute to higher evaporative heat losses (Quiniou and Noblet, 1999). A respiratory rate of more than 28 breaths per minute in sows and more than 55 breaths per minute in piglets is considered as panting (Welfare Quality®, 2009). **Sensitivity/specificity:** The ABM is sensitive: heat stress always results in increased respiration and panting. The ABM is not specific: in the absence of heat stress, panting may still occur due to increase of physical exercise or respiratory disease and impaired lung function.
Skin temperature	**Definition:** the temperature of the skin surface as measured by infra-red thermography (Schmitt and O'Driscoll, 2021). **Interpretation:** Pigs feel thermally comfortable at a specific skin temperature, and the skin temperature, as well as the lying behaviour, can be used as an index of the thermal state of the pigs (Andersen et al., 2008). **Sensitivity/specificity:** The ABM is sensitive: if a pig is truly heat stressed, it will have an increased skin temperature. The ABM is not specific: if a pig is not heat stressed, its skin temperature may still be elevated by sympathetic responses or proximity to radiant heat sources (Prunier et al. 2013).
Rectal temperature	**Definition:** A proxy for the body temperature of the pig as measured by a thermometer inserted in the rectum (Yundong, 2012). **Interpretation:** The elevated ambient temperature induces an increase of rectal temperature (Lynch, 1977; Schoenherr et al., 1989; Lorschy et al., 1994; Prunier et al., 1997), which contributes to maximising the gradient between core and ambient temperatures and to improving conductive heat losses (Quiniou and Noblet, 1999). **Sensitivity/specificity:** The ABM is sensitive: if a pig is heat stressed, it will have an increased rectal temperature. The ABM is not specific: A pig without heat stress may still have high rectal temperature in the case of infection and fever, or via sympathetic responses which might also increase rectal temperature.
Ratio of lying in sternal position/lying laterally	**Definition:** 'Lying in sternal position' is when most of the ventral part of the body contacting the floor and 'Lying laterally' is when most of one side of the body contacting the floor and with most of the udder accessible to piglets (Muns et al., 2016). **Interpretation:** In lateral lying posture, the skin surface in contact with the floor is greater than in sternal lying, therefore maximising the heat loss through conduction. Sows in the thermal neutral zone spent a higher proportion of time lying in sternal position, whereas sows in heat stress spent a higher proportion of time lying in the lateral position. **Sensitivity/specificity:** The ABM is not sensitive: heat stress does not always result in a decreased sternal/lateral ratio, as animals may be prevented from laying laterally due to e.g. insufficient space. The ABM is not specific: absence of heat stress may not be associated with increased sternal/lateral ratio as animals may be comfortable lying laterally even at normal temperatures.
Wallowing behaviour	**Definition:** Wallowing behaviour is coating the body surface with fluid to increase evaporative cooling (Bracke, 2011). **Interpretation:** Pigs lack functional sweat glands and wallowing in mud is an effective behavioural control mechanism in pigs to prevent hyperthermia.

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is not sensitive: heat stress is not associated with wallowing if there is no access to mud or other suitable fluid. The ABM is not specific: if there are no heat stress problems, pigs may still wallow as a form of skin care.
Skin soiling with faeces	**Definition:** The level of soiling of the skin with excrement. (Nannoni et al., 2020). **Interpretation:** When the ambient temperature is too high, pigs will lie down in areas of the pen which are also used for defecation in order to wet the skin and increase evaporative cooling. An increased level of heat stress is thus associated with increased soiling of pigs. **Sensitivity/specificity:** The ABM is not sensitive: heat stress may not be associated with dirty pigs if on slatted flooring. The ABM is not specific: if there are no heat stress problems, pigs may still have lack of space and be obliged to lie in their excrement.

3.4.12. Cold stress and related ABMs

Description: The animal experiences stress and/or negative affective states such as discomfort and/or distress when exposed to low effective temperature.

Classified as highly relevant: The pig categories and the husbandry systems for which 'cold stress' was classified as highly relevant are listed in Table 27; the specific relevance for each pig category is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 28.

Table 27: Pig categories and husbandry systems and for which 'cold stress' was classified by experts as a highly relevant welfare consequence

Pig category	Husbandry system
Piglets	Outdoor farrowing paddock systems
Weaners	Outdoor paddock systems

General considerations: Cold stress occurs when the heat lost from the body of the pig by conduction, convection, radiation and evaporation exceeds the heat produced by metabolic processes in the body or supplied by supplementary sources in the environment (Black et al., 1999). The air temperature at which the pig goes into negative heat balance unless it can increase its heat output is defined by the Lower Critical Temperature (LCT). This is dependent on the size of the pig, since a smaller pig has a bigger surface area from which heat is lost relative to its body mass which produces metabolic heat. It also depends on feed intake, since the digestion and metabolism of food generates significant heat as a by-product of the chemical processes.

Relevance for piglets: Piglets are vulnerable to low ambient temperature and rely on shivering thermogenesis to maintain their body temperature (Herpin et al., 2002). Moreover, they show huddling behaviour to reduce heat loss (Vasdal et al., 2009). Rearing of newborn piglets in a cold environment leads to a drop in the rectal temperature, a poor body carbohydrate utilisation and a decrease in colostrum intake (Aumaitre and Le Dividich, 1984). Exposing piglets experimentally to an ambient temperature of 14°C, Lossec et al. (1998) found that the thermoregulatory response and carbohydrate metabolism of the piglets were seriously impaired below a body temperature of 34°C. Pedersen et al. (2013a) reported that the decrease in the piglets' rectal temperature during the first 30 min postpartum was more pronounced when they were kept in 15 °C farrowing rooms compared to 20°C and 25°C rooms. Consequently, the risk that a piglet would die before nursing colostrum increased with decreasing room temperature. Moreover, low birth-weight piglets had a greater decrease in rectal temperature during the first 30 min postpartum and a lower 24-h rectal temperature than heavy birth-weight piglets. Baxter et al. (2009) investigated behavioural and physiological indicators of survival in piglets raised on an outdoor farm and identified rectal temperature 1 h after birth and birth weight as the most significant postnatal survival indicators. Skin temperature of newborn piglets is generally a good indicator as the skin is very thin and does not have any brown adipose tissue (Schmitt and O'Driscoll, 2021).

Relevance for weaners: Weaned pigs find cold stress unpleasant and will work in an operant task to receive supplementary heat at low air temperature (Swiergiel, 1998). It can also predispose the pigs to disease such as post-weaning diarrhoea (Le Dividich and Herpin, 1994). Since the newly weaned pig is still relatively small and experiences a sudden drop in food intake, its LCT of 26–28°C is increased compared to that of a suckling piglet of the same weight at 22–23°C (Madec et al., 2003). The exact LCT will depend on a number of factors including flooring, airspeed and group size (Bruce and Clark, 1979). Housing on uninsulated floors without bedding or with wet bedding will increase heat loss by conduction and evaporation, whilst draughty conditions will increase heat loss from the body surface by convection. Pigs experiencing cold will first seek to reduce heat loss by behavioural means, seeking shelter from draught, burrowing into bedding, avoiding heat loss to the floor by maximising sternal lying at the expense of lateral lying and huddling with other conspecifics where these actions are possible. They will then seek to increase heat production by shivering. If these attempts are unsuccessful at remedying the situation, they will become lethargic as body temperature decreases. Blood flow is restricted to the body core to minimise heat loss, and frostbite of vulnerable extremities such as the ears can occur in extreme winter conditions (Webster, 1997; Gegner, 2001).

Table 28: ABMs for assessing of 'cold stress', definition, interpretation, qualitative assessment of their sensitivity and specificity, and indication to which pig categories they apply. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Rectal temperature (All pigs)	**Definition:** A proxy for the body temperature of the pig as measured by a thermometer inserted in the rectum (Yundong, 2012). **Interpretation:** Examination of animals with hypothermia will reveal low rectal temperatures (down to 35°C).[(a)] **Sensitivity/specificity:** The ABM is sensitive: Cold stress is almost always associated with low rectal temperature. The ABM is specific: If there are no cold stress problems, rectal temperature will not be low.
Skin temperature (All pigs)	**Definition:** The temperature of the skin surface as measured by infra-red thermography **Interpretation:** Pigs feel thermally comfortable at a specific skin temperature, and the skin temperature, as well as the lying behaviour, can be used as an index of the thermal state of the pigs (Andersen et al., 2008). **Sensitivity/specificity:** The ABM is sensitive: Cold stress is almost always associated with low skin temperature. The ABM is specific: If there are no cold stress problems, skin temperature will not be low.
Shivering (All pigs)	**Definition:** Shaking slightly and uncontrollably as a result of being cold, frightened or excited[(b)] **Interpretation:** Shivering indicates the animal suffers from low ambient temperature. Correct detection of cold stress is the positive outcome. **Sensitivity/specificity:** The ABM is sensitive: Cold stress is almost always associated with shivering. The ABM is not specific: If there are no cold stress problems, pigs may shiver as a result of e.g. fear.

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Huddling behaviour (mainly relates to piglets)	**Definition:** An active and close aggregation of animals (Gilbert et al., 2010) **Interpretation:** A group of pigs which is huddling is likely to suffer from cold ambient temperature. Huddling behaviour of piglets and older animals suggests that chilling is occurring and may support the presence of hypothermia[(a)] **Sensitivity/specificity:** The ABM is sensitive: cold stress is almost always associated with huddling in group housed pigs. The ABM is not specific: if there are no cold stress problems, pigs may also huddle due to fear.
Ratio of Lying in sternal position/Lying laterally (all pigs)	**Definition:** 'Lying in sternal position' is when most of the ventral part of the body contacting the floor and 'Lying laterally' is when most of one side of the body contacting the floor and with most of the udder accessible to piglets (Muns et al., 2016). **Interpretation:** In sternal lying posture, the skin surface in contact with the floor is smaller than in lateral lying. This posture helps to reduce heat loss through conduction and may indicate that the animal is getting cold. **Sensitivity/specificity:** The ABM is sensitive: cold stress always results in an increased sternal/lateral lying ratio. The ABM is not specific: absence of cold stress may not be associated with a decreased sternal/lateral ratio as animals in limited space may be unable to lie laterally.
Colostrum intake (piglets)	**Definition:** Colostrum is the first form of milk produced by the mammary glands of mammals (including humans) immediately following delivery of the newborn (Ballard and Morrow, 2013). Obtaining colostrum is essential for proper immune development of the newborn piglet. **Interpretation:** Cold stress can result in poor colostrum intake due to lack of vigour in getting access to the udder. **Sensitivity/specificity:** The ABM is not sensitive: cold stress may not always result in reduced colostrum intake. The ABM is not specific: in the absence of cold stress, reduced colostrum intake can still occur due to other factors such as teat competition or poor maternal health.
Live-born mortality (piglets)	**Definition:** The proportion of live-born piglets which have died from birth to weaning (preweaning mortality). **Interpretation:** Death due to cold stress is always associated with a prolonged period of suffering. This needs to be reduced to the absolute minimum. Cold stress also induces lethargy and increased risk of crushing. **Sensitivity/specificity:** The ABM is not sensitive: cold stress is not necessarily indicated by increased mortality, as cold stress does not always result in death. The ABM is not specific: absence of cold stress does not mean that mortality cannot be high, due to other reasons.

(a): https://www.pigprogress.net
(b): https://dictionary.cambridge.org

3.4.13. Locomotory disorders (including lameness) and related ABMs

Description: The animal experiences negative affective states such as pain or discomfort due to impaired locomotion behaviour induced by e.g. claw overgrowth, bone, joint, skin or muscle damage.

Classified as highly relevant: The pig categories and the husbandry systems for which 'locomotory disorders (including lameness)' was classified as highly relevant are listed in Table 29; the specific relevance for each pig category is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 30.

Table 29: Pig categories and husbandry systems for which 'locomotory disorders (including lameness)' was classified by experts as a highly relevant welfare consequence

Pig category	Husbandry system
Gilts and dry sows	Indoor group housing
Rearing pigs	Indoor group housing
	Indoor systems with access to an outdoor area
Boars	Indoor individual housing in pens

General considerations: Lameness is a painful, multifactorial disorder which presents as an abnormal gait as a result of physical injury or infection in the limbs or back (Velarde and Geers, 2007). Issues relating to limb pathology are the most common cause of lameness; these include osteochondrosis, epi- and apophysiolysis and (infectious) arthritis (Jensen et al., 2007; Zimmerman et al., 2012). Physical injury such as claw lesions, joint lesions, muscle damage, tendon damage and bone fractures are other common causes of lameness (Jensen and Toft, 2009). Overgrowth of the weight bearing claws is a common claw disorder that disrupts locomotion (Newman et al., 2015), causes discomfort while standing (Calderón Díaz et al., 2015b) and increases the risk of injury and amputation. The welfare of the pig is reduced because lameness is associated with pain and discomfort (Dewey et al., 1993; Kirk et al., 2005; Jensen et al., 2007; Mustonen et al., 2011). However, lameness also negatively impacts welfare because it impairs pig's ability to compete for resources and increases lying time which may give rise to pressure injuries, e.g. calluses and bursitis

Relevance for dry sows and gilts: Lameness is considered one of the main welfare issues for sows (D'Eath, 2012; Heinonen et al., 2013; Nalon et al., 2014). Lameness can persist chronically (D'Eath, 2012), contributing to elevated stress levels (Contreras-Aguilar et al., 2019), and consequently, impaired reproductive performance (Anil et al., 2009; Fitzgerald et al., 2012). For instance, lame sows had lower numbers of piglets born alive in the study of Anil et al. (2009). Unsurprisingly then, it remains one of the primary reasons for culling of young sows (Dewey et al., 1993; Jensen et al., 2007; Anil et al., 2009; Mustonen et al., 2011; Pluym et al., 2011) results in a higher work load for staff and increased veterinary expenses. (D'Eath, 2012; Heinonen et al., 2013; Nalon et al., 2014). One of the most common claw abnormalities observed in breeding herds is overgrowth of the weight bearing claws, with around 10% of sows affected (Bonde et al., 2004; KilBride et al., 2010). Overgrown claws affect several aspects of sow behaviour with negative implications for sow welfare (Bonde et al., 2004; Fitzgerald et al., 2012; Calderón Díaz et al., 2015b).

Relevance for rearing pigs: Lameness is recognised as a significant welfare problem in rearing pigs, however research in this topic appears more limited than in sows. KilBride et al. (2009c) indicated a prevalence of 19.7% in abnormal gait of finishing pigs on UK farms. They also found that abnormality in gait was higher in systems that had minimal or no bedding compared to those with deep bedding. Lameness problems in pigs are attributed to a number of causes. These include osteochondrosis, a degenerative joint condition, which is linked to a number of factors including fast growth rates in rearing pigs (Busch and Wachmann, 2011). Lesions to claws and to the integument of limbs are also associated with locomotory issues in rearing pigs, and there is evidence that they influenced by floor type (see Falke et al., 2018). Other conditions including infectious arthritis also affect leg health in rearing pigs (Jensen and Toft, 2009). Lameness is associated with pain and stress in fattening pigs (Contreras-Aguilar et al., 2019) and may therefore cause reduced activity and increased susceptibility to disease. These factors may also contribute to reduced performance and increased culling. Increased lying associated with abnormal gait may also contribute to development of limb lesions such as bursitis in finishing pigs (KilBride et al., 2009c).

Relevance for boars: The ability to move is important for boars, especially during mounting behaviour. When they are used for semen collection on a dummy or during natural service, a lot of weight is put on their hind limbs. Also, teaser boars must perform a considerable amount of walking during stimulation of the sows. So far, there are only few studies reporting the prevalence of lameness in boars. At boar testing stations, a prevalence of 4–6% was reported (Jensen et al., 2007 and Wang et al., 2019). Lameness in boars can result in reduced reproductive performance of boars and sows, increased antibiotic treatments, reduced mean daily weight gain and culling (Jensen et al., 2007). Reasons for lameness in boars include overgrown claws, any type of claw lesions (e.g. heel overgrowth, cracked walls or soles), problems with dew claws or bursitis (Wang et al., 2019). Furthermore, during the development of bones and joints, problem such osteochondrosis or epiphysiolysis can occur (Zimmerman et al., 2012). Risk factors for lameness in boars included floor type, age and breed (Wang et al., 2019).

Table 30: ABMs for assessing of 'locomotory disorders (including lameness)', definition, interpretation and qualitative assessment of their sensitivity and specificity, and indication to which pig categories they apply. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Abnormal gait (all pigs)	**Definition:** According to Pairis et al., (2011) gait scoring systems are designed to categorise the degree of lameness shown during locomotion. **Interpretation:** Poor lameness scores are based on gait abnormalities during movement and deviations from normal posture while standing (Sprecher et al. 1997). **Sensitivity/specificity:** The ABM is sensitive: locomotory disorders are by definition associated with abnormal gait scores. The ABM is not specific: if there are no locomotory disorders, the gait score can still be abnormal if the floor is slippery or the claws are overgrown.
Claw lesions (all pigs)	**Definition:** Claw lesions are injuries to the feet of pigs, and often associated with lameness. The most frequently observed claw lesions in sows, varying in severity, are heel horn erosions, defects in the heel horn/sole junction, white line defects, horizontal and vertical wall cracks, claw and dewclaw overgrowth or amputation, ulcers and skin lesions (Van Riet et al, 2019). There are several claw lesions scoring systems described in scientific publications for research purposes (e.g. Calderón Díaz et al., 2013, 2014) and also in some farm advisory (grey) literature, e.g. the Dutch Klauwencheck (Lamers, 2006). Claw lesions are indirectly related to aggression and may occur if claws slip or get caught during aggressive interactions. **Interpretation:** Claw lesions and lameness are painful and can be caused by injury due to poor housing conditions, non-infectious and infectious conditions and degenerative diseases (e.g. Taylor, 1999). **Sensitivity/specificity:** The ABM is not sensitive: locomotory disorders are not always associated with claw lesions, as these disorders may also be caused by leg or back injuries. The ABM is not specific: if there are no locomotory disorders, significant claw lesions may still be present.
Overgrown claws (sows, boars)	**Definition:** Overgrowth is a common claw lesion in sows and boars that is evidenced by excessive length of the weight bearing claws and/or the accessory digits/dewclaws. The rear hooves are the major location for overgrowth (Fitzgerald et al., 2012). **Interpretation:** Overgrowth of the weight bearing claws impede movement and cause discomfort while standing (Calderón Díaz et al., 2015b).

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is not sensitive: locomotory disorders are not always associated with overgrown claws, as these disorders may also be caused by joint or back injuries. The ABM is not specific: if there are no locomotory disorders, there may still be overgrown claws.
Calluses and bursitis (sows, rearing pigs, boars)	**Definition:** Calluses and bursitis are pressure injuries; callosities are a build-up of hard, thick areas of skin The Pig Site[(a)] refers to bursitis as 'a common condition that arises from constant pressure and trauma to the skin overlying any bony prominence. The membrane or periosteum covering the bone reacts by creating more bone, a swelling develops and the skin becomes thicker until there is a prominent soft lump. Bursitis may cause the skin to become broken and secondary infection can develop'. **Interpretation:** Callosities develop on e.g. legs as a consequence of prolonged lying on (hard) floor. The main causes of bursitis are poor solid floor surfaces or poor slats, lack of bedding, high stocking densities. Bursitis develops due to prolonged rubbing of the affected area. Lame animals show prolonged lying period which can cause pressure injuries. **Sensitivity/specificity:** The ABM is not sensitive: locomotory disorders are not always associated with calluses and bursitis, as these disorders may also be caused by joint or claw disorders. The ABM is not specific: if there are no locomotory disorders, pressure injuries may still develop on poor quality flooring.

(a): https://www.thepigsite.com/disease-guide/bursitis-joint-inflammation

3.4.14. Soft tissue lesions and integument damage and related ABMs

Description: The animal experiences negative affective states such as pain, discomfort and/or distress due to physical damage to the integument or underlying tissues e.g. multiple scratches, open or scabbed wounds, ulcers or abscesses. This welfare consequence may result from negative social interactions such as aggression or tail biting, from handling or from damaging environmental features or from mutilation practices (e.g. tail docking).

Classified as highly relevant: The pig categories and the husbandry systems for which 'soft tissue lesions and integument damage' was classified as highly relevant are listed in Table 31; the specific relevance for each pig category is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation, some qualitative assessment of their sensitivity and specificity and an indication to which pig categories they apply are listed in Table 32.

Table 31: Pig categories and husbandry systems for which 'soft tissue lesions and integument damage' was classified by experts as a highly relevant welfare consequence

Pig category	Husbandry system
Gilts and dry sows	Indoor group housing
Farrowing and lactating sows	Individual farrowing crates
Piglets	Individual farrowing crates
	Individual farrowing pens
	Outdoor farrowing paddock systems
Weaners	Indoor group housing
	Indoor systems with access to an outdoor area
Rearing pigs	Indoor group housing
	Indoor systems with access to an outdoor area

Relevance for gilts and dry sows: Skin lesions in dry sows and gilts reflect either protruding elements or other aspects of a poor design of the pen or floor, which may cause injuries, or they may indicate a degree of negative social interactions. Velarde (2007) reviews the occurrence of skin lesions in dry sows and lists injuries due to rank order fights (e.g. Wood-Gush, 1984; Luescher et al., 1990), but also competition for food (Leeb et al., 2001). The latter appear mainly as wounds to the rear of the pig, whereas the former leaves injuries in the head, ears and shoulder area. Other skin lesions (in particularly in the back area of the sow) can be caused by mounting attempts and scratches by the front claws. Finally, vulva wounds due to vulva biting can occur when access to feed or drinkers is highly competitive (Rizvi et al, 1998). Although often associated with group housing, soft tissue lesions also frequently occur in stalled sows (e.g. De Koning, 1985; Boyle et al., 1999). They may be caused by the stall size or any protruding elements, or through poor and abrasive flooring conditions, in the case of shoulder ulcers or bursitis.

Relevance for farrowing and lactating sows: In a comparison of gilts kept in different farrowing systems, Boyle et al. (2000) reported that crated gilts generally showed the highest lesion scores, gilts in pens with bedding the lowest scores and gilts in pens without bedding intermediate scores. Contrary to this, however, Singh et al. (2017) compared the number of fresh skin injuries in sows kept either in a crate or a pen from 3 days postpartum until weaning and found that sows in crates sustained less injuries. To explain the difference, they mentioned that the plastic flooring used in the pens of their study may have been slippery when wet and that this could have contributed to difficulties sows may have had in changing posture or moving about the pen, and consequently may have contributed to increased injuries.

Norring et al. (2006) observed no difference in the number of lesions between sows kept in farrowing crates on concrete vs. polyurethane flooring. However, the sows had significantly more and larger lesions at weaning (22 days post-farrowing) than prior to farrowing. On average, the sows developed 20.6 cm2 of mild lesions and 2.7 cm2 of severe lesions during the lactation period. Floor quality (perforated rubber lying mat or metal slatted flooring) in the farrowing crate did not affect the total number of body lesions in sows in a study of Ruff et al. (2017), but the number of total lesions was lower at the weaning stage (21 days after farrowing) compared to measurements while in gestation.

With regard to udder lesions, Verhovsek et al. (2007) reported that 40% of the sows kept in farrowing crates had at least one severe teat lesion and 20% had two or more lesions on day 23 post farrowing, whereas only 20% of the sows loose-housed in pens showed one teat lesion. Moreover, crated sows had a significantly higher prevalence of skin lesions on the udder and on the limbs. Correspondingly, Lohmeier et al. (2019) observed that sows in farrowing crates were more likely to suffer skin lesions of the udder compared to sows kept in free-farrowing pens.

Bonde et al. (2004) examined 570 lactating sows in 10 commercial sow herds to determine the prevalence of different types of skin lesions. Shoulder wounds occurred in 12% of the sows, ranging from 3% to 25% in the 10 herds, wounds on hind feet in 22% of the sows (range 2–43%), lesions on udder and teats in 8% (range 2–12%), carpal wounds in 3% (range 0–10%) and hock wounds occurred in 2% (range 0–8%). Moreover, 26% of the sows had long or overgrown hooves, 12% were slightly lame (range 3–18%) while 3% were visibly lame (0–9%).

Relevance for piglets: Piglets in farrowing systems receive facial injuries due to competition for access to the udder during suckling bouts (Fraser and Thompson, 1991). Comparing piglets with intact, partially clipped and fully clipped teeth, Weary and Fraser (1999) found that facial injuries were more pronounced with unclipped teeth. Similarly, Lewis et al. (2005b) reported that both clipping and grinding the needle teeth reduced the piglets' facial lesion scores. Hansson and Lundeheim (2012), however, observed no difference in the litter facial lesion score between piglets with intact or grinded teeth.

Piglets also develop abrasion injuries on their front legs from contact with the floor during suckling. For example, Mouttotou and Green (1999) reported that, during the first 23 days of life, 89% of the piglets developed hairless patches, 60% developed skin abrasions and 70% developed healed wounds. Whereas Gravås (1979) found no effect of floor type (concrete, epoxy painted concrete, rubber mat) on the number of knee wounds, Furniss et al. (1986) showed that knee damage incidence and severity were worse on an old cement screed than on more recently laid cement, fibrocem or latex screeds. Moreover, Mouttotou et al. (1999) found that the risk for skin abrasions on the front limbs of piglets was higher on part-concrete, part round-weld-mesh flooring compared to solid floors and higher on floors covered with sparse wood shavings than without bedding. To explain the effect of sparse bedding, they hypothesised that splinters of wood may penetrate or shear off the skin when wedged between concrete and skin. Finally, measuring the number of piglet skin lesions on the front knees and fetlocks, Norring et al. (2006) observed no difference between animals kept on concrete and polyurethane-covered flooring.

With regard to skin lesions in preweaning piglets reared in outdoor paddocks, KilBride et al. (2009b) did a study including 88 indoor and outdoor pig farms and reported that the prevalence of limb lesions was higher in indoor housed piglets than in outdoor housed piglets.

Suckling piglets may also have lesions on their teats. However, Furniss et al. (1986) found that the level of teat damage was low, compared to the level of knee (carpal) damage. In addition, they showed that the incidence and severity of teat damage were higher on concrete than on plastic-covered wire flooring.

Crushing of suckling piglets by the sow is accompanied with major trauma including soft tissue lesions. In conventional (crated) farrowing accommodations, crushing is associated with more than half of all preweaning mortality and is estimated to result in death of 3–7% of piglets (Kamphues, 2004). According to Marchant et al. (2001) nearly half of the deaths due to crushing occurred within the first 24 h after birth. The peak in crushing coincides with a peak in frequency of postural changes in a study by Weary et al. (1996). Most piglets are crushed when the sow moves from standing to lying or when she rolls over while already lying (Damm et al., 2005). Farrowing crates are designed to reduce or slow down these postural changes and prevent sudden drops or sudden rolling over of the sow whilst the piglets are in close proximity. These gives piglets more time to move away from the area under the sow.

Relevance for weaners: Soft tissue lesions are seen in some weaned pigs on the majority of farms. For example, in a survey of 31 Irish farms, Van Staaveren et al (2018) reported the following median (and interquartile ranges) of prevalences for first stage and second stage weaners, respectively: Skin lesions 3.7 (1.85–8.62) and 4.4 (1.86–6.27); tail lesions 2.8 (2.01–6.96) and 5.9 (04.13–7.72); ear lesions 7.6 (2.58–13.23) and 9.1 (2.64–26.38) and flank lesions 0.0 (0.00–0.00) and 0.4 (0.00–0.90). Both ear and flank lesions may show necrotic development as a result of the action of *Staphylococcus hyicus*, following invasion of sites of slight trauma caused by the behaviour of penmates (Mirt, 1999). Baumgartner (2007) emphasised that lesions on different parts of the body may have different behavioural contexts and therefore should be measured separately. Lesions on the body and ears result mainly from the aggression which occurs at the time of mixing, peaking at approximately day 5 after weaning in mixed groups and then decreasing once social stability is established (Baumgartner 2007). However, he noted that limited feeding space allowance resulted in an increased level of aggression at the feeding place and a high number of bites targeting the ear of the feeding pigs, even in unmixed groups. Tail lesions are usually a result of tail biting behaviour, which can develop when weaner housing has a high stocking density or lacks adequate enrichment (Grümpel et al., 2018; Zonderland et al., 2008). Lesions of the feet and limbs can also occur as a result of unsuitable flooring, including too large a void area with sharp edges which can injure the feet, or an abrasive or hard lying surface causing scrapes and pressure sores. Wounds are more prevalent on slatted floors, whilst pressure injuries such as bursae are more prevalent on unbedded concrete floors (Kelly et al., 2000a; Kilbride et al., 2009a).

Soft tissue lesions and integument damage are scored as an important welfare consequence in indoor and semi-outdoor systems, where common commercial practice includes higher stocking densities and only basic enrichment. Aggression and injurious pig-directed behaviours, as well as injuries from flooring, occur more frequently under such conditions (Beattie et al., 1996; Kelly et al., 2000a,b; Zonderland et al., 2008), whereas in outdoor systems, with soil as the surface. They are rare because of the greater space and foraging opportunities.

Relevance for rearing pigs: Rearing pigs can sustain aggression-related skin injuries if they have to compete for access to resources such as feed or if they are regrouped. These injuries can be sufficiently severe to remain evident for at least 10 weeks (Carroll et al., 2018a). Harmful social behaviours such as tail, ear and leg chewing may also cause soft tissue lesions. Claw and limb injuries (e.g. lesions, swellings or abscesses) in finishing pigs are also linked to hard flooring and use of slats (Kongsted and Sørensen, 2017; Falke et al., 2018). Rearing pigs can also sustain skin damage during slaughter practices, with fasting, loading and lairage times (Guárdia et al., 2009) and also lorry conditions (Arduini et al., 2017) being contributory factors.

Soft tissue lesions in rearing pigs can be readily surveyed at abattoirs (Carroll et al., 2016), but differences in methodology between studies make findings difficult to compare. Kongsted and Sorensen (2017) examined over half a million pigs from conventional indoor systems at one Danish abattoir. They found an average herd prevalence of 3% for leg swellings and for abscesses in the head or trunk, of 1% for skin lesions and of < 1% for hoof abscesses and tail lesions. Other studies record a higher prevalence of 'skin blemishes' at the abattoir. For example, 16.6% of 15,659 pigs surveyed at five Spanish abattoirs showed evidence of moderate or severe skin blemishes (Guárdia et al., 2009). An earlier study of 5484 pigs at Danish, Portuguese and UK abattoirs found that 10% had moderate to severe skin blemishes (Warriss et al., 1998). Bottacini et al. (2018) evaluated 648 batches of heavy slaughter weight pigs at an Italian abattoir and found a median batch prevalence of severe scratches of 64% for the anterior part of the carcass and 46% for the posterior. Abattoir-based surveys have also focussed on tail lesions specifically. Harley et al. (2012) examined almost 37,000 pigs in six abattoirs on the island of Ireland and found that ~ 42% showed no evidence of tail lesions. Most of these pigs were tail docked and a more recent abattoir-based survey of undocked pig populations in Finland described 49% of tails as fully intact (Valros et al., 2020). The presence of skin blemishes (Warriss et al., 1998) and tail lesions (Carroll et al., 2018a) is associated with increased levels of cortisol in pigs, and this may reflect the pain of the injury or the stress associated with its infliction. Skin injuries provide an entry point for pathogens and are linked with disease incidence in pigs (e.g. Teixeira et al., 2016). These types of injury may also cause debilitation and contribute to early culling of rearing pigs.

Table 32: ABMs for assessing of 'soft tissue lesions and integument damage', definition, interpretation, qualitative assessment of their sensitivity and specificity and indication to which pig categories they apply. The ABM which is generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts is not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Facial injuries (mainly in piglets)	**Definition:** Skin lesions on the face of suckling piglets, associated with competition to access for teats. The fighting is part of the natural establishment of teat order and occurs after pigs are born. **Interpretation:** In the first week of life, fighting may be more apparent if they are part of a large litter, if there is a disruption of the teat order due to cross-fostering or if there is interruption in the supply of milk as a result of mastitis or agalactia.[(a)] **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with facial injuries, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any facial injuries.
Skin lesions on the front limbs (mainly in piglets)	**Definition:** Skin lesions on the front limbs, especially carpus, that can be seen as broken skin causing some degree of blood loss. **Interpretation:** Newborn piglets may develop foot and skin lesions during their first days of life, due to the roughness of the floor surface of farrowing pens. The abrasions on the front legs that are most severe are the result of paddling behaviours during suckling (Zoric, et al., 2009). **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with skin lesions on the front limbs, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any skin lesions to the front limbs.
Teats and udder lesions (lactating sows)	**Definition:** Broken skin of teats or udder. **Interpretation:** Traumatic teat and udder lesions can be the consequence of injuries induced by piglets or other sows, or by slipping on slatted floors (Boyer and Almond, 2014). **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with teat lesions, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any teat lesions.

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Tail lesions (piglets, weaners, rearing pigs)	**Definition:** Skin lesions to the tail, ranging from mild bite marks, with or without puncture of the skin, up to a complete tail loss (Gentz et al., 2019) **Interpretation:** Tail lesions are associated with several risk factors including a barren environment and social unrest. **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with tail lesions, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any tail lesions.
Body lesions (all pigs)	**Definition:** Lesions on the trunk of the body (excluding e.g. legs, tail, ears and vulva) that can be seen as broken skin causing some degree of blood loss. **Interpretation:** Body lesions can be the result of physical damage by the environment or other pigs (Velarde, 2007). **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with body lesions, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any body lesions.
Vulva lesions (sows)	**Definition:** Lesions to the skin of the vulva which might be bleeding cuts, scabbed wounds or deformed vulvar tissue after healing (Rizvi et al., 2000). **Interpretation:** Vulva lesions usually result from biting injury in pregnant sows and are more common in late pregnancy when the vulva begins to swell. Vulva lesions are associated with several risk factors including competition for food or frustrated feeding motivation within the group (Gjein and Larssen, 1995a; Rizvi et al., 2000). **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with vulva lesions, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any vulva lesions.
Leg injuries (all pigs)	**Definition:** Injuries including those where the integument is damaged, causing discomfort or pain to the animal in particular when the legs are used for posture changes or walking (shown as lameness). **Interpretation:** Lameness can be caused by injury due to poor housing conditions, non-infectious and infectious conditions and degenerative diseases (e.g. Taylor, 1999). **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with leg injuries, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any leg injuries.
Ear lesions (mainly weaners, in some cases piglets)	**Definition:** Superficial lesions to the skin of the ears as well as ear necrosis, indicated by large erosive lesions on the ears, and potentially leading to partial or in extreme cases, total loss of the ear (Weissenbacher-Lang et al. 2012). **Interpretation:** Ear lesions can be a result of increased chewing of the ear by other pigs associated with boredom and insufficient exploratory behaviour. **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with ear lesions, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any ear lesions.

ABM (pig categories)	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Shoulder ulcers (mainly in sows)	**Definition:** Decubital shoulder ulcers are lesions in post-farrowing sows caused by pressure inflicted by the flooring, leading to oxygen deficiency in the skin and the underlying tissue. They are thought to be comparable with human pressure sores (Herskin et al., 2011). Scoring systems can be based on the diameter (on live animals) or on layers affected (*post-mortem* only): ulcers restricted to the superficial skin layers, to all skin layers and sometimes even the underlying bone (Meyer et al., 2019). **Interpretation:** In sows, the ulcers are caused by oxygen deficiency in the skin and the underlying tissue caused by prolonged lying on hard flooring usually in combination with poor body condition (Herskin et al., 2011; Rioja-Lang et al., 2018). **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with shoulder ulcers, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there will not be any shoulder ulcers.
Bursitis (all pigs)	**Definition:** The Pig Site refers to bursitis as 'a common condition that arises from constant pressure and trauma to the skin overlying any bony prominence. The membrane or periosteum covering the bone reacts by creating more bone, a swelling develops and the skin becomes thicker until there is a prominent soft lump. Bursitis may cause the skin to become broken and secondary infection can develop'.[(a)] **Interpretation:** The main causes are poor solid floor surfaces or poor slats, lack of bedding, high stocking densities. **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with bursitis, as these lesions may also occur on other parts of the body. The ABM is specific: if there are no soft tissue lesions, there is no bursitis.
Live-born mortality (piglets)	**Definition:** The proportion of live-born piglets in one litter that die before weaning. **Interpretation:** Crushing of piglets by the sow causes major soft tissue and organ damage and is the most common cause of neonatal mortality (Edwards and Baxter, 2015). Because of this, the overall level of live-born piglet mortality during the lactation period is a good proxy for the prevalence of crushing in situations where a precise cause of mortality cannot be reliably diagnosed. **Sensitivity/specificity:** The ABM is not sensitive: soft tissue lesions are not always associated with preweaning mortality, as these lesions may also occur in piglets which do not die. The ABM is not specific: if there are no soft tissue lesions, piglets may still have died from other causes.

(a): https://www.pigprogress.net

3.4.15. Respiratory disorders and related ABMs

Description: The animal experiences negative affective states such as discomfort, pain, air hunger and/or distress due to impaired function or lesion of the lungs or airways.

Classified as highly relevant: 'Respiratory disorders' was classified as highly relevant in rearing pigs in the following systems:

- Indoor group housing
- Indoor systems with access to an outdoor

The specific relevance is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed in Table 33.

Relevance for rearing pigs: Respiratory disorders are often described as one of the most significant health concerns in pig production globally (e.g. Merialdi et al., 2012; Rodrigues da Costa et al., 2020; Museau et al., 2020), largely because of associated economic losses, antibiotic usage and welfare effects in fattening pigs. They often occur as part of a syndrome in rearing pigs called the Porcine Respiratory Disease Complex (PRDC). Examination of lung lesions indicates that PRDC is associated with different types of pneumonia and with pleuritis (Ruggeri et al., 2020). PRDC is multifactorial in nature, involving interactions between different infectious agents and environmental, management and host factors (Čobanović et al., 2021). Aetiological agents can be bacteria, viruses or mycoplasmas (Ruggeri et al., 2020), and include *Mycoplasma hyopneumoniae*, *Actinobacillus pleuropneumoniae*, Swine Influenza Virus, Porcine Circovirus type-2 and Porcine Reproductive and Respiratory Syndrome virus. The presence of multiple pathogens, and the variability in pathogen profile between regions adds to the complexity of the problem. Very many aspects of farm management and facility design have been linked to respiratory disease in pigs (see Stärk, 2000), again adding to the complexity of the problem. Recent research with slaughter pigs in Finland found that both herd type and size were risk factors for being high pleurisy herds (Hälli et al., 2020), and that factors such as poor air quality and poor pen cleanliness and condition were associated with increased antibiotic treatments for respiratory issues (Stygar et al., 2020).

Prevalence figures for respiratory disorders vary considerably between studies but emphasise the significance of this problem in rearing pigs. Alban et al. (2015) found a prevalence of 23.9% for chronic pleuritis in Danish finishing pigs from conventional systems, and 0.3% for chronic pneumonia. A study of heavy slaughter weight pigs in Italy showed evidence of pleural lesions in 47.5% of lungs (Merialdi et al., 2012). An evaluation of the outcome of veterinary inspections of pigs in Czech slaughterhouses over a long-term period indicated lung lesions in 41% of finisher pigs (Vecerek et al., 2020). A recent study in Ireland found an estimated average within-farm prevalence of pleurisy and pneumonia of 13 and 11%, respectively, in slaughter pigs (Rodrigues da Costa et al., 2020). Coughing and sneezing are clinical signs of respiratory disorders in pigs (Pessoa et al., 2021). These disorders are associated with increased mortality and morbidity in rearing pigs (Harms et al., 2002), but additional research quantifying these effects on European farms would be beneficial. Respiratory disorders are also associated with reduced growth rate and meat quality in rearing pigs (Čobanović et al., 2021).

Table 33: ABMs for assessing 'respiratory disorders' in rearing pigs: definition, interpretation and qualitative assessment of their sensitivity and specificity. ABMs which are generally considered to be linked to the welfare consequence but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Coughing	**Definition:** To expel air from the lungs with a sudden sharp sound. **Interpretation:** A high incidence of coughing is associated with respiratory disease (Zimmerman et al., 2012). **Sensitivity/specificity:** The ABM is not sensitive: many, but not all, respiratory disorders are strongly associated with coughing. The ABM is specific: if there are no respiratory disorders, persistent coughing is unlikely to occur.
Lung lesions	**Definition:** Macroscopic lesions indicative of pneumonia, pleurisy, pleuropneumonia or abscesses. Enzootic pneumonia-like lesions are described by Eze et al. (2015) as 'a red-tan-grey discolouration, and consolidation affecting cranioventral regions of the lungs in a lobular pattern'. The same authors described pleurisy as 'fibrous or fibrinous adhesions on the lung or between the lung and the chest wall', and pleuropneumonia lesions as 'focal areas of lung consolidation with overlying pleurisy usually affecting the middle or caudal lobes'. **Interpretation:** A high incidence of lung lesions is associated with respiratory disease. These can be observed in animals dying on the farm, but are more commonly monitored in abattoir surveillance. **Sensitivity/specificity:** The ABM is not sensitive: Many but not all respiratory disorders are strongly associated with lung lesions. The ABM is specific: If there are no respiratory disorders, piglets will not have lung lesions.

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Sneezing	**Definition:** A sudden audible involuntary expulsion of air through the nose and mouth. **Interpretation:** A high incidence of sneezing is associated with respiratory disease (Zimmerman et al., 2012). **Sensitivity/specificity:** The ABM is not sensitive: Respiratory disorders are not always associated with sneezing. The ABM is not specific: In the absence of respiratory disorders, sneezing can still occur due to irritation from airborne particles such as dust.
Mortality	**Definition:** The proportion of animals which have died. **Interpretation:** Due to respiratory disorders is likely to be accompanied by severe suffering preceding. This needs to be reduced to the absolute minimum. **Sensitivity/specificity:** The ABM is not sensitive: Respiratory disorders are not always associated with mortality, as pigs may not die from less severe respiratory disorders. The ABM is not specific: If there are no respiratory disorders, pigs may still die from other causes.

3.4.16. Gastro-enteric disorders and related ABMs

Description: The animal experiences negative affective states such as discomfort, pain and/or distress due to impaired function of the gastro-intestinal tract resulting from, e.g. nutritional deficiency, infectious, parasitic or toxigenic agents.

Classified as highly relevant: 'Gastro-enteric disorders' was classified as highly relevant in weaners in all the three husbandry systems were assessed:

- Indoor group housing
- Indoor systems with access to an outdoor
- Outdoor paddock systems

The specific relevance is described in the following text.

The ABMs that can be used for assessing this welfare consequence, their definition, interpretation and some qualitative assessment of their sensitivity and specificity are listed in Table 34.

General considerations: Disorders of the gastro-enteric tract are diverse in anatomical location, aetiology and manifestation. In the stomach, the most significant problem is gastroesophageal ulceration. This results from changes in the volume, fluidity and acidity of stomach contents, with the most commonly identified risk factors for this condition being feed particle size and stress (Friendship, 2004). In the small intestine, inflammatory responses occur as a result of dietary antigens and bacterial endotoxins, whilst diarrhoea can also result from viral and coccidial infections. In the large intestine, colitis may result from pathogenic or nutritional factors (Thomson and Friendship, 2012). Gastrointestinal disorders change the rate of passage of digesta and the loss of surface enterocytes caused by pathogenic infections results in fluid exudation and watery diarrhoea. Evidence of diarrhoea can be seen through soiling of the skin or flooring of the pen. The consistency, colour and odour of the faeces can be used in differential diagnosis of a range of different enteric diseases (Thomson, 2006). When the gut endothelium is damaged as a result of infection with various pathogenic agents (e.g. Lawsonia *intracellularis, Brachyspira hyodysenteriae, Escherichia coli)*, or diet induced gastroesophageal ulceration, blood can be leaked into the gut and appear in the faeces (Thomson, 2006). Where the cause is parasitic, examination of the faeces for the presence of parasite eggs can be diagnostic (Roepstorff and Nansen, 1998). The McMaster method (MAFF, 1986) is the most widely used FEC technique to assess endoparasite burden. The species of parasite can be identified by the morphological characteristics of the eggs using a microscope (Thienpont et al, 1979) Gastro-intestinal disorders are frequently associated with loss of body condition, since feed intake may be reduced, and nutrients are poorly digested and absorbed which compromises growth of body tissues (Thomson, 2006).

Relevance for weaners: Enteric disease in the weaned piglet is normally manifest as diarrhoea; post-weaning diarrhoea (PWD) is a commonly reported health problem in this stage of production in all systems (van Staaveren et al., 2018; Leeb et al., 2019). The risk is greater in indoor housing where animal density, and therefore, infection pressure is higher. Historically the problem was mitigated by the widespread inclusion of prophylactic antibiotics in the diets for weaned pigs, but this solution is no longer permitted under EU legislation.

Whilst suckling the sow, the piglet ingests a highly digestible milk diet which contains protective immunoglobulins. At the time of weaning, the withdrawal of maternal passive protection is accompanied by stressful events such as handling, relocation and mixing, a sudden decrease in feed intake and gut contents and exposure to novel dietary antigens which can induce inflammatory responses in the gut endothelium. These events bring about major changes in gut morphology and function, accompanied by dysbiosis of the gut microflora (Hopwood and Hampson, 2003). Diarrhoea can result from colonisation and overgrowth of bacteria, viruses or parasites, or from a nutritional imbalance causing irritation and/or increased luminal osmotic forces. The agent most commonly implicated in post-weaning diarrhoea is *Escherichia coli*, although *Salmonella*, *Brachyspira* and *Lawsonia* spp. may also be found, as may rotaviruses, coronaviruses and coccidia. Diarrhoea is also seen as part of the syndrome of post-weaning multisystemic wasting disease (PMWS), which has been associated with weaning stressors in the presence of porcine circovirus-2 (PCV-2) (Madec et al., 2008). Pigs which experience PWD show low dry matter faeces, dehydration, weight loss, lethargy and, in extreme cases where treatment is not provided, death from dehydration or septicaemia (Taylor, 2013, pp. 150–154).

A further gastro-enteric disorder which might be a welfare problem in weaned pigs is gastric ulceration. There are few data to assess the problem in this production stage, but a recent report surveyed 10 high-risk Danish herds, selected on the basis of historic records of gastric ulceration in finisher pigs or sows, the use of commercially produced feed and ad libitum feeding. From each of the 10 farms, 20 clinically healthy nursery pigs were selected by systematic random sampling from 15 to 20 different pens. They observed an overall prevalence of 35.5% for pars oesophageal ulcers in nursery pigs, with variation between farms from 0% to 84% (Peralvo-Vidal, 2021).

Table 34: ABMs for assessing of 'gastro-enteric disorders' in weaners: definition, interpretation and qualitative assessment of their sensitivity and specificity. ABMs which are generally considered to be linked to the welfare consequence, but in the opinion of the EFSA experts are not considered to be sensitive nor specific can be found in the bottom of the table, marked in grey

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
Abnormal faeces	**Definition:** Faeces may be abnormal in respect of a low dry matter content, different colour and different smell (Thomson, 2006). **Interpretation:** A subjective faecal consistency score has been used as an ABM in studies of enteric disease with very good intra- and inter-observer reliability (Pedersen and Toft, 2011). **Sensitivity/specificity:** The ABM is not sensitive: Most gastro-enteric disorders are strongly associated with abnormal faeces production, but not in the case of subclinical gastric ulcers. The ABM is specific: If there are no gastro-enteric disorders, piglets will have normal faeces.
Faecal egg count	**Definition:** The number of endoparasite eggs present per gram of faeces. **Interpretation:** Faecal egg count relies on the relationship between adult worm burden and the number of eggs per gram of faeces (Roepstorff and Nansen, 1998). **Sensitivity/specificity:** The ABM is not sensitive: gastro-enteric disorders may not be associated with faecal egg counts, as the problem may be caused by factors other than parasites. The ABM is specific: if there are no gastro-enteric disorders, pigs will also not have a high faecal egg count.
Blood in faeces	**Definition:** The faeces show blackened or reddened colouration due to the presence of blood. **Interpretation:** Pathogenic infections usually result in bloody diarrhoea, whereas gastric ulceration is characterised by scant, black and tarry faeces (Friendship, 2004)

ABM	Definition, interpretation and qualitative assessment of sensitivity and specificity to the welfare consequence (with Refs.)
	Sensitivity/specificity: The ABM is not sensitive: gastro-enteric disorders may not be associated with blood in the faeces, as the problem may not be severe enough for this outcome. The ABM is specific: if there are no gastro-enteric disorders, pigs will also not have blood in the faeces.
Faecal staining of the skin	**Definition:** Soiling of the skin with diarrhoea. **Interpretation:** When abnormal faeces are produced, the profuse production of more sticky diarrheic faeces can cause soiling of the skin surface, sometimes with a yellow coloration. The extent of faecal soiling of the skin has been used as an ABM with fair intra- and inter-observer reliability (Pfeifer et al., 2019). **Sensitivity/specificity:** The ABM is not sensitive: Most gastro-enteric disorders are strongly associated with skin fouling by faeces, but not in the case of subclinical gastric ulcers. The ABM is not specific: if there are no gastro-enteric disorders, pigs may still have their skin soiled by faeces because of lack of space or high ambient temperatures.
Body condition	**Definition:** The body condition reflects body reserves or fat accumulation of an animal. Body condition scoring is used to critically examine the nutritional status of a pig. **Interpretation:** Gastrointestinal disorders will frequently cause a loss in body condition. **Sensitivity/specificity:** The ABM is not sensitive: most gastro-enteric disorders are strongly associated with loss of body condition, but not in the case of subclinical gastric ulcers The ABM is not specific: if there are no gastro-enteric disorders, pigs may still lose body condition due to other health disorders or lack of food.
Soiling of floor	**Definition:** Soiling of the floor with diarrhoea. **Interpretation:** Enteric disease may result in an increased urge to defecate or urinate and consequent loss of differentiation of functional areas within the pen (Nannoni et al., 2020). The appearance of the faeces visible on the soiled floor allows identification of abnormal faeces production. **Sensitivity/specificity:** The ABM is not sensitive: most gastro-enteric disorders are strongly associated with floor fouling by faeces, but not in the case of subclinical gastric ulcers. The ABM is not specific: if there are no gastro-enteric disorders, pigs may still have their floor soiled by faeces because of lack of space or high ambient temperatures.

4. Assessment of the welfare of gilts and dry sows

Gilts and dry sows are housed in the same facilities, and thus, they experience the same highly relevant welfare consequences (which are described in Section 3.4). The welfare of gilts and dry sows is explored further in this chapter.

In Section 4.1, the welfare consequences that were identified as highly relevant are listed; for each of them, reasoning explaining its high relevance, the hazards that may lead to it and corresponding preventive, corrective and mitigation measures are described. Other welfare consequences may negatively affect the welfare of gilts and dry sows, but they were classified as less or moderately relevant compared to the highly relevant ones. An overview of the expert judgement on the welfare consequences is presented in Appendix B.

The husbandry systems for gilts and dry sows assessed in the General ToRs are individual stalls, indoor group housing and outdoor paddock systems and described in Section 3.3.2. In Section 4.2, the link between the highly relevant welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures in the three systems are presented (see Table 35). A comparison among the three systems is reported in Section 4.3.

The welfare of gilts and sows, from entering the service area until the end of the fourth week of pregnancy (Specific ToR 1) is further assessed in Section 4.4.

The welfare of pregnant gilts and sows, from the time they are transferred into the farrowing facilities up to the completion of farrowing (Specific ToR 2) is discussed in Section 5.7 together with the farrowing and lactating sows, as they share the same (farrowing) systems.

Sows that are not kept until farrowing but are culled are considered in Chapter 9 (Specific ToR 5).

Finally, **summary conclusions and recommendations** on the overall assessment of the welfare of gilts and dry sows are listed in Sections 4.5 and 4.6.

4.1. Highly relevant welfare consequences for gilts and dry sows: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5)

4.1.1. Restriction of movement

Restriction of movement was identified as highly relevant for gilts and dry sows housed in individual stalls. Conventional stalls prohibit sows and gilts from turning around, from adopting certain body postures and impede freedom of movement (high severity). Additionally, they cause continuous restriction of movement throughout the period animals are in individual stalls, which can last up to 28 days after service (long duration). All animals kept in this type of system are affected by this welfare consequence (high prevalence).

Hazards, preventive, corrective and mitigating measures

The hazards that could lead to this welfare consequence are listed below, together with potential preventive/corrective measures for each hazard that could mitigate the welfare consequence:

1) **Insufficient space:** inadequate space allowance is the main impediment of movement (e.g. to turn around), even if other conditions (e.g. health, enriched environment) are good overall.
   To prevent this hazard, sows and gilts should be housed in groups instead of individual stalls. No corrective measures were identified for this hazard because it would require changing the husbandry system to a group housing system (or theoretically, to larger individual stalls/pens).
2) **Poor floor quality:** flooring should ensure that sows move easily without incurring leg injuries. Floors fail in this regard because of poor maintenance (worn surface or broken slats) and/or design flaws (e.g. slat dimensions: slat too narrow/gap too wide; abrasive or slippery floors).
   To prevent this hazard, it is important to select and maintain appropriate flooring. This means that the slats, should be of good quality and be replaced when they become worn and/or broken. Solid floors should not be slippery or abrasive and also be maintained regularly. Corrective measures include the provision of adequate substrate on the floor: addition of bedding (straw, sawdust) or providing rubber mats.

4.1.2. Resting problems

The welfare consequence 'resting problems' was identified as having high relevance for gilts and dry sows kept in individual stalls because conventional stalls tend to be narrow and do not allow animals to lie laterally or to alternate easily between body postures, both of which preclude adequate resting (high severity). Individual stalls cause continuous resting problems throughout the entire period animals are kept in this system which can last up to 28 days (long duration). This welfare consequence affects all animals kept in this type of system (high prevalence).

Hazards, preventive, corrective and mitigating measures

1) **Insufficient space:** As described in 4.1.1, inadequate space allowance is the main impediment of movement and does not allow the sow to rest comfortably.
   Increasing the width of the stall or the height of the lowest bar and increasing the length to the rear gate could allow sows to more easily change posture and lie laterally, and therefore rest properly. No corrective measures were identified for this hazard because it would require changing to a group housing system (although theoretically, sows could be moved to a larger individual stall or pen).
2) **Poor floor quality:** flooring should allow sows to move easily and to rest comfortably. It is impossible for sows to achieve complete comfort while resting on concrete. However, sows prefer to rest on well-maintained solid floors compared to slatted floors.

To prevent this hazard, it is important to select and maintain appropriate flooring. This means avoiding hard and abrasive floors, providing a solid portion of concrete floor for lying and, if slatted, ensuring appropriate dimensions and maintenance such that broken parts do not hurt sows while lying. Flooring should also offer appropriate thermal properties, e.g. to minimise conductive heat loss at low temperatures. Corrective measures would include to add substrate on the floor or provide the sow with a rubber mat.

3) **Wet and dirty floor:** This refers to poor floor hygiene; if the floor is wet and dirty the sows cannot rest comfortably.
Preventive measures consist in selecting and maintaining appropriate flooring, including use of appropriate floor design and material, as well as management procedures that ensure that the floor is kept clean and dry. Corrective measures are to clean the floor and/or provide bedding, if possible, with floor design.

4.1.3. Group stress

Group stress was identified as highly relevant (high severity, long duration, high prevalence) in all three husbandry systems that were fully assessed in the General ToRs for gilts and dry sows: individual stalls, indoor group housing and outdoor paddock systems.

When housed in individual stalls, gilts and sows are in close proximity to other individuals, despite the physical separation between stalls. Such proximity, which allows visual contact but provides no room for hiding or keeping a distance from animals that are perceived as threatening, can be especially intimidating for gilts or younger sows housed near older animals. Similarly, for sows or gilts neighbouring other individuals of similar ranking, there is no effective way of establishing the hierarchy and tension between individuals is sustained (Marchant et al., 1997). For more details, see also Section 3.4.3. For this reason, 'group stress' was ranked as highly relevant for animals kept in individual stalls. Due to the inability to resolve the dominance rank order, such stress has a continuous effect throughout the period animals are kept in individual stalls, which in the EU is legally allowed to last up to 28 days (long duration) and may affect all animals kept in this type of system (high prevalence).

Group stress was also identified as highly relevant for grouped-housed gilts and sows kept indoors or in outdoor paddock systems. There are two primary causes of group stress: 1, the need to establish a social hierarchy, and 2, competition for access to resources. Regarding the first cause, rank order fights are potentially severe, but are usually seen only during the first 2 days after mixing of unfamiliar animals. After this period, the social hierarchy is established, and rank order fights rarely occur. Aggression over access to resources (e.g. food, water, lying space) may occur throughout the entire pregnancy (long duration) whilst animals are in the group housing system. Medium ranking animals are subjected most to fights over resources, and dominants and subordinates to a lesser extent (medium prevalence). However, subordinates are more affected if resources are limited and if they have to compete with the medium ranking animals.

Hazards, preventive, corrective and mitigating measures

1) **Inability to show submission or otherwise avoid aggression:** it is relevant to all three systems as it relates to the presence of aggressive sows in the group or in adjacent stalls and to the lack of space; it might therefore affect animals in stalls as well as in group-housing systems.
In individual stalls, the use of protective features, e.g. vertical-barred barriers, can act as preventive measures. Visual barriers might be helpful in group housing systems, as well as increasing the space allowance, to provide avoidance and escape possibilities (e.g. straw bales, barriers, outdoor areas) and ensure that there are designated areas for different activities.
In group housing, a corrective measure is to remove sows to increase the space available or, in all cases, to remove the aggressive or bullied sows and to treat the affected (e.g. injured) sows.
2) **Socially unstable groups** (relevant to all three systems): Unstable/dynamic groups, in which the social hierarchy is not established, are associated with aggressive behaviour, subsequent lesions and injuries and a negative affective state.
Preventive measures are to minimise mixing and, if mixing is needed, to facilitate subgrouping behaviour and the ability of individuals to hide or flee during the period after mixing. A specialised mixing pen with sufficient space and hiding opportunities could be used during the first few days after mixing unfamiliar animals. For stall housed animals, a preventive measure is to minimise the relocation of sows causing unfamiliarity of neighbours. Corrective measures are required before serious injuries occur and include

removal of the aggressive or bullied sows. Injured sows may need treatment.

3) **Insufficient access to resources** (relevant to indoor group housing and outdoor paddock systems): Aggression over resources may result from the limited access to the resource, or from limited availability of the resource.
Preventive measures aim at minimising competition for resources and include spatial separation of limited resources (e.g. drinkers and feeding troughs), wider distribution of feed (e.g. in floor feeding systems), increasing the amount of the resource which is offered (e.g. lying space, straw or feed), or provide protected individual feeding facilities and improve access to the feeding systems, to ensure correct rationing, respectively. Corrective measures include removing the aggressive or bullied sows, increasing limiting resources (e.g. enrichment) and/or access to resources and treating the injured sows. If the consequence is serious, the animals should be isolated in hospital/separation pens (see Section 3.3.8).

4.1.4. Inability to perform exploratory or foraging behaviour

Inability to perform exploratory or foraging behaviour was classified as highly relevant for gilts and dry sows kept in individual stalls and in indoor group housing.

In individual stalls, exploration is almost impossible due to the very limited space available. In addition, individual stalls typically have slatted/concrete floors with no bedding, which further limits opportunities for foraging or exploring. Even if enrichment items such as ropes are provided, they are likely to give few opportunities for meaningful exploration (high severity). This welfare consequence has a continuous effect throughout the time animals are kept in individual stalls (long duration) and affects all animals kept in this system (high prevalence).

In indoor group housing, exploratory or foraging behaviour is possible if appropriate substrates are provided as bedding or in other ways (such as in racks), but this tends to be rare in indoor housing systems in Europe. The limited indoor space with absence of bedding or other environment enriching materials results in very few opportunities for performing exploration or foraging activities (high severity). As in the case of individual stalls, this welfare consequence has long duration and high prevalence in indoor group housing.

Hazard, preventive, corrective and mitigating measures

Absence or inadequate access to appropriate enrichment/foraging material (relevant to individual stalls and indoor group housing): Exploratory behaviour is an intrinsic need of pigs, and provision of an adequate amount of appropriate enrichment material is a preventive and corrective measure. Council Directive 2008/120/EC states that pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities. In group housed pigs, this means that any individual should be able to access the material when motivated to do so (Commission Recommendation (EU) 2016/336[26]). This material should be clean and regularly replaced/replenished, and should have one of more of the following characteristics – be edible or feed-like, chewable, investigable (e.g. rootable) and/or manipulable (e.g. the pig can change its location, appearance or structure) (Commission Recommendation (EU) 2016/336).

This material can be provided as bedding or in a rack/dispenser (e.g. straw, hay), or suspended/attached to pen fixtures (e.g. wood, natural rope). In systems with fully slatted floor, it is more difficult to provide appropriate enrichment materials as these easily fall through the slats, and therefore commonly only e.g. objects attached to pen features are used. A preventive measure is to consider solid or partly slatted flooring when designing the system. As a corrective and mitigating measure, a rubber mat can be provided in a specific area of the pen to allow provision of enrichment materials on the floor.

The need for enrichment by sows and gilts in days shortly before farrowing is discussed in the section on the farrowing systems (Section 5.7).

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[26] Commission Recommendation (EU) 2016/336 of 8 March 2016 on the application of Council Directive 2008/120/EC laying down minimum standards for the protection of pigs as regards measures to reduce the need for tail-docking. OJ L 62, 9.3.2016, p. 20–22.

4.1.5. Prolonged hunger

Prolonged hunger was classified as having high relevance in all three husbandry systems that were fully assessed for gilts and dry sows: individual stalls, indoor group housing and outdoor paddock systems.

Regardless of the system, all pregnant gilts and sows experience hunger due to the fact that they are fed restricted on a concentrate diet. This supplies the nutrients required for good health and performance but fails to induce satiety due to inadequate bulk and limited time spent in appetitive and consummatory behaviours. For this reason, prolonged hunger tends to occur across all housing systems (individual stalls, indoor and outdoor group housing) that do not provide food ad libitum or a bulky diet, as is typically the case in Europe (high severity, high prevalence). Prolonged hunger persists throughout gestation (long duration) and can be a cause of serious aggression in group-housed sows. It may also lead to inequitable intake of nutrients in housing systems with no individual feeding (i.e. where an allowance for the whole group is provided, which is consumed disproportionately by those animals higher up in the hierarchy).

Hazards, preventive, corrective and mitigating measures

1) **Insufficient nutrients supplied** (relevant in all the three systems): This can arise from an inadequate amount of diet or a diet which is imbalanced in nutrients. The feeling of hunger and the induction of feeding motivation can result from inadequacy in both macronutrients (energy, protein) and micronutrients (minerals, specific amino acids, trace elements) since pigs can detect specific deficiencies within their diet.
   Preventive measures are to correctly calculate and supply a diet which meets all the metabolic needs for nutrients. These measures can be used also to correct the hazard.
2) **Unsatisfying diet form and inability to functionally express foraging motivation** (relevant in all three systems): Even when the diet provides adequate nutrients, if these are given in a concentrated form which is low in bulk and consumed in a short time, the animal will not feel behaviourally satiated (Lawrence and Terlouw, 1993; D'Eath et al., 2018). In these circumstances, feeding motivation will remain high and, if this cannot be expressed in an appropriate form of appetitive behaviour (searching, rooting, chewing), then abnormal behaviours (aggression, stereotypies) can result.
   Preventive as well as corrective measures are to increase dietary bulk and prolong feeding time by reducing nutrient density and increasing dietary fibre, which gives prolonged fermentation in the gut. This may be done by modifying the composition of the concentrate diet or by giving additional access to bulky feedstuffs such as straw/hay, silage or root vegetables. Providing substrate to allow appropriate expression of foraging behaviour will help to prevent unsatisfied feeding motivation redirected as undesirable abnormal behaviour. Outdoor sows can forage and root in soil (if not fitted with nose rings) but for indoor sows provision of straw or manipulable material is necessary.
3) **Competition for access to feed** (relevant in indoor group housing and outdoor paddock systems): Because the provision of feed ad libitum to fully satiate sows in most circumstances will cause obesity, some degree of hunger is always likely to exist in pregnant sows. As a result, there will be competition for access to the feed which is provided. If the feeding system does not sufficiently prevent 'stealing' of feed, inequality of intake within a group can result in less competitive individuals receiving a significantly lower share of the group allowance and experiencing disproportionately greater hunger.
   Preventive measure is to ensure the access of all individuals to their allocated amount of feed, and protection while eating this, by installing an appropriate individual feeding system (lockable feeding stall or transponder feeding system). Where a fully protected feeding system is not possible, partial protection through head and shoulder dividers at a trough, or very wide distribution of feed in the case of floor feeding could help. In this case, grouping sows with others of similar age and size, will allow having a more similar eating speed. Corrective measure is to improve the feed distribution and to remove sows which are not able to successfully compete for access within their group to alternative accommodation where higher intake can be ensured.
4) **Insufficient water intake** (relevant to all three systems): Insufficient water intake will not only give rise to the welfare consequence of thirst but will also cause sows to reduce their feed intake. Insufficient water intake can occur if drinkers are absent or malfunctioning

(blockage or low flow rate), if social competition restricts access, or if the water provided is not potable (high mineral content, contamination).
Preventive measures are to ensure the adequate and continuous access to water of appropriate quality, by ensuring that drinkers work properly, that they are clean, easily reachable and in sufficient number considering the number of animals in the group. Corrective measures are the fixing of issues related to water supply and water distribution, and the provision of alternative drinking water if water quality is compromised.

4.1.6. Locomotory disorders (including lameness)

The welfare consequence 'locomotory disorders (including lameness)' was identified as having high relevance for gilts and dry sows kept in indoor group housing. Indoor group housing systems tend to have slatted flooring with no bedding, and vigorous interactions between sows can result in slipping and twisting movements, often leading to lameness problems (high severity). Locomotory disorders tend to occur through the period sows and gilts are kept in group housing (high duration) and affects many animals in these systems (high prevalence). Whilst locomotory problems are prevalent also in stalls, the welfare consequence related to inability of lame animals to access resources is less severe here than in groups.

Hazards, preventive, corrective and mitigating measures

1) **Poor flooring design:** Claw injuries can be caused on slatted floors where the slat width is too narrow, putting high pressure on points on the sole, or the gap width is too great, causing trapping and twisting of the claw or tearing of the dew claw. Injuries can also be caused by sharp slat edges, or abrasive solid flooring. A floor material which does not provide good foothold will increase the risk of slipping. If there are no areas of hard/abrasive flooring, as in deep bedded systems, claw wear may be inadequate to prevent claw overgrowth.
   Preventive measures are to select and maintain appropriate flooring, e.g. slat design and material. Corrective measures are to provide adequate substrate on solid floors if slippery or abrasive, and to carry out trimming of overgrown claws.
2) **Floor hygiene:** Poor floor hygiene may make floors more slippery. Flooring permanently covered with excreta will also cause softening and weakening of the hoof and will act as a reservoir of pathogenic agents which enter through any cuts or abrasions and cause local or systemic infections.
   Preventive measures are to provide adequate drainage, plan appropriate cleaning management and design the pen layout and room ventilation so that sows are encouraged to develop distinct functional areas, separating excretion from other activities. Corrective measures are to increase cleaning frequency, and on solid floors to provide fresh bedding more frequently or in greater quantity to soak up moisture.
3) **Lesions and infectious disease:** lameness may be caused by infectious diseases such as erysipelas or by ingress of pathogenic agents through damaged tissue.
   Preventive measures include internal biosecurity measures (e.g. frequent manure removal) and to ensure a non-injurious environment through optimal floor quality/integrity, regular claw trimming and appropriate vaccination program. As corrective measures, more bedding can be provided. Affected animals need to be treated or euthanised if not responding to treatment.
4) **Aggressive behaviour between sows:** sows engaging in or receiving aggression may slip, twist or fall during sudden or uncontrolled movements.
   Preventive measures are to minimise the occurrence of situations leading to aggression, such as mixing of unfamiliar animals or competition for resources. Where mixing is necessary, use of a specialised mixing pen with greater space, non-slip flooring and hiding possibilities can reduce risk of injury. Designing pen layouts to provide for subgrouping behaviour may also reduce the frequency of fights.
5) **Occurrence of oestrus behaviour:** during oestrus sows will mount and ride other sows which can result in injuries to both the actor and recipient through slipping, falling and twisting.
   Preventive measures are to group sows of similar size and weight, to provide flooring with good grip and space to avoid or escape from the attentions of animals in oestrus.

6) **Genetic predisposition:** leg conformation and the predisposition to show joint disorders such as osteochondrosis have a genetic component.
Preventive measures are to choose replacement gilts from genetic stock selected against such leg problems and to cull gilts with poor leg conformation prior to entry into the breeding herd. Where lean and fast-growing genotypes are used, these should be managed nutritionally during rearing to restrict their growth rate.
7) **Inappropriate nutrition:** A high plane of nutrition during gilt rearing can predispose to leg problems after breeding. A diet for breeding animals which contains inadequate levels, or an imbalance, of calcium and phosphorus will result in weaker bone development, whilst deficiencies in micronutrients such as biotin can affect claw strength.
Preventive measures are to ensure an appropriate plane of nutrition and diet formulation for the genotype in use, consulting a specialist nutritional advisor. Monitoring the herd prevalence of locomotory disorders and reviewing/changing the diet as a corrective measure if an increasing problem is detected should be a routine management procedure.

The most important measure to mitigate the welfare consequence is to isolate and treat affected animals. Early detection of slight abnormalities in locomotion is important, potentially acting as an early warning sign of a developing lameness disorder (Lagoda et al., 2021). Early detection allows corrective measures to be applied at a stage when it is likely to be more effective (Conte et al., 2015), consequently reducing the likelihood of chronic problems and the risks to sow welfare and reproductive performance. Monitoring the herd prevalence of locomotory disorders and reviewing possible hazards if an increasing problem is detected should be a routine management procedure.

4.1.7. Soft tissue lesions and integument damage

The welfare consequence ‘soft tissue lesions and integument damage’ (which includes lesions in various parts of the body and, specifically in the case of sows, also of the vulva) was classified as having high relevance for gilts and dry sows kept in indoor group housing. These types of lesions, especially the deeper ones, often lead to severe pain (high severity). They can be more common in groups kept in small spaces and occur more frequently in dynamic groups compared to static ones, as a result of aggression activities to establish social dominance (high prevalence). They can occur throughout the time gilts and sows are kept in groups (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Inability to show submission or otherwise avoid aggression:** this hazard relates to the presence of aggressive sows in the group, in combination with a lack of space to allow aggression avoidance behaviour by receiving animals.
The use of physical and visual barriers in the pen (e.g. straw bales, barriers, outdoor areas) may be helpful, in addition to increasing the space allowance, to provide avoidance and escape possibilities. These features are incorporated in the design of specialised mixing pens (see Figure 10). It is possible that physical structures in the pen may also allow for clearer separation of functional areas and thus reduce aggression, provided they are not causing a barrier to fleeing sows. Corrective measures are to remove sows to increase the space available, and to remove aggressive (bullying) sows.
2) **Socially unstable groups**: Unstable and dynamic groups in which the social hierarchy has not been fully established are associated with aggressive behaviour, resulting in lesions and injuries and a negative affective state.
Preventive measures are to minimise mixing and, if mixing cannot be avoided, to facilitate subgrouping behaviour and the ability of individuals to hide or flee during the period after mixing. A specialised mixing pen with sufficient space and hiding opportunities could be used during the first few days after mixing unfamiliar animals. Corrective measures are required before serious injuries occur and include removal of the aggressive or bullied sows.
3) **Insufficient access to resources:** Aggression over resources may result from limited access or limited availability of the resource. Limited access may occur e.g. if one animal can dominate all access points to the resource (e.g. when feeders are too close together). Limited availability means there is not enough of the resource (such as insufficient space to rest properly).

Preventive measures include spatial separation of limited resources (e.g. drinkers and feeding troughs), wider distribution of feed (e.g. in floor feeding systems) or increasing the amount of the resource which is offered (e.g. lying space or straw). Corrective measures include removing the aggressive or bullied sow and increasing limiting resources.

4) **Hunger:** Hunger in combination with restricted access to food may result in increased aggression and lesions. It seems that restriction of access to feed itself (compared to unrestricted ad libitum feeding) will result in increased aggression, in particular if sows need to compete for access to the feeder/food. Epidemiological evidence suggests an association between low body condition in a herd and the level of aggression which occurs (Edwards, 1992).

   Preventive measures include ad libitum feeding, and the provision of a safe feeding place to reduce competition for access or reduce aggression during feeding. Corrective and mitigating measures consist of removing bullying or bullied sows.

5) **Poor floor quality:** The effects on lesions of aggression related to dominance or resources can be exacerbated by poor quality flooring or pen maintenance. Floor quality (including slipperiness) will affect the grip that sow feet have on the floor whilst engaging in aggressive or avoidance behaviours. Poor slats may injure claws, and a slippery floor may cause animals to slide or fall.

   Provision of a substrate may help to absorb moisture. Pen maintenance, in particular related to protruding elements, may also have a direct effect on soft tissue lesions. Preventive measures include the selection and maintenance of appropriate flooring and pen fixtures. Corrective measures consist in repairing damaged pen features and providing adequate substrates to increase grip.

4.2. Outcome table on the welfare of gilts and dry sows

Table 35 presents an overall outcome on the elements requested by the General ToRs on the welfare of gilts and dry sows: identification of the relevant welfare consequences and related ABMs, hazards and relevant preventive, corrective or mitigating measures. This relates to the three husbandry systems for gilts and dry sows that were fully assessed in the General ToRs (individual stalls, indoor group housing and outdoor paddock systems).

Table 35: Welfare of gilts and dry sows: outcome table linking the highly relevant welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures in the three husbandry systems that have been fully assessed in the General ToRs (individual stalls, indoor group housing, outdoor paddock systems). Cross-reference to the sections describing the welfare consequences and related ABMs, and husbandry systems is provided

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Restriction of movement **(overall description: Section 3.4.1; details in Section 4.1.1)**	Individual stalls Section 3.3.2.2)	– Insufficient space	– Change to a group housing system	None	**(Table 12 – Section 3.4.1)** – Nest-building behaviours – Locomotory behaviour – Lying behaviour – *Posture changes* – *Atypical lying down movements (mainly in sows)* – *Pressure injuries (shoulder ulcers, calluses and bursitis)* – *Dewclaw injuries*
		– Poor floor quality	– Select and maintain appropriate flooring	– Provide adequate substrates or rubber mats on the floor	
Resting problems **(overall description: Section 3.4.2; details in Section 4.1.2)**	Individual stalls (Section 3.3.2.2)	– Insufficient space	– Change to a group housing system – Match the size of stalls to sows' needs	None	**(Table 14 – Section 3.4.2)** – Lying behaviour – Pressure injuries: shoulder ulcers, calluses and bursitis – *Pig cleanliness*
		– Poor floor quality	– Select and maintain appropriate flooring – Have more solid flooring	– Provide adequate substrates or rubber mats on the floor	
		– Wet and dirty floor	– Select and maintain appropriate flooring	– Clean the floor and/or provide bedding, if possible with floor design	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Group stress **(overall description: Section 3.4.3; details in Section 4.1.3)**	All three systems: – Individual stalls (Section 3.3.2.2) – Indoor group housing (Section 3.3.2.3) – Outdoor paddock systems (Section 3.3.2.5)	– Inability to show submission or otherwise avoid aggression (relevant to all three systems)	– Increase space allowance (no stalls) – Provide avoidance and escape possibilities (e.g. straw bales) * (no stalls) – Provide protective features (e.g. vertical bars in stalls, visual barriers in group housing systems) – Ensure that there are designated areas for different activities	– Remove sows to increase the space allowance per animal (no stalls) – Remove aggressive or bullied animals – Treat affected sows (e.g. injured)	**(Table 16 – Section 3.4.3)** – Agonistic behaviour – Skin lesions – Body condition – *Abnormal gait* – *Claw lesions*
		– Socially unstable groups (relevant to all three systems)	– Minimise mixing occasions – Provide for subgrouping behaviour – Minimise the relocation of sows causing unfamiliarity of neighbours (stalls) – Utilise mixing pen – Group animals of similar size	– Remove aggressive or bullied animals – Treat affected animals (e.g. injured)	
		– Insufficient access to resources (relevant to indoor group housing and outdoor paddock systems)	– Minimise competition for resources – Spatial separation of limited resources – Wider distribution of feed – Increase the amount of the resource (lying space, enrichment, feed)	– Remove aggressive or bullied animals – Increase limiting resources and access to resources – Treat affected animals (e.g. injured), if consequence is serious	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
			– Provide protected individual feeding facilities and improve access to the feeding systems, to ensure correct rationing	then isolate the animal (hospital/separation pens)	
Inability to perform exploratory or foraging behaviour **(overall description: Section 3.4.6; details in Section 4.1.4)**	– Individual stalls (Section 3.3.2.2) – Indoor group housing (Section 3.3.2.3)	– Absence or inadequate access to appropriate enrichment/foraging material (relevant to both systems)	– Provide enrichment and foraging material* (for solid floor systems) – Provide part solid floor when offering loose materials (both systems) – Use systems with solid or partly slatted floor	– None in (slurry based) stall systems – Provide a rubber mat in a specific area of the pen to allow provision of enrichment materials on the floor (for slurry based group housing systems)	**(Table 20 – Section 3.4.6)** – Exploratory behaviours directed at enrichment material – Exploratory behaviour directed to pen-fittings – Re-directed exploratory behaviour, towards pen mates – Stereotypic behaviour – *Skin lesions on body parts other than tail and ears*
Prolonged hunger **(overall description: Section 3.4.9; details in Section 4.1.5)**	All three systems: – Individual stalls (Section 3.3.2.2) – Indoor group housing (Section 3.3.2.3) – Outdoor paddock systems (Section 3.3.2.5)	– Insufficient nutrients supplied (relevant to all three systems)	– Calculate and supply nutrient needs*		**(Table 24 – Section 3.4.9)** – Stereotypic behaviours – *Body Condition*
		– Unsatisfying diet form and inability to functionally express foraging motivation (relevant to all three systems)	– Increase dietary bulk and prolong feeding time* – Provide fibrous diet, *ad libitum* feeding of low density diet* – Provide foraging material* (mainly indoor systems)		

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Competition for access to feed (indoor group housing and outdoor paddock systems)	– Improve access to the feeding systems* – Provide protection while eating	– Remove sows which are not able to successfully compete for access to feed	
		– Insufficient water intake (relevant to all three systems)	– Ensure adequate and continuous access to appropriate quality water*	– Provision of alternative drinking water if water quality is compromised	
Locomotory disorders (including lameness) **(overall description: Section 3.4.13; details in Section 4.1.6)**	Indoor group housing (Section 3.3.2.3	– Poor flooring design	– Select and maintain appropriate flooring	– Provide adequate substrates – Claw trimming	**(Table 30 – Section 3.4.13)** – Abnormal gait – *Claw lesions* – *Overgrown claws* – *Calluses and bursitis*
		– Floor hygiene	– Provide adequate drainage – Plan appropriate cleaning management – Design the housing to encourage the use of functional areas	– Provide appropriate cleaning – Replace old bedding	
		– Lesions and infectious disease	– Ensure external and internal biosecurity – Ensure optimal floor quality/integrity – Claw trimming* – Appropriate vaccination program	– Isolate and treat affected animals – Provide more bedding – Euthanasia if not responding to treatment	
		– Aggressive behaviour between sows	– Minimise mixing occasions – Provide for subgrouping behaviour – Utilise mixing pen – Minimise competition for resources	– Isolate and treat affected animals	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Occurrence of oestrus behaviour	– Group animals of similar size – Provide escape possibilities	– Isolate and treat affected animals	
		– Genetic predisposition	– Choose gilts with good leg conformation and selected against osteochondrosis – Manage the rearing of fast-growing genotypes	– Isolate and treat affected animals	
		– Inappropriate nutrition	– Ensure appropriate diet formulation	– Change the diet formulation	
Soft tissue lesions and integument damage **(overall description: Section 3.4.14; details in Section 4.1.7)**	Indoor group housing (Section 3.3.2.3)	– Inability to show submission or otherwise avoid aggression	– Provide protective features (e.g. visual barriers) – Increase space allowance – Provide avoidance and escape possibilities (e.g. straw bales) * – Provide sufficient designated resting areas – Utilise mixing pen	– Remove sows to increase the space allowance per animal – Remove aggressive or bullied animals	**(Table 32 – Section 3.4.14)** – Body lesions – Vulva lesions – Leg injuries – Shoulder ulcers – Bursitis
		– Socially unstable groups	– Minimise mixing occasions – Provide for subgrouping behaviour – Utilise mixing pen – Group animals of similar size	Remove aggressive or bullied animals	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) for the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Insufficient access to resources	– Spatial separation of limited resources – Provide wider distribution of feed – Increase the amount of the resource (lying space, enrichment)	– Remove aggressive or bullied animals – Increase limiting resources and access to resources	
		– Hunger	– Feeding ad libitum – Provision of a safe feeding place	– Remove aggressive or bullied animals	
		– Poor floor quality	– Select and maintain appropriate flooring – Provide adequate substrates*	– Repair damaged pen features	

*: The preventive measures that may also be used to correct an ongoing problem have been marked with a star key (*).
**: The ABMs considered neither sensitive nor specific (see Section 3.4) are presented in 'Italics' but for information purposes only and are not recommended to be used in practice.

4.3. Comparison of the systems for gilts and dry sows

The welfare aspects of the three gilt and dry sow systems can be compared based on the information in Section 4.1 and Table 35. A welfare consequence which is common to all three systems is 'Prolonged hunger', which in all systems can lead to stereotypic behaviour. In the two group housing systems, it is also associated with aggression when competing over access to food. Another welfare consequence that all three systems have in common is 'Group stress'. In the two group housing systems, this may be mainly related to access for resources (food, lying space) following the establishment of a dominance hierarchy. In individual stall housing, competition over access to resources is not an issue, but the rank order between neighbouring sows can often not be resolved and group stress persists. The main drawbacks of stall housing are related to two other welfare consequences: 'Restriction of movement' and 'Resting problems'. For indoor group housing systems, they are 'Locomotory disorders' and 'Soft tissue lesions'. Finally, the welfare consequence that is shared by the two indoor systems (stalls and group housing) is 'Inability to perform exploratory and foraging behaviour'. This is considered not to be a highly relevant welfare consequence in outdoor group housing systems which offer a more enriched and diverse environment. The comparison between the systems can be found in Table B.1, in Appendix B.

4.4. Assessment of Specific ToR-1: The welfare of gilts and sows – from entering the service area until the end of the fourth week of pregnancy

As explained in the interpretation of ToRs, Specific ToR 1 refers to gilts and dry sows, from entering the service area until the end of the fourth week of pregnancy. Council Directive 2008/120/EC allows these animals to be kept in individual stalls during these 4–5 weeks, after which they have to be housed in groups. The exposure variable that is considered relates to the timing of moving individually housed sows into a group, relative to the moment of service. This was labelled 'grouping time'.

4.4.1. Background

Currently, in the EU, pregnant gilts and sows can be housed in stalls until 28 days post-service (Council Directive 2008/120/EC) but some Member States have stricter legislative restrictions on the use of stalls (see Section 3.3.2.2 for further details).

The common rationale for keeping sows in stalls for the first month post-service is to protect them from stressors associated with grouping and social competition during the early phase of pregnancy and to promote embryo survival (Spoolder et al., 2009), as discussed in Section 4.4.6. However, the adverse impact on sow welfare of close confinement in gestation stalls is clear (SVC, 1997). In short, their ability to move and socialise is severely restricted, as is their ability to perform sexual behaviour if housed in stalls post-weaning. EFSA (2007b) concluded that keeping sows in individual stalls is inevitably associated with poor welfare; stalls severely restrict sow movement to the extent that they have difficulty lying down and standing up. Against this background, the European Citizens' Initiative (End the Cage Age, 2018) calls for an end to the use of stalls for pregnant gilts and sows.

The welfare consequences that EFSA experts identified as highly relevant (based on severity, duration and frequency of occurrence) for gilts and dry sows kept in stalls are described elsewhere in this opinion. They are restriction of movement, resting problems, group stress, inability to perform exploratory or foraging behaviour and prolonged hunger (see Sections 3.4 and 4.1).

There are other relevant welfare consequences that were not identified as highly relevant in the common ToRs for sows and gilts in stalls. They include heat and cold stress, and the inability to perform comfort behaviour. Under total confinement in stalls, sows cannot move from a location where they feel cold, or hot, to a more comfortable thermal environment nor can they maintain a distinct and separate location for excretion away from their lying area (SVC, 1997). The performance of sexual behaviour is also thwarted if gilts and sows are introduced to stalls at the onset of oestrus as they are unable to express oestrous behaviour. While there are no studies investigating the welfare implications of sows' inability to express this behaviour if housed in gestation stalls, Algers et al. (2007) suggested that it likely causes stress and frustration. Inability to express sexual behaviour was not identified as a highly relevant welfare consequence because it is experienced for a limited period of time (short duration). Separation stress is a welfare consequence potentially relevant for gilts, as housing in gestation stalls either from the onset of oestrus or from the time of breeding often represents their first experience of close confinement and separation from a group. Unsurprisingly, gilts show an intense behavioural reaction on first introduction to gestation stalls resulting in injuries, particularly to the forelimbs (Boyle et al., 2002a). Similar to inability to express sexual behaviour, separation was not identified as a highly relevant welfare consequence because it is experienced only by gilts and for a limited period of time (low occurrence and short duration). An overview of the expert judgement on the welfare consequences that may affect the welfare of gilts and dry sows in stalls is presented in Appendix B.

There are measures to mitigate some of the above welfare consequences (e.g. resting problems can be mitigated by cleaning the floor and/or providing bedding). However, most welfare consequences cannot be mitigated except by moving the animals from stalls into a group-housing system (e.g. restriction of movement) (see Sections 4.1 and 4.2 for more details).

4.4.2. Introduction

There is higher potential for better sow (and gilt) welfare under optimal group housing conditions compared to housing in stalls (Broom et al., 1995). However, many commercial group-housing systems severely challenge animal welfare, particularly if fully slatted, with lameness as a major problem (KilBride et al., 2009c; Cador et al., 2014; Calderón Díaz et al., 2014). Furthermore, Karlen et al. (2007) found that sows in large groups on deep litter faced more welfare challenges in the early stages of gestation than sows in stalls, based on indicators related to the consequences of aggression (higher skin lesions, rates of return to oestrus and cortisol levels).

Aggression associated with establishment of the dominance hierarchy during mixing or grouping of sows causes an increase in cortisol (e.g. Ison et al., 2014). Cortisol is the primary mediator between the hypothalamic-pituitary-adrenal and the hypothalamic-pituitary-gonadal (HPG) axes, wherein the activation of one affects the function of the other and vice versa. The release of cortisol has an inhibitory effect upon gonadal hormone secretion (Toufexis et al., 2014) and can disrupt reproductive processes at the level of the brain or the ovaries (Einarsson et al., 1996; Toufexis et al., 2014). Hence, chronic stressors that elevate cortisol prior to implantation could potentially result in embryonic losses and increase the number of mummified fetuses and stillbirths later in pregnancy and at farrowing, respectively (Turner et al., 2005; Turner and Tilbrook, 2006).

Implantation or attachment is a particularly cortisol-sensitive period in the reproduction cycle in pigs that occurs from approximately day 11 to day 16 after service when the embryos implant in the uterine wall, with the associated maternal recognition of pregnancy (Spoolder et al., 2009). Stress during this stage could potentially cause attachment or implantation failures leading to loss in litter size or a complete loss of the pregnancy (Spoolder et al., 2009). However, these authors report that there is little compelling evidence to support this theory in the scientific literature on different grouping times.

Nevertheless, there is clearly good reason to avoid the potential detrimental effects of stress on pregnancy. One way to achieve this is to group sows after weaning, as is done in countries such as Sweden and the UK (Kemp and Soede, 2012). Under such circumstances, there is intense behavioural activity when sows and gilts enter oestrus which corresponds to their desire to seek a boar (Signoret et al., 1970) and includes male-like sexual behaviour characterised by pursuing, nosing and mounting other females and social activity including nose to body contact (Pedersen et al., 1993). These behaviours are so intense that appetite might even be suppressed/depressed (Friend, 1971, 1973). In response to the sound, smell, sight and eventually nuzzling of a boar, the sow or gilt assumes a rigid, immobile, receptive stance known as 'standing heat' (Signoret, 1970). Given its intensity, oestrous behaviour could exacerbate welfare consequences carried over by sows from the farrowing facilities (see Section 3.4). However, there is no consideration of this issue in the literature.

The aim of this scientific assessment is to define the conditions under which we can support the phasing out of gestation stalls before day 28 of gestation and how to mitigate the behavioural, physical and physiological (welfare) implications of grouping sows and gilts. Specifically relating to sows, another aim was to characterise their condition at weaning as this could influence the conditions under which phasing out of gestation stalls before day 28 of gestation can be supported.

Hereafter in the assessment of this Specific Scenario, the term 'sows' is used to describe both gilts and sows, unless otherwise specified; in addition, the term 'grouping' is used in place of 'mixing' (both are synonymous).

4.4.3. Approach

The first step to address this Specific ToR was to characterise the period under consideration (see Section 4.4.4). After that, three exercises were conducted to achieve the aims outlined above.

The first exercise was to characterise the physical, psychological and physiological condition of sows post-weaning supported by information available in the literature (see Section 4.4.5).

Secondly, an extensive literature search (ELS) was carried out to identify scientific evidence reporting welfare implications of grouping sows and associated ABM(s) (see Section 2.2.1.2). Details of the literature search strategy and results are reported in Appendix B. Relevant data on ABM(s) with strong relationship to the exposure variable 'grouping time' were extracted and analysed. Results of the ELS are reported in Section 4.4.6.

Thirdly, an expert consensus exercise identified the welfare consequences of grouping sows in the period under consideration. These are described in Section 4.4.7 together with general principles of grouping sows and the measures that can be used to prevent and mitigate them, thereby facilitating grouping of sows from weaning.

4.4.4. Characterisation of the period under assessment

For the above-mentioned second and third exercise, the focus is on the period immediately prior to service through the first month (28 days) of pregnancy; a period of ~ 5 weeks in total. The period prior to service, a period of ~ 4–5 days, includes the early post-weaning period (for sows only), and the oestrous period for both sows and gilts. In order to facilitate the structured assessment and presentation of the results of these two exercises, four distinctly separate periods or 'stages' corresponding to the specific physiological status of the sow were characterised, namely: 1. Pre-service, 2. Week 1 post-service, 3. Weeks 2 and 3 post-service and 4. Week 4 post-service.

For sows, stage 1 represents the time from the day of weaning (day -4) to the day of service (day 0). A number of factors influences the exact number of days from weaning until a sow enters oestrus but it is usually around 4 days. Stage 1 also applies to gilts although 'the day of weaning' clearly does not. There is considerable variation between farms in the way in which gilts are managed prior to service and hence in the number of days that correspond to the 'preservice' stage for gilts. We will not attempt to describe the myriad of practices in this document.

Stage 2 relates to the day of the first service (day 0) until 7 days post-service and applies to both sows and gilts. Females typically receive at least two inseminations during oestrus or standing heat, as the precise time of the onset of oestrus is rarely known. This helps ensure that sperm are present at an optimum time relative to ovulation for fertilisation to occur. Hence, females are typically inseminated about 12 h after the beginning of standing oestrus is observed and again 18–24 h after the first insemination.

Stage 3 corresponds to the period from day 8 to 21 post-service and it is considered the most sensitive period for embryo survival in the reproductive cycle; this is when the blastocysts elongate into long (2–3 feet), stringy masses, and begin to attach to, or implant in, the uterine wall accompanied by maternal recognition of pregnancy.

Stage 4 represents the time when pregnancy is confirmed or contradicted. Pregnancy failed if sows return to oestrous ('standing heat') at around 21 days post-service and pregnancy is indicated if sows do not show oestrus in the period from day 21 to day 28 post-service and this is then confirmed by pregnancy diagnosis. Death of the embryos at any stage before 16 days post insemination, i.e. before implantation, results in embryo reabsorption (resorption) and the sow returns to oestrus (around 21 days post-service), without showing any other perceivable sign (Madec, 2009). In this case, sows are either re-inseminated or culled.

4.4.5. Condition of the sow post-weaning

For sows, the lactation period is risky and it represents the stage of the production cycle when they are at their highest risk of dying or experiencing consequences leading to being removed from the herd at weaning and culled (Sasaki and Koketsu, 2008). This mainly reflects the risks associated with farrowing but also the intensity of the metabolic stress that sows are under during this time (Anil et al., 2006). As lactation progresses and the energy demands become more intense, sows mobilise their body reserves (Quesnel and Prunier, 1995). They enter a catabolic state, facilitating the mobilisation of body fat into milk (Uvnäs-Moberg, 1989) which is exacerbated by large litters (Baxter et al., 2013). Demands for milk synthesis increase with litter size and, if sows cannot maintain a high feed and water intake, they will start to lose body condition (Baxter et al., 2013). Unsurprisingly then, sows are often in poor body condition at weaning (Greer et al., 1991; Boyle et al., 1999), when they may be sent to the slaughterhouse (for more details on the transport on cull sows see EFSA AHAW Panel, in press).

Bone weight and strength of sows also decreases during lactation (Giesemann et al., 1998). Indeed, the period between late gestation and the end of lactation (weaning) is the most intensive period for bone metabolism in sows (van Riet et al., 2016). However, bone mineral loss that occurs during lactation is readily reversible (Currey, 1973; Kent et al., 1990) being mainly caused by the requirements of milk production (Liesegang et al., 2007). Hence, as soon as lactation stops so does the period of bone resorption and, assuming correct nutrition post-weaning, replenishment of bone reserves commences immediately. This is possibly enhanced where sows are grouped into pens compared to stall housing systems, either at weaning or early after service, given the beneficial impact of exercise on bone density and strength (Schenck et al., 2008). Nevertheless, it could be expected that given the nature of the changes in the bones during lactation there might be a higher risk for fractures and lameness in the sow post-weaning. However, findings on locomotion ability (there is no research on risk of fractures) of sows and gilts at different stages of the production cycle are equivocal. Lagoda et al. (2021) reported that while specific aspects of locomotory disorders were highest in gilts at weaning, overall lameness scores increased during pregnancy and were highest on transfer to the farrowing crate. D'Eath (2012) found no effect of stage in the reproductive cycle on lameness scores. However, Pluym et al. (2013) found the second lowest lameness prevalence (5.5%) when sows were moved to insemination cages compared to when sows were moved into the gestation unit (8.1%) (with lameness levels after moving to the farrowing pens at 4.1%). It is possible that any potential lameness associated with poor bone strength at weaning does not manifest until later in the productive cycle. Finally, it is worth mentioning that 5–20% of lameness is due to claw lesions (Dewey et al., 1993) and there are reports of claw lesions deteriorating in farrowing crates especially if sows are on slatted steel rather than cast iron floors (Calderón Díaz et al., 2014). Hence, newly weaned sows could have poor claw health depending on the flooring used in the farrowing facilities.

Sows kept in confined conditions during lactation are often affected by injuries at weaning which occurred due to movement restrictions and bodily contact with fixtures and fittings (i.e. farrowing crates) (Boyle et al., 2002b; Bonde et al., 2004; Schmitt et al., 2019; Maschat et al., 2020). The latter authors recommend keeping the confined period around farrowing as short as possible to minimise injuries to sows (Maschat et al., 2020). Injuries to the udder and limbs are primarily associated with the change of environment prior to farrowing and thereafter with the high activity levels and associated distress of frustrated nest-building in farrowing crates (Boyle et al., 2000, 2002a). These authors found no further increase in skin lesion scores of sows and gilts between farrowing and weaning. Fogsgaard et al. (2018) reported that recently weaned cull sows (i.e. sows which were still lactating) were at higher risk of having deviations from normal such as udder swellings and inflammations compared to non-lactating cull sows. Challenges with manoeuvring in close confinement on injurious flooring are compounded by body condition in losses in sows during lactation (Boyle et al., 1999; Bonde et al., 2004). This suggests a protective effect on the bony prominences of fat coverage and that thin sows are more susceptible to injury.

Finally, sows are weaned from their piglets after 21–28 days of lactation, which in most countries is commonly spent in the confined environment of a farrowing crate. Most studies of weaning stress focus on effects on the piglets (Weary et al., 2008) but sows clearly experience separation stress at removal of their piglets (de Passillé and Robert, 1989; de Passillé et al., 1990; Pajor et al., 1999). However, there are no studies examining how long such distress persists post-weaning.

Zobel et al. (2015) discuss that there are numerous potential effects on animals' affective states associated with management related to dry-off of dairy cows and small ruminants, including pain, hunger and frustration. Indeed, the abruptly weaned sow probably also experiences such negative affective states as udder distension persists for 2–7 days post-weaning (Ford et al., 2003).

Hence, sows at weaning and in the immediate days following are possibly distressed psychologically by the absence of their piglets and may experience feelings of pain, hunger and frustration associated with dry-off. They are often in poor body condition, may have lesions to the limbs and shoulders caused by confinement on injurious flooring as well as udder swellings and inflammations and weakened bones. In some cases, (cull) sows in that state are sent to the slaughterhouse (for further discussion on fitness for transport and associated welfare risks to cull sows, see EFSA AHAW Panel, in press).

Taken together these findings suggest that newly weaned sows are in a weakened and vulnerable physical and mental condition at a time when they potentially experience an accumulation of additional psychological stressors. Indeed, Rault et al. (2014) discuss that such an accumulation of various stressors possibly explains why sows grouped into groups at weaning had higher cortisol concentrations than those grouped within 2 days after insemination.

4.4.6. Results of the ELS of grouping time on sow welfare and reproductive performance

4.4.6.1. Welfare ABMs

The ELS revealed 20 studies reported in 17 papers related to grouping times. Of these, 12 studies measured ABMs associated with the welfare consequences of grouping. They are listed below. It should be noted that not all of these ABMs are described in the section above on gilts and dry sow housing systems, as they relate specifically to grouping (and not the systems themselves).

1) Lameness (Harris et al., 2006; Karlen et al., 2007; Chidgey et al., 2013; Li and Gonyou, 2013; Knox et al., 2014; Rault et al., 2014; Cunha et al., 2018).
2) Behaviour [including aggression] (Harris et al., 2006; Karlen et al., 2007; Strawford et al., 2008; Knox et al., 2014; Rault et al., 2014).
3) Immune function (Hemsworth et al., 2006; Karlen et al., 2007; Stevens et al., 2015).
4) Stress [cortisol, heart rate] (Harris et al., 2006; Hemsworth et al., 2006; Karlen et al., 2007; Strawford et al., 2008; Knox et al., 2014; Rault et al., 2014; Stevens et al., 2015).
5) Skin lesions (Karlen et al., 2007; Strawford et al., 2008; Chidgey et al., 2013; Li and Gonyou, 2013; Knox et al., 2014; Rault et al., 2014; Stevens et al., 2015; Cunha et al., 2018).

Relatively few studies measured ABMs relevant to welfare consequences associated with different grouping times and while a range of relevant ABMs were used in the available studies, they were not used in all of them. Furthermore, where an ABM was used across several of the studies (e.g. skin lesions and lameness) there was considerable variation in the way in which it was measured. For example, in relation to lameness, some authors measured claw lesions (Cunha et al., 2018), others reported on leg inflammations (Knox et al., 2014) or % lame sows (Li and Gonyou, 2013) and others on culling due to lameness (Karlen et al., 2007; Cunha et al., 2018). Meanwhile Rault et al. (2014), Harris et al. (2006) and Karlen et al. (2007) conducted locomotion/gait scoring following different grouping times.

A descriptive review of the ABMs related to the welfare consequences of different grouping times also shows little or no consistency in the direction of the findings between different ABMs. For example, Stevens et al. (2015) found that sows grouped in the first week post-service were more aggressive at mixing than those grouped 5–6 weeks after service. Accordingly, sows grouped early had more skin lesions 7 days after grouping than those grouped later in gestation. In contrast, Strawford et al. (2008) and Knox et al. (2014) reported that aggression after grouping was similar for sows grouped in the first week post-service compared to 35–46 days after insemination. However, Knox et al. (2014) found that sows grouped soon after service had more skin injuries, a greater incidence of lameness and more vulva lesions than sows grouped later in gestation. These effects did not persist in the long term. Furthermore, Stevens et al. (2015) found no effects of different grouping times on skin lesions at day 91 of pregnancy. However, Li and Gonyou (2013) reported that sows grouped in the first week post-service had more skin injuries before farrowing than those grouped late in gestation.

Hence, due to the issues described above but particularly the lack of standardisation of the observed ABMs between the studies reported in different papers, it was not possible to identify specific 'reference' ABM(s) to assess the welfare consequences through a quantitative EKE (see methodology, Section 2.2.2.3). A qualitative approach was instead adopted and the results are presented in Section 4.4.7.

4.4.6.2. Effects on reproductive performance of grouping sows in the period under assessment

Given the potential challenges for reproduction of grouping sows in early pregnancy outlined in the introduction, data relating to reproductive outcomes were also extracted from the selected papers. In contrast to the ABMs related to welfare consequences associated with different grouping times, data on reproductive outcomes were reported in the majority of the studies (18 of 20 studies). These data are discussed qualitatively below. Of the sow reproductive performance measures, farrowing rate (the proportion of females served that farrow) was consistently reported across the majority (n = 15) of the available studies and hence further detail is provided on this parameter in the following Section.

In addition to the 20 studies retrieved in the ELS, we considered findings from an additional two studies namely, van der Mheen et al. (2003) and Galli et al. (under review).

Whilst stress in gilts grouped in the pre-oestrous period may induce oestrus (Signoret et al., 1990), there is also some evidence to suggest that social interactions may suppress oestrous signs in subordinate sows (Tsuma et al., 1996). Furthermore, some studies suggest that ovulation is a stress sensitive period (Brandt et al., 2007). Einarsson et al. (2007) simulated the stresses for sows in groups by injection of small doses of adrenocorticotropic hormone for ~ 48 h to multiparous sows around pro-oestrus and oestrus. They found that ovulation was disturbed and that when the sows were euthanised at 48 or 60 h after ovulation, fewer oocytes/embryos were retrieved. In contrast, Soede et al. (2007) found no effect of repeatedly applied acute stressors on gilts during the follicular phase. Similarly, a review by Turner and Tilbrook (2006) showed that reproduction in female pigs is unaffected by acute or repeated acute stress or acute or repeated acute elevation of cortisol imposed during the days that lead up to oestrus and ovulation.

In general, if grouping takes place immediately or in the first days after service, reproductive performance can be as good as that with grouping at 4 weeks after service (van der Mheen et al., 2003; Kirkwood and Zanella, 2005; Stevens et al., 2015; Cunha et al., 2018; Bampi et al., 2020). This is supported by Soede et al. (2007) who found no effect of repeatedly applied acute stressors on gilts in early pregnancy on the reproductive processes. Similarly, van Wettere et al. (2008) saw no differences in pregnancy rate or embryo survival of gilts that were not grouped (but remained in their premating group), or that were grouped at either day 3–4 or day 8–9 of pregnancy (and slaughtered on day 26 post-service).

Van der Mheen et al. (2003) looked at 375 sows during 800 pregnancies and found the highest litter size in sows that were introduced (grouped) into dynamic groups immediately after insemination compared to sows introduced to dynamic groups at 2 or 4 weeks post-service. The majority of other studies show no effect of grouping time on litter size (Galli et al., under review; Kirkwood and Zanella, 2005; Li and Gonyou, 2013; Knox et al., 2014; Stevens et al., 2015; Cunha et al., 2018; Bampi et al., 2020). However, Knox et al. (2014) reported lower pregnancy rates for sows grouped in early pregnancy (d3) compared to sows regrouped 14 or 35 days after service (the low space allowance in this study of 1.74 m^2/sow should be noted).

Turner et al. (2005) suggests that only stressors that can lead to severe and prolonged elevation of cortisol, negatively affect embryo survival. The regular disruption of the dominance hierarchy in dynamic groups could constitute such a stressor and supports the findings of Bokma (1990) who reported that mixing sows into a dynamic group of 40 sows with an electronic sow feeder during the first week of pregnancy resulted in a 20% return rate compared to 10% associated with grouping during the fourth week. They suggested that sows mixed into the group during the first week of pregnancy experienced disruptions and associated stress every week thereafter which may have contributed to the poor results. However, van der Mheen et al. (2003) also mixed sows into dynamic groups and found the lowest level of regular returns to oestrus in sows that were introduced (grouped) into dynamic groups at ~ 3 days after insemination compared to sows introduced to dynamic groups at 2 or 4 weeks post-service.

As presented in the introduction, pigs have a particularly cortisol (i.e. stress) sensitive period (day 11–16 post-service) in their reproductive cycle (Turner et al., 2005; Turner and Tilbrook, 2006; Spoolder et al., 2009). However, van der Mheen et al. (2003) found no negative effect on any reproductive parameters of introducing sows to a dynamic group 2 weeks post-service. Indeed, sows in this treatment had the second highest number of live-born piglets (of three grouping treatments). In this study, sows grouped at 2 or 4 weeks post-service were kept in a group (rather than in stalls) after service until the time of introduction into the dynamic group; this may have influenced the results. Cassar et al. (2008) found no effect on litter size of grouping on day 14 post-service (compared to grouping at 2, 7, 21 or 28 days after service). However, after 5 weeks in groups, all sows in that study were re-housed in individual stalls until farrowing which may have affected the results. Meanwhile, Knox et al. (2014) found similar conception (pregnancy rates) in sows grouped (into static groups) at 14 days post-service compared to sows kept in stalls throughout or to sows grouped 35 days post-service. Another study (reported in Kirkwood and Zanella, 2005) grouped sows (also into static groups) in the stress sensitive period and, similar to Knox et al. (2014), they found no effect on total piglets born or on born alive. Meanwhile, an epidemiological study of risk factors within group housing during the first month of pregnancy on 96 farms (Geudeke, 2008) reported the poorest reproductive results in systems where sows were introduced into groups between 1 and 2 weeks after insemination.

Farrowing rate

Table 36 shows effects on farrowing rate of grouping sows at the four identified stages and the number of studies (n = 15) associated with each stage: stage 1 (n = 3 studies), stage 2 (n = 15), stage 3 (n = 3) and stage 4 (n = 11). Comparisons to stalls (n = 9) are also indicated, when reported in the papers. Stage 2 was represented in all the studies.

Cunha et al. (2018) found that re-grouping on days 7 and 30 resulted in significantly lower farrowing rates than for sows continuously housed in stalls. In contrast, Bates et al. (2003) found a higher farrowing rate for sows regrouped in the first week post-service compared to sows in stalls. Meanwhile, both Hansen et al. (2000) and Kirkwood and Zanella (2005) found no difference in farrowing rates between sows housed in stalls and sows grouped at several different stages post-service.

Most of the studies show no effect on farrowing rate of grouping at 3 compared to 28 days post-insemination (van der Mheen et al., 2003; Kirkwood and Zanella, 2005; Stevens et al., 2015; Cunha et al., 2018; Bampi et al., 2020; Galli et al., under review). However, two studies reported lower farrowing rates for sows grouped very soon after insemination compared to sows grouped 4 weeks later (Li and Gonyou, 2013 [82.3 vs. 86.7%]; Knox et al., 2014 [82.8 vs. 90.5%]). Similarly, a study by Barbari et al. (2002) that included two years of data from 30,000 sows in 82 farms in Northern Italy showed a lower farrowing rate in sows grouped at 7 days post-service (69.6%) compared to sows grouped at 32 days post-service (72.7%) (in year 1 but not in year 2 and the data were not analysed statistically).

As mentioned above, there are only a few studies investigating effects of grouping sows during the critical implantation period (days 8–21). This is possibly because of the established biological theory that this is a critically sensitive period for embryo survival. Cassar et al. (2008) introduced 617 sows to groups of 15 at days 2, 7, 14, 21 or 28 after service and found no effects of grouping on day 14 on farrowing rates (not included in Table 36, as all sows in that study were re-housed in individual stalls after 5 weeks in groups). Three relevant studies are included in Table 36. The Van der Mheen et al. (2003) study is shown in two rows as sows were introduced both to dynamic and stable groups at 3 days post-service (i.e. in stage 2) and compared to grouping in stage 3 or stage 4. These studies yielded completely contrasting findings relating to farrowing rate. Kirkwood and Zanella (2005) found that grouping floor-fed groups of 15 sows during this period (days 13–17 precisely) gave the lowest farrowing rate (69.8%) compared to grouping sows 2 days post-service (86%). In contrast, Knox et al. (2014) found no difference in farrowing rate between grouping on day 35 (90.5%) or on days 8 and 20 (87.8%) with sows grouped 3–7 days after service having the lowest farrowing rate (82.8%). Meanwhile van der Mheen et al. (2003) found no effect on farrowing rate of grouping into stable or dynamic groups in stage 3 compared to stage 2 or stage 4.

The wide variation between studies in the feeding systems used, group management (static or dynamic), size and composition, floor quality and space and pen design as well as differences in sow factors such as genetics likely explains the lack of conclusive evidence on the effect of grouping time on farrowing rate from the available studies. Another complicating aspect is that many factors of group housing are mutually related: feeding systems, bedding used, group size and group dynamics are often inextricably linked to each other (Edwards, 2000).

Table 36: Effects of grouping sows at different stages or housing in stalls throughout pregnancy (when reported in the papers) on farrowing rate (ns = not statistically significant; na = no statistical analysis) (The level of precision is reported as in the original papers)

Farrowing rate %	Study size N = no. sows	Grouping stage				Stalls	p value
		Stage 1: Pre-service	Stage 2: days 1–7	Stage 3: days 8–20	Stage 4: days 21+		
Cunha et al., 2018	711		83.2		84.9	89.7	0.04
Knox et al., 2014	1441		82.8	87.8	90.5	92.8	0.001
Li and Gonyou, 2013	1571		82.3		86.7	86.2	< 0.05
Stevens et al., 2015	800		83.0		83.0		ns

Farrowing rate %	Study size N = no. sows	Grouping stage				Stalls	p value
		Stage 1: Pre-service	Stage 2: days 1–7	Stage 3: days 8–20	Stage 4: days 21+		
Kirkwood and Zanella, 2005 (Exp. 4)	309		83.8	69.8	75.8	79.7	ns
Bampi et al., 2020	522		91.5		91.23		ns
Barbari et al., 2002 (1997 data)	30k (71 farms)	76.28	69.6		72.68	76.71	na
Barbari et al., 2002 (1998 data)	30k (72 farms)	75.85	70.56		70.59	76.61	na
Karlen et al., 2007	640		66.0			76.9	0.01
Chidgey et al., 2013	14 farms	88.77	89.6		86.48		na
Bates et al., 2003	388		94.3			89.4	< 0.05
Hansen et al., 2000	3 farms		87.0			87.0	ns
van der Mheen et al., 2003/study a	375		86.73 (stable groups)	87.29	85.15		ns
van der Mheen et al., 2003/study b	375		90.08 (dynamic group)	87.29	85.15		ns
Galli et al., under review	146		85		90		ns

Using the data presented in Table 36, the effect of stage on farrowing rate was analysed by first standardising all the values within a study to a reference of stage 2 as 100% (stage 2 was selected as the reference because this was the only treatment present in all of the studies). The standardised values were then compared and the results are shown in Figure 8.

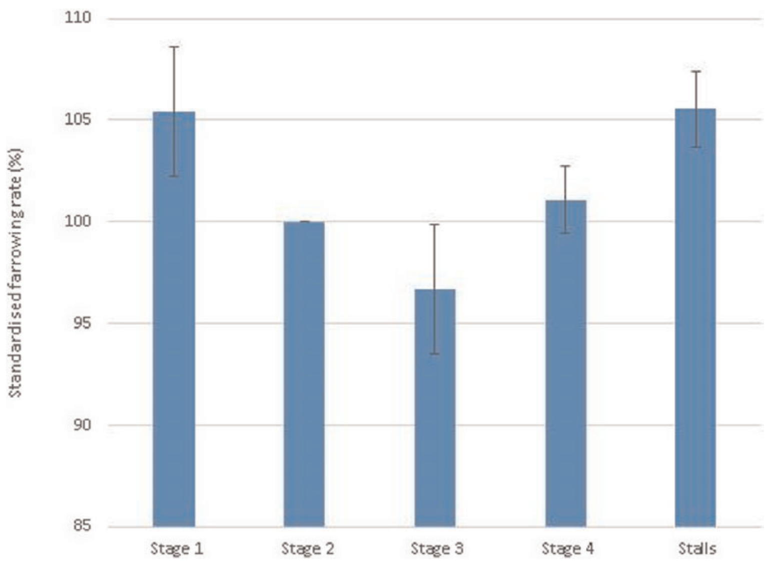


Figure 8: Effects of grouping sows at different stages on farrowing rate (using values standardised within study relative to stage 2, set to 100%). Comparison to stalls is also indicated

Figure 8 shows that on average the farrowing rates of sows grouped at stage 2 and stage 3 were lower than for sows kept in stalls, whereas there was no indication that this was the case for sows grouped at stage 1.

It is clear that the limited number of studies that investigated the effects of timing of grouping on different aspects of reproductive performance yielded conflicting and therefore inconclusive results.

Attempts to demonstrate a direct relationship between early embryonic development and stress failed and the scientific evidence supporting implantation as a stress sensitive period is weak. However, the outcome of the analysis conducted above supports that grouping in stage 3 should be avoided due to possible detrimental effects on farrowing rate, in line with conclusions reached by Spoolder et al. (2009). The sensitivity to stress in stage 2 is also suggested but requires further investigation. We include reproductive performance represented by farrowing rate, in the exercise presented in Section 4.4.7.

4.4.7. Results of the consensus exercise on welfare consequences affecting sows when grouped in the period under assessment and related mitigation measures

4.4.7.1. Identification of the welfare consequences

Starting from the list of highly and moderately relevant welfare consequences identified for gilts and dry sows when housed in groups (see Appendix B), a qualitative (yes/no) assessment, via expert consensus, was performed to identify the welfare consequences affecting sows when grouped during the period under consideration.

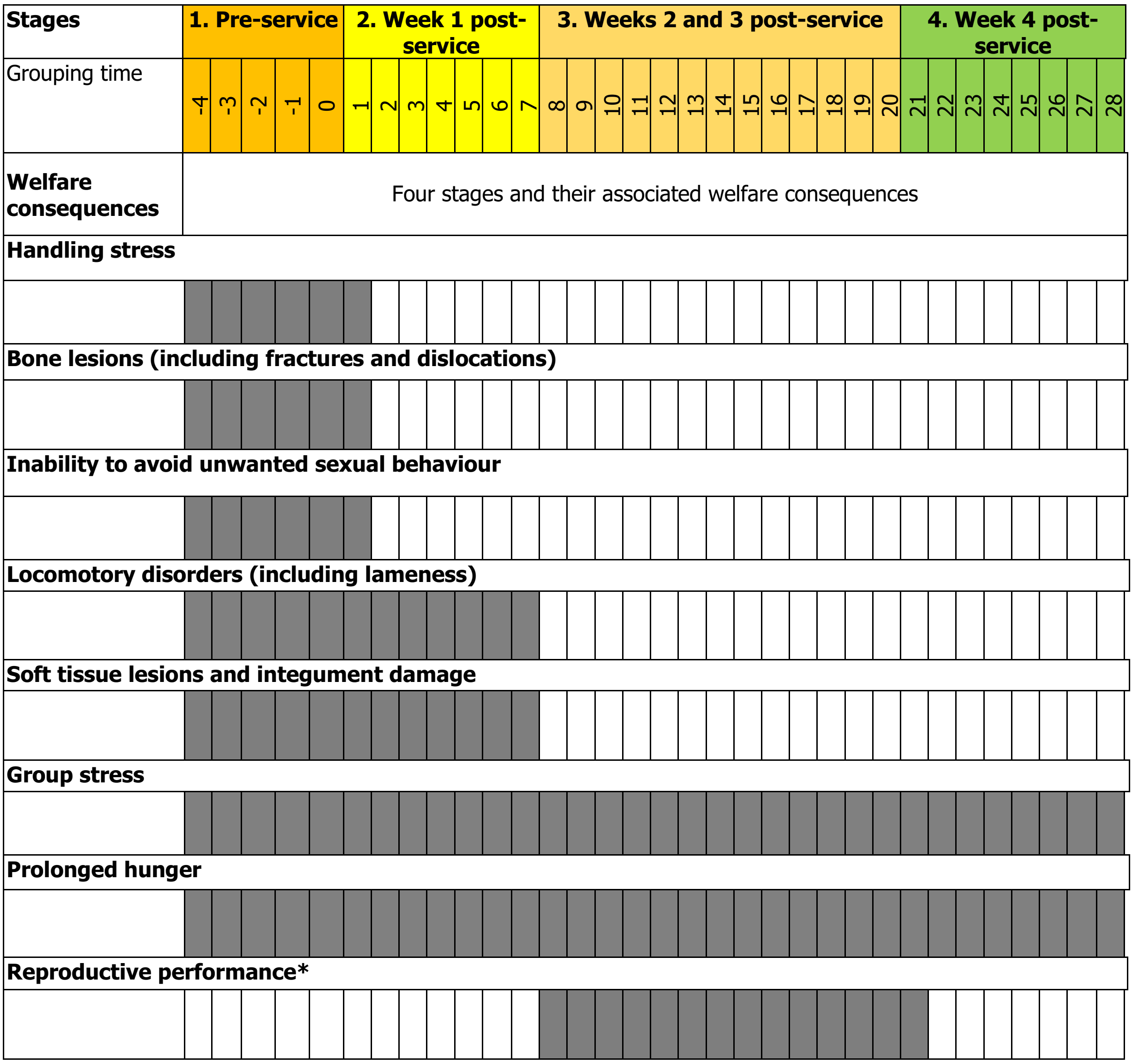
Seven welfare consequences were deemed relevant for this specific scenario as they are experienced by sows grouped during the period under assessment (Table 37). These were group stress, handling stress, inability to avoid unwanted sexual behaviour, prolonged hunger, locomotory disorders, soft tissue lesions and integument damage and bone lesions.

Table 37: Identification of the welfare consequences that characterise grouping of sows during the period under assessment. The welfare consequences listed in the first column are those that were identified as highly or moderately relevant for gilts and dry sows in indoor group housing (for the description, see Sections 2.2.2.1 and 3.4)

Welfare consequence	Relevance to the period under assessment (expert opinion)
Group stress	Yes: there is continuous stress in group-housing initially due to fighting to establish the dominance hierarchy and after due to competition for resources.
Handling stress	Yes: particularly when animals are kept in groups in the insemination phase and during pregnancy diagnosis.
Inability to avoid unwanted sexual behaviour	Yes: when in groups, the animal can experience stress and/or negative affective states such as pain and/or fear resulting from inability to avoid the attentions of other sows in oestrus (e.g. mounting behaviour). This is particularly relevant in the first stage.
Prolonged hunger	Yes: the group situation may continuously hamper animals' ability to access feed unless lockable individual feeding stalls are provided.
Locomotory disorders (including lameness)	Yes: aggression after grouping can lead to lameness. Early grouping may increase lameness due to the presence of weak animals (sows only) after lactation.
Soft tissue lesions and integument damage	Yes: due to group fights. Soft tissue lesions and integument damage may be more evident in weakened sows grouped early after weaning following lactation in farrowing crates.
Bone lesions (including fractures and dislocations)	Yes: being in groups increases risks of being jumped-on and aggression with bone lesions as consequence. Early grouping may increase bone lesions due to presence of weak animals and demineralised bones which are more prone to fractures (sows after lactation) and the occurrence of oestrus behaviour at this time.
Restriction of movement	No: not considered to be specifically relevant for the period under assessment
Resting problems	
Inability to perform comfort behaviour	
Inability to perform exploratory or foraging behaviour	
Prolonged thirst	
Heat stress	

Table 37 explains that there are certain stages in which the welfare consequences are particularly relevant. In Figure 9, this relationship is visualised with the aim to show the differences between the four stages. However, it should be noted that most welfare consequences are also relevant to the other stages, albeit perhaps to a lesser extent. For explanation, refer to Sections 4.4.5 and 4.4.7.

Although reproductive performance it is not a welfare consequence, the postulated sensitive days in terms of reproductive performance are added to this figure in order to give a complete picture of the implications of grouping in the period of assessment (see Section 4.4.6).



*As discussed in Section 4.4.4, grouping during the stress sensitive period (i.e., stage 3) warrants caution because of potential negative effects on reproductive performance. Therefore, although it is not a welfare consequence, the postulated sensitive days in terms of reproductive performance are added to this figure in order to give a complete picture of the implications of grouping in the period of assessment.

Figure 9: The welfare consequences and effect on reproductive performance (farrowing rate) gilts and dry sows may experience when grouped at four different stages during the post-weaning/preservice and early pregnancy period. Day '0' indicates the day of service, with gilts and dry sows arriving in the service area 4 days before (i.e. day -4). Grey cells indicate when a day is particularly relevant for that welfare consequence

As illustrated in Figure 9, when gilts and dry sows are grouped in the days prior to service (which in the case of sows is also the post-weaning period), they are subjected to a number of welfare consequences, i.e.: handling stress, inability to avoid unwanted sexual behaviour, bone lesions (including fractures and dislocations), locomotory disorders (including lameness), soft tissue lesions and integument damage, group stress and prolonged hunger. These will affect animals differently depending on their condition post-weaning (sows only – see Section 4.4.5) and the time of the onset of oestrus.

When grouped in the first week after service (stage 2), both sows and gilts experience the welfare consequences associated with competitive behaviour (group stress and prolonged hunger). For sows, it is likely that they have started to recover (physically and mentally) from the stresses associated with lactation/abrupt weaning (Section 4.4.5) and no longer being in oestrus are in a calmer behavioural state. However, for sows grouped in this stage, welfare consequences associated with their compromised physical condition after lactation (i.e. locomotory disorders [including lameness] and soft tissue lesions and integument damage) are still likely to be influencing factors.

When grouped from the second week post-service until the end of the period under consideration (stages 3 and 4) sows and gilts experience group stress and prolonged hunger (see Figure 9).

Other than these, there are no specific welfare consequences for sows and gilts associated with grouping in stage 3, given the postulated pregnancy loss that can occur in weeks 2 and 3 after service, grouping in this period is not considered further (see the critical period for reproductive performance described in Section 4.4.6.2 and shown in Figure 9).

4.4.7.2. Identification of the mitigation measures

Finally, EFSA experts identified the measures to prevent and mitigate the welfare consequences and to facilitate grouping of sows. These measures are shown in Table 38, by stage and pertaining to four main themes, i.e. grouping management, general management, good home/pen design and feeding management.

Table 38: Measures to prevent risks or mitigate welfare consequences when grouping gilts and sows in the four stages

Stages	**Stage 1**			**Stages 1 and 2**		**Stages 1, 2, 3 and 4**	
Welfare consequences	**Handling stress**	**Inability to avoid unwanted sexual behaviour**	**Bone lesions (incl. fractures and dislocations)**	**Locomotory disorders (incl. lameness)**	**Soft tissue lesions and integument damage**	**Group stress**	**Prolonged hunger**
Mitigation measures							
Grouping (mixing) management							
Use specialised mixing pens (see Section 6.1)		x(*)	x	x	x	x	
Form subgroups and provide for subgrouping behaviour				x	x	x	
Reduce grouping/ mixing occasions, mixing into same groups to keep familiarity between individuals				x	x	x	
Group animals of similar size			x	x	x	x	x
Avoid grouping compromised animals		x	x	x	x	x	x

Stages Welfare consequences	Stage 1			Stages 1 and 2		Stages 1, 2, 3 and 4	
	Handling stress	Inability to avoid unwanted sexual behaviour	Bone lesions (incl. fractures and dislocations)	Locomotory disorders (incl. lameness)	Soft tissue lesions and integument damage	Group stress	Prolonged hunger
General management							
Good hygiene, e.g. appropriate cleaning, ensure non-injurious environment				x			
Use pain relief			x	x			
Staff training (**)	x						
Handling facilities and tools	x						
Manage the rearing of fast-growing genotypes			x	x			
Choose gilts with good leg conformation and selected against osteochondrosis			x	x			
Vaccination				x			
Move compromised/ aggressive animals to hospital/ separation pens		x	x	x	x	x	x
Good home pen design/layout							
High space allowance		x			x	x	
Designated areas for different activities, e.g. resting, feeding, spatial separation of limited resources (e.g. environmental enrichment, foraging materials)		x		x	x	x	
Provide protective features, places to hide, avoidance and escape possibilities (e.g. straw bales)		x		x	x	x	x
Good flooring and drainage, e.g. use of solid dry/clean floors, rubber mats, deep straw bedding			x	x	x		
Wide distribution of/good access to resources, e.g.: wider distribution of feed, access to the feeding systems, increase limiting				x	x	x	x

Stages	**Stage 1**			**Stages 1 and 2**		**Stages 1, 2, 3 and 4**	
Welfare consequences	**Handling stress**	**Inability to avoid unwanted sexual behaviour**	**Bone lesions (incl. fractures and dislocations)**	**Locomotory disorders (incl. lameness)**	**Soft tissue lesions and integument damage**	**Group stress**	**Prolonged hunger**
resources, adequate access to appropriate quality water, minimise competition for resources, adequate environmental enrichment							
Feeding management							
Correct lactation feeding to minimise loss in body condition			x				
Calculate and supply nutrient needs/good diet formulation, maintain appropriate body condition score				x	x		x
Provide fibrous diet to promote satiety by increasing dietary bulk and feeding duration					x	x	x
Provide protected individual feeding facilities to ensure correct rationing					x	x	x

(*): Only if sows are still in the mixing pen by the time they enter oestrus.
(**): Staff training is specifically relevant for mitigating handling stress; however, staff training is important in identifying and mitigating all the welfare consequences in each of the other stages.

4.4.7.3. General principles when grouping sows

A suggested space allowance of 3.5 m^2 (37 ½ sq. ft) per sow is required to ensure appropriate sow behaviour at grouping/mixing. The distance required for a sow to escape a higher ranking individual following a fight is crucial to the rapid development of a stable dominance hierarchy. In scientific studies where sows were grouped in very large pens, some sows were pursued over 20 m during fights (Edwards and Riley, 1986). Hence, Spoolder et al. (2009) suggested that pens should provide a flight distance of 10–12 m (Spoolder et al., 2009). However, Arey and Edwards (1998) suggested that while greater space allowance appears to have little effect on fighting at mixing it can reduce aggression in the longer term. In reality, large groups have more shared space than small groups. However, the downside is that they have more hierarchy positions to resolve and so have more fighting compared to small groups.

Irrespective of group size, if there are individual free-access feeding stalls within the group pen they serve as barriers for sows to hide behind and protect themselves (Andersen et al., 1999). Barriers can limit aggression by allowing loser sows to escape more easily. However, in many group-housing systems there are no feeding stalls. Hence, pens should include barriers and ideally these should be flexible, e.g. bales or a suspended rubber partition. It is important to ensure that there are no sharp edges or protuberances in the pen. If possible, the floor should be covered with mats or straw to protect the feet during fighting. If sows must be grouped on slatted floors there should be no large gaps between the slats and the void edges should not be jagged or broken. Void openings should not exceed 20 mm and slat widths should not be less than 80 mm although even wider slats (120 mm) provide better foothold (Boyle et al., 2012).

In many group-housing systems, the above criteria will be difficult to achieve so there are strong arguments for the use of specialised mixing pens incorporating the features outlined above. In such pens, sows can fight to establish a dominance hierarchy/pecking order in more safety than in conventional pens. Once they establish a 'pecking order' the group is transferred into conventional gestation pens for the duration of pregnancy. However, it is possible that sows grouped at weaning could remain in such specialised 'mixing' pens through to service such that they are protected from the welfare consequences associated with oestrous behaviour. For this to work, mixing pens would need to be located in the service house and include insemination stalls.

Gilts mixed into groups of older sows whether in a specialised mixing pen or in the pen they will stay in until moved for farrowing, are much more at risk of the welfare consequences associated with grouping (Hodgkiss et al., 1998; Kirkwood and Zanella, 2005). This obvious relationship between physical strength and the likelihood to dominate over resources raises the question as to whether sows should be housed in single parity groups or at least in groups where young and old animals are not mixed. Results of both Hoy et al. (2000) and Li et al. (2012) suggest that sorting by parity helps to protect first-parity sows from severe injuries caused by mixing-induced aggression to improve their welfare and performance in group-housing systems.

Training of staff to recognise when animals are affected by welfare consequences associated with grouping is crucial. However, staff training is specifically relevant for mitigating handling stress around the time of service and pregnancy diagnosis.

Figure 10 shows an example of a specialised mixing pen with a dedicated lying area with deep straw, protective features and barriers to let subordinate sows to hide, feeders and drinkers in a sufficient number to avoid competition, enough space and non-slippery floor.

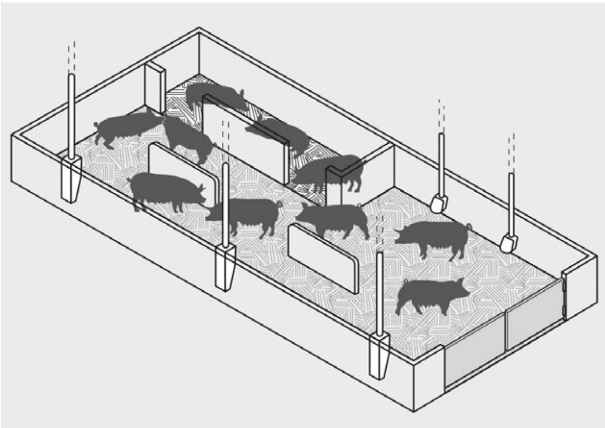


Figure 10: Drawing representing a 'well-designed' mixing pen to allow sows to establish a dominance hierarchy in safety (based on a photo courtesy of Vermeer H)

4.4.7.4. Description of the welfare consequences and related preventive and mitigation measures

The characteristics of the welfare consequences that occur in more than one stage (e.g. group stress) are largely the same in all stages and are described in the following sections. Some of these welfare consequences were described in Section 3.4 and here the implications specific to the period under consideration are elucidated as well as the associated mitigation measures.

Handling stress

Sows regrouped at weaning require a certain amount of handling because there is moving of the sows for oestrous detection and insemination (Peltoniemi et al., 2016). Other reasons for extra handling of sows and gilts in groups during oestrus might include the need for separation of an injured sow or for intervention during aggression.

<u>Prevention/mitigation:</u> well-trained staff that perform the service procedure and pregnancy diagnosis correctly and with care can reduce stress due to handling. Good handling facilities and handling tools, such as driving boards are also helpful because they help moving sows with minimum disturbance.

Inability to avoid unwanted sexual behaviour

Sows regrouped at weaning experience intense sexual behaviour including mounting which is likely one of the major stresses for sows weaned into groups (Einarsson et al., 2007). Low ranking sows are at greater risk of being mounted by high-ranking sows in oestrus (Pedersen et al., 1998). Furthermore, these animals show fear related behaviour in response to boar stimulation even when in standing oestrous (Pedersen et al., 2003). Hence, position in the dominance hierarchy influences the amount of stress experienced by sows around oestrous and for low-ranking sows, sexual behaviour is likely unwanted.

Prevention/mitigation: avoid introducing compromised animals to groups until recovered in hospital pens. Home pens should have a high space allowance, designated areas for different activities and presence of protective features, with places to hide, avoidance and escape possibilities to allow gilts and sows to avoid unwanted sexual behaviour. The use of mixing pens can mitigate this welfare consequence if sows remain in the mixing pen during oestrus.

Bone lesions (including fractures and dislocations)

Studies on welfare consequences of entire male pig production systems demonstrate that sexual behaviour, especially mounting, is injurious (Rydhmer et al., 2006) and can lead to fractures and damage to the joint cartilage (Hartnett et al., 2019). Fast growth rates (Quinn et al., 2015) and slippery floors may exacerbate the risk of bone lesions. Furthermore, these consequences are possibly aggravated for sows in fragile condition after lactation and weaning (see also Section 4.4.5).

Prevention/mitigation: use of specialised mixing pens. Grouping animals of the same size and moving highly aggressive or forceful sows to separation pens can reduce the occurrence of bone lesions due to sexual behaviours. The use and maintenance of good flooring (solid dry/clean floors, rubber mats, deep straw bedding) and drainage and correct lactation feeding reduces the risk of bone lesions. Use of hospital pens to recover compromised animals (avoid grouping of such animals). Treatment with pain relief can mitigate pain due to bone lesions. Mitigate the risk of bone lesions by careful management of fast-growing genotypes of pigs and choosing replacement gilts with good leg conformation. In addition, minimising time sows spend in farrowing crates and ensuring sows are weaned in good physical conditions can mitigate this welfare consequence if sows are to be grouped in early gestation.

Locomotory disorders (including lameness)

Locomotory disorders (including lameness) in group housed gilts and sows are fully described in Section 3.4.13. In summary, locomotory disorders can occur due to sexual, competitive and aggressive behaviours from pen-mates (e.g. mounting, establishment of dominance hierarchy). Nevertheless, locomotory disorders may be provoked in gilts and sows by poor general management and pen design. Specifically in relation to sows in the period under consideration, detrimental bone and claw status after lactation and weaning could exacerbate locomotory disorders (see Section 4.4.5).

Prevention/mitigation measures: Reduce grouping/mixing occasions and mix sows into same groups, form subgroups and provide for subgrouping behaviour, group animals of the same size, move aggressive sows into separation pens, ensure spatial separation, wide distribution and good access to resources. Provide protective features, places to hide, avoidance and escape possibilities, as well as the use of mixing pens. The use and maintenance of good and clean flooring and drainage, designated areas for different activities (e.g. resting) and a good diet formulation with balanced nutrients can also prevent the occurrence of locomotory disorders. Locomotory disorders can also be reduced by intervening in genetic selection (e.g. by choosing gilts with good leg conformation and selected against osteochondrosis), managing the rearing of fast-growing genotypes and with vaccination against diseases that interfere with locomotion ability (e.g. erysipelas). Compromised animals can recover in hospital pens to reduce risk of incurring lameness at grouping. Treatment with pain relief can also mitigate pain due to locomotory disorders. In addition, minimising time sows spend in farrowing crates and ensuring sows are weaned in good physical conditions can mitigate this welfare consequence if sows are to be grouped in early gestation. Further information on hazards, preventive, corrective and mitigation measures on group housed gilts and sows are in Section 4.1.6.

Soft tissue lesions and integument damage

Soft tissue lesions and integument damage in group housed gilts and sows are described in Section 3.4.14. Similar to locomotory disorders, soft tissue lesions and integument damage can occur due to competitive and aggressive behaviours from pen-mates and to poor feeding management and pen design. The above could be exacerbated by the fact that sows are in a poor physical condition caused by lactation (see Section 4.4.5).

Prevention/mitigation: reduce grouping/mixing occasions and mixing sows into same groups, form subgroups and provide for subgrouping behaviour, move aggressive sows in separation pens and ensure spatial separation, wide distribution and good access to resources to minimise competition and the provision of protective features, places to hide, avoidance and escape possibilities, as well as the use of mixing pens. Pens with a high space allowance, designated areas for the different activities, good and well-maintained flooring, protected individual feeding, proper access to the feeding system and a good diet formulation with balanced nutrients, increased fibre and foraging possibilities can also prevent the occurrence of soft tissue lesions and integument damage. Hospital pens can be used to recover compromised animals, avoiding their grouping. In addition, minimising time sows spend in farrowing crates and ensuring sows are weaned in good physical conditions can mitigate this welfare consequence if sows are to be grouped in early gestation. Hazards, preventive, corrective and mitigation measures characterising group housed gilts and sows are in Section 4.1.7.

Group stress

Group stress in group housed gilts and sows is described in Section 3.4.3. Group stress clearly arises due to aggression at grouping, when unfamiliar animals are grouped in a pen together and fight to establish a dominance hierarchy. There are concerns that the stage of the reproductive cycle at which sows are grouped in early pregnancy may affect aggression because of changes in hormone levels (Verdon et al., 2015).

Prevention/mitigation: group stress can be mitigated by reducing competitive and aggressive behaviours, e.g. move aggressive sows in separation pens, use hospital pens to recover compromised animals and avoid grouping them, reduce grouping/mixing occasions and mix sows into same/familiar groups, form subgroups and provide for subgrouping behaviour, group animals of the same size, use pens with high space allowances, designated areas for different activities, with spatial separation of resources, presence of protective features and facilities (also while feeding), with places to hide, avoidance and escape possibilities, provide wide distribution and good access to resources and increase fibre/foraging, as well as the use of mixing pens (see further information in Section 4.1.3).

Prolonged hunger

Prolonged hunger in group housed gilts and sows is described in Section 3.4.9. Prolonged hunger is a ubiquitous feature of all commercial pig production systems worldwide as sows and gilts are not fed to appetite irrespective of the way they are managed during pregnancy. Sows are typically fed to appetite during lactation and generously between weaning and service, but there is a dramatic reduction in feed level after service. Prolonged hunger may be aggravated in groups because of competition for access to feed which also contributes to group stress.

Prevention/mitigation: Move aggressive sows into separation pens, use hospital pens to recover compromised animals and avoid grouping such animals, group animals of the same size, use pens with protective features while feeding, ensure places to hide, avoidance and escape possibilities and wide distribution and good access to resources (e.g. feed, water, enrichment). Good feeding management that allows provision of a fibrous diet (increase dietary bulk and feeding duration). Good diet formulation, balancing nutrient needs, maintaining appropriate body condition score, are also essential as is providing protection for sows during feeding. Further information is in Section 4.1.5.

4.5. Summary Conclusions on the welfare of gilts and dry sows

4.5.1. Summary Conclusions from the General ToRs

1) The highly relevant welfare consequences experienced by **gilts and dry sows in stalls** are restriction of movements, resting problems, group stress, inability to perform exploratory or foraging behaviour and prolonged hunger. Other welfare consequences may negatively affect the welfare of gilts and dry sows, however, they were classified less or moderately relevant (see Appendix B). Hazards leading to the highly relevant welfare consequences and ABMs that can be used to assess them are presented in Section 4.2.
2) There are measures to mitigate some of the highly relevant welfare consequences experienced by gilts and dry sows in stalls (e.g. resting problems by cleaning the floor and/or providing

bedding), however, other welfare consequences (e.g. restriction of movement and inability to perform exploratory behaviour) cannot be mitigated except by removing the animals from the stalls.

3) The welfare consequences that were identified as highly relevant for **gilts and dry sows in outdoor paddock systems** are group stress and prolonged hunger.

4.5.2. Summary Conclusions from Specific ToR 1

1) The welfare consequences experienced by **gilts and dry sows in groups** are primarily associated with competitive behaviour in groups (i.e. group stress and prolonged hunger), risks from physical condition after lactation (i.e. locomotory disorders and soft tissue lesions and integument damage) and detrimental consequences of oestrus behaviour (i.e. inability to avoid unwanted sexual behaviour, bone lesions and handling stress).
2) The risks for welfare consequences resulting from grouping are greater in stages 1 and 2 after weaning for those newly weaned sows that are physically compromised by lactation. The risk is also increased by behaviour exhibited during oestrus and for gilts if mixed with older sows.
3) The welfare consequences associated with grouping gilts and sows can be mitigated at any stage by adhering to the principles of good mixing, including the use of mixing pens, good home pen design/layout and good feeding and general management. These may differ between different stages, as shown in Table 38.
4) Grouping gilts and dry sows in the period between 8 and 21 days post-service, may cause detrimental effects to reproductive function indicative of stress. Farrowing rate (as parameter of reproductive performance) following grouping of sows at weaning is comparable to housing in stalls for the duration of pregnancy.

4.6. Recommendations on the welfare of gilts and dry sows

4.6.1. Recommendation from the General ToRs

Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for gilts and dry sows, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 4.2).

4.6.2. Recommendations from Specific ToR 1

1) To avoid the welfare consequences of stall housing and the possible consequences of stress during early pregnancy for reproductive performance, sows should be grouped at the time of weaning (see Figure 9).
2) The welfare consequences associated with grouping gilts and sows should be mitigated at any stage (including for cull sows) by good mixing practice, including the use of mixing pens, good home pen design/layout and good feeding and general management (see Table 38).
3) Staff should be trained to mitigate handling stress in sows, particularly in stage 1 (preservice), and in identifying and mitigating the other welfare consequences in all stages.
4) The management of sows in lactation should ensure that sows are weaned (including cull sows) in good physical condition for grouping.

5. Assessment of the welfare of farrowing and lactating sows and piglets

The welfare of farrowing and lactating sows, from the moment they are moved into the farrowing accommodation, and the welfare of piglets are further explored in this chapter.

Farrowing and lactating sows and their piglets are normally housed in the same farrowing facilities (except in the case of piglets housed in artificial rearing systems). However, these pig categories might be subjected to different hazards and, thus, experience different welfare consequences. Therefore, they are assessed in separate sections: the welfare consequences that were identified as having high relevance for farrowing and lactating sows are listed in Section 5.1, whereas the highly relevant welfare consequences identified for piglets are in Section 5.4. For each of these welfare consequences, reasoning explaining its high relevance, the hazards that may lead to it and corresponding preventive, corrective and mitigation measures are also described. General descriptions of these welfare consequences in pigs and the related ABMs are reported in Section 3.4.

An overview of the expert judgement on the welfare consequences is presented in Appendix B.

As visualised in Table 9 (Section 3.3.1), the **systems for farrowing and lactating sows** that have been fully assessed in the General ToRs are individual crates, individual pens and outdoor paddock systems. These systems are described in Section 3.3.3.

Highly relevant welfare consequences were identified for sows kept in individual crates. For this system, an outcome table linking these welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures was developed in Section 5.2. In the case of individual pens and outdoor paddock systems no welfare consequences were identified as highly relevant. Although other welfare consequences may negatively affect the welfare of farrowing and lactating sows in the opinion of the EFSA experts, they were classified as of minor or moderate relevance. A comparison of the husbandry systems in terms of welfare of farrowing and lactating sows is reported in Section 5.3.

In the case of **piglets**, the **systems** that have been fully assessed in the General ToRs, following the methodology described in Section 2.2.2.1, are individual farrowing crates, individual farrowing pens, outdoor paddock systems and artificial rearing systems. Section 5.5 presents the outcomes of the link between the highly relevant welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures in the four systems. A comparison of these systems is reported in Section 5.6.

In Section 5.7, the **welfare of sows and piglets**, from farrowing to weaning in different farrowing housing systems offering different degrees of behavioural freedom (Specific ToR 3) is further analysed. Also, Specific ToR 2 on the pre-farrowing situation deals with farrowing housing systems (although looking at the welfare of gilts and dry sows only), and it is assessed in Section 5.7 as well.

Additional considerations on farrowing systems, in relation to the time needed for animals and caretaker to adapt to the new systems, and on the effect of litter size on the welfare of sow and piglets, are reported in Sections 5.7.17 and 5.7.18.

Finally, **summary conclusions** on the welfare of farrowing and lactating sows and of piglets are listed in Sections 5.7 and 5.8; relevant **recommendations** are in Sections 5.7 and 5.9.

5.1. Highly relevant welfare consequences for farrowing and lactating sows: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5)

5.1.1. Restriction of movement

Restriction of movement was identified as a highly relevant welfare consequence for farrowing gilts and sows kept in individual crates. Conventional farrowing crates have limited space available and only allow the sow to stand up and to take a short step forward or back. The sow cannot turn around nor adopt certain body postures causing serious movement restriction (high severity). All farrowing and lactating sows housed in this type of system suffer from restriction of movement (high prevalence) and this is a non-interrupted welfare consequence for the time they are kept in crates (long duration).

Hazards, preventive, corrective and mitigating measures

The hazards that could lead to this welfare consequence are listed below, together with the measures that could help to prevent/correct each hazard or that can mitigate the welfare consequence.

1) **Insufficient space:** inadequate space allowance is the main impediment of movement (e.g. to turn around). In the pre-farrowing period, movements also include leaving and entering the nest site when performing nest-building behaviour. During lactation, sows typically leave the nest site for defaecation and urination. Thus, behavioural restrictions are more pronounced in farrowing and lactating sows kept in individual crates compared to gestating sows in crates.

   The effective preventive measure is to house farrowing and lactating sows in loose farrowing systems. No corrective measures are identified for this hazard, because they would require changing the husbandry system during the farrowing and lactation phase.
2) **Poor floor quality:** flooring should ensure that sows move easily and rest comfortably without incurring leg or udder injuries. Floors can fail in this regard because of poor maintenance (worn surface or broken slats) and/or design flaws (e.g. sharp edges; abrasive or too slippery floors).

To prevent this hazard, it is important to select and maintain appropriate flooring. This also requires replacing them when they become worn and/or broken. Corrective measures include the addition of bedding (straw, sawdust) or the provision of rubber mats.

5.1.2. Resting problems

Sows kept in farrowing crates are also affected by resting problems. Farrowing crates allow the sow to adopt a lateral recumbency posture, but often the sow body contacts with the metal bars while in this resting posture. Due to the limited space available it is not possible for the sow to alternate easily between positions and body postures to rest adequately (high severity). All farrowing and lactating sows housed in this type of system suffer from resting problems (high prevalence) and this is a non-interrupted welfare problem for the time they are kept in crates (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Insufficient space:** As described in 5.1.1, inadequate space allowance is the main impediment of movement and does not allow the sow to rest comfortably.
   Prevention of this hazard consists in housing sows in loose farrowing systems or to use farrowing crates which are better adapted to the sow's needs (in terms of physical dimensions). No corrective measures are identified for this hazard because it would require changing the husbandry system to a loose farrowing system.
2) **Poor floor quality:** flooring type should allow sows to move easily and rest comfortably thereby avoiding shoulder, leg and udder injuries.
   To prevent this hazard, it is important to select and maintain appropriate flooring. This requires avoiding slippery and abrasive floors, as well as floors with sharp edges. Corrective measures would include adding bedding (straw, sawdust) on the floor or providing the sow with a rubber mat.
3) **Wet and dirty floor:** if the floor is wet and dirty the sows cannot rest properly. During lactation, sows typically leave the nest site for defaecation and urination, thus avoiding soiling of the floor in the nest.
   Preventive measures include use of appropriate floor design and material, as well as management procedures that ensure that the floor is maintained clean and dry. Corrective measures are to clean the floor and/or provide a rubber mat or bedding, if possible, with floor design.

5.1.3. Group stress

Group stress was classified as having high relevance for farrowing and lactating sows kept in individual crates. Due to the limited space available and pen design, the sow is never able to keep some distance from the litter. This can cause considerable stress (high severity), affects all sows kept in these systems (high prevalence) and lasts for the whole lactation period (long duration), becoming more problematic as lactation progresses and the piglets become more demanding for suckling.

Hazard, preventive, corrective and mitigating measures

Insufficient space: sows show an increase in avoidance behaviour to their suckling piglets, directly related to the increasing pressure piglets put on the sow to obtain milk. If insufficient space is available to the sow to allow this avoidance behaviour, this may cause stress. Farrowing crates allow relatively little avoidance behaviour.

The prevention of this hazard implies that sows are housed in systems where avoidance behaviour can be shown (preferably a loose farrowing system). No corrective measures are identified for this hazard because it would require changing the husbandry system to a loose farrowing system.

5.1.4. Inability to perform exploratory or foraging behaviour

Inability to perform exploratory or foraging behaviour was classified as having high relevance in individual crates. Confinement in a crate with very limited space, frequently with slatted floors, results in impossibility to perform any kind of exploratory or foraging behaviour (high severity). This welfare consequence affects all sows kept in these systems (high prevalence) and lasts for the whole period sows are kept in farrowing crates (high duration).

Hazards, preventive, corrective and mitigating measures

1) **Absence or inadequate access to appropriate enrichment/foraging material:** exploratory behaviour is an intrinsic need of pigs, and provision of an adequate amount of appropriate enrichment material is a preventative and corrective measure (SVC, 1997; EFSA, 2014). This material should be clean and regularly replaced/replenished, and, according to the Commission Recommendation (EU) 2016/336, it should have one of more of the following characteristics: be edible or feed-like, chewable, investigable (e.g. rootable) and/or manipulable (e.g. the pig can change its location, appearance or structure).
   For sows kept in farrowing crates, enrichment/foraging material can be offered in a rack placed above the feeding trough (e.g. long-stemmed straw, hay) or be suspended/attached in the front part of the crate (e.g. wood, natural rope, jute sack) (for more details see Section 5.7.15). When provided on the floor, if not replaced regularly, it is moved out of reach when manipulated by the crated sow. In systems with fully slatted floor, it is more difficult to provide appropriate enrichment materials as these easily fall through the slats, and therefore commonly only e.g. objects attached to pen features can be used. A preventive measure is to consider solid or partly slatted flooring when designing the system. As a corrective and mitigating measure a rubber mat can be provided within reach of the sow to allow provision of enrichment materials on the floor.
2) **Insufficient space:** inadequate space presents a hazard as the sow is not able to move and manipulate enrichment/foraging material that is out of reach outside the crate.
   Prevention of this hazard consists in housing sows in loose farrowing systems. No corrective measures were identified for this hazard because that would require moving the sow to a loose farrowing system.

5.1.5. Inability to express maternal behaviour

Inability to express maternal behaviour was classified as having high relevance in individual crates. The restriction of movement provoked by the crate bars results in difficulty in expressing maternal behaviours such as nest-building and piglet nursing and interaction (high severity). This welfare consequence affects all sows kept in these systems (high prevalence) and lasts for the whole period sows are kept in farrowing crates (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Absence or inadequate access to appropriate nesting material:** this hazard prevents the sow from performing nest-building behaviour, such as carrying nesting material, rooting or pawing. Nesting material is difficult to provide on slatted flooring, as it has to be replaced regularly.
   Preventive measures include changing to a loose housing system with a solid floor in the nest area on which nesting material can be offered in sufficient amount or giving sows access to nesting material in the front part of the crate. Corrective measures consist in providing nesting material in a rack placed above the feeding trough, offering the sow a hessian bag to manipulate or replacing nesting material provided on the floor regularly, as this will get out of reach when manipulated by the crated sow.
2) **Insufficient space:** crating of lactating sows prevents them from approaching piglets outside the crate area and initiating social interactions with them. Furthermore, the piglets try to get access to the teats of a crated sow even though she is not willing to suckle them, which may result in an increased number of non-nutritive nursings.
   Prevention of this hazard consists in housing sows in loose farrowing systems. No corrective measures were identified for this hazard because that would require moving the sow to a loose farrowing system.

5.1.6. Heat stress

Heat stress was classified as having high relevance in individual crates. Farrowing crates impair sows' ability to thermoregulate and increased heat stress (high severity). This welfare consequence affects many sows kept in these systems, especially during summertime (high prevalence) and lasts for the whole period these sows are kept in farrowing crates (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Room temperature too high:** this hazard is relevant for lactating sows, as milk production is associated with high physiological activity and heat production. Thus, the sow has a need to thermoregulate and dissipate heat to lower body temperature. The hazard becomes more pronounced with increasing ambient temperature and humidity. There is no clear cut-off value for the start of heat stress when ambient temperature is increased, but it has been suggested that room temperatures above 25°C are critical for lactating sows (Black et al., 1993).
   Preventive and mitigating measures are to reduce room temperature (e.g. cooling of air supplied to the room) and to provide cooling systems (e.g. floor cooling, snout cooling systems; Barbari et al., 2007; Bjerg et al., 2020).
2) **Insufficient space:** crating of lactating sows prevents them from moving to a pen area where they could thermoregulate more efficiently (because of e.g. lower floor temperature, wet floor, circulating air with lower temperature).
   Prevention of this hazard consists in housing sows in loose farrowing systems providing access to different pen areas. No corrective measures were identified for this hazard because that would require moving the sow to a loose farrowing system.

5.1.7. Soft tissue lesions and integument damage

The welfare consequence 'soft tissue lesions and integument damage' was classified as having high relevance in individual crates. The frequent contact between the sow body, metal bars and the floor and the difficulty in changing the body posture due to the very restricted space frequently leads to appearance of skin lesions (high severity). This welfare consequence is likely to affect most sows kept in these systems (high prevalence) and skin lesions affect the animals during the whole period they are kept in farrowing crates (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Not enough space to avoid frequent contact between the sow body and metal bars:** this hazard is inherent to farrowing crates as these are designed such that the sow cannot turn around. When lying, standing up and lying down, the sow often touches or hits against the metal bars of the crate.
   The use of crates adjusted to sow size, in order to allow sufficient space to get up and lie down can prevent this hazard. A better alternative is to house farrowing and lactating sows in loose farrowing systems. No corrective measures are identified for this hazard because that would require structural adjustments or moving the sow to a loose farrowing system.
2) **Poor floor quality:** it's important that flooring ensures that sows rest comfortably without incurring shoulder, leg or udder lesions. Floors may fail in this regard because of poor maintenance (e.g. worn surface or slipperiness due to blocked drainage) and/or design flaws (e.g. sharp edges, lack of proper drainage, abrasive floors).
   To prevent this hazard, it is important to provide and maintain appropriate flooring. This also means replacing them when they become worn and/or broken. Preventive and corrective measures to reduce slipperiness include the addition of bedding (straw, sawdust) if the flooring system within reach of the sow permits or providing rubber mats.

5.2. Outcome table on the welfare of farrowing and lactating sows

Table 39 presents an overall outcome on the elements requested by the General ToRs on the welfare of farrowing and lactating sows: identification of the relevant welfare consequences and related ABMs, hazards and relevant preventive, corrective or mitigating measures. This relates to the individual farrowing crates as being the systems where highly relevant welfare consequences were identified. Individual farrowing pens and outdoor farrowing systems were also fully assessed, but no welfare consequences were classified as having high relevance. Other welfare consequences may negatively affect the welfare of farrowing and lactating sows, but they were classified as less or moderately relevant (see Appendix B).

Table 39: Welfare of farrowing and lactating sows kept in individual farrowing crates (described in Section 3.3.3.3): outcome table linking the highly relevant welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures. Cross-reference to the sections describing the welfare consequences and related ABMs is provided

Welfare consequence	Hazard(s)	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Restriction of movement **(overall description: Section 3.4.1; details in Section 5.1.1)**	– Insufficient space	– Change to a loose housing system	None	**(Table 12 – Section 3.4.1)** – Nest-building behaviours – Locomotory behaviour – Lying behaviour – *Posture changes* – *Atypical lying down movements (mainly in sows)* – *Pressure injuries (shoulder ulcers, calluses and bursitis)* – *Dewclaw injuries*
	– Poor floor quality	– Select and maintain appropriate flooring	– Provide adequate substrates or rubber mats on the floor	
Resting problems **(overall description: Section 3.4.2; details in Section 5.1.2)**	– Insufficient space	– Change to a loose housing system – Match the size of crates to sows' needs	None	**(Table 14 – Section 3.4.2)** – Lying behaviour – Pressure injuries: shoulder ulcers, calluses and bursitis – *Pig cleanliness* – *Teat lesions*
	– Poor floor quality	– Select and maintain appropriate flooring	– Provide bedding or rubber mats on the floor	
	– Wet and dirty floors	– Select and maintain appropriate flooring	– Clean the floor and/or provide a rubber mat or bedding, if possible with floor design	
Group stress **(overall description: Section 3.4.3; details in Section 5.1.3)**	– Insufficient space	– Change to a loose housing system	None	**(Table 16 – Section 3.4.3)** – Termination of a nursing bout

Welfare consequence	Hazard(s)	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Inability to perform exploratory or foraging behaviour **(overall description: Section 3.4.6; details in Section 5.1.4)**	– Absence or inadequate access to appropriate enrichment/foraging material	– Use systems with solid or partly slatted flooring – Provide part solid floor when offering loose materials – Provide (and replace regularly) appropriate enrichment and foraging material* (for solid floor systems)	– Provide a rubber mat to allow provision of enrichment materials within reach of the sow	**(Table 20 – Section 3.4.6)** – Exploratory behaviours directed at enrichment material – Exploratory behaviour directed to pen-fittings – Stereotypic behaviour – *Skin lesions on body parts other than tail and ears*
	– Insufficient space	– Change to a loose housing system	None	
Inability to express maternal behaviour **(overall description: Section 3.4.7; details in Section 5.1.5)**	– Absence or inadequate access to appropriate nesting material	– Change to a loose housing system – Give sow access to nesting material (e.g. provide nesting material in a rack, offer a hessian bag)* – Replace nesting material on the floor regularly, if possible, with floor design*		**(Table 21 – Section 3.4.7)** – Nest-building behaviours – Farrowing duration – Social contact with piglets – Piglet mortality – *Non-nutritive nursings*
	– Insufficient space	– Change to a loose housing system	None	
Heat stress **(overall description: Section 3.4.11; details in Section 5.1.6)**	– Room temperature too high	– Reduce room temperature* – Provide cooling systems*		**(Table 26 – Section 3.4.11)** – Respiratory rate and panting – Skin temperature – Rectal temperature – *Ratio of lying in sternal position/lying laterally* – *Wallowing behaviour* – *Skin soiling with faeces*
	– Insufficient space	– Change to a loose housing system	None	

Welfare consequence	Hazard(s)	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Soft tissue lesions and integument damage **(overall description: Section 3.4.14; details in Section 5.1.7)**	– Not enough space to avoid frequent contact between the sow body and metal bars	– Change to a loose housing system – Match the size of crates to sows' needs	None	**(Table 32 – Section 3.4.14)** – Teats and udder lesions – Body lesions, Leg injuries – Shoulder ulcers – Bursitis
	– Poor floor quality	– Select and maintain appropriate flooring – Provide adequate substrates or rubber mats within reach of the sow*		

*: The preventive measures that may also be used to correct an ongoing problem have been marked with a star key (*).
**: The ABMs considered neither sensitive nor specific (see Section 3.4) are presented in 'Italics' but for information purposes only and are not recommended to be used in practice.

5.3. Comparison of the systems for farrowing and lactating sows

The welfare aspects of the three housing systems for farrowing and lactating sows (individual crates, individual pens, outdoor paddocks) can be compared based on the information in Section 5.1 and Table 39. In the case of well-functioning individual pens and outdoor paddock systems, no welfare consequences were identified as highly relevant because they provide the sow with greater space. The critical issue is thus the crating of the sow, exposing her to the bars of the crate and the floor in the crate without an option to avoid their negative impact regarding body lesions. Furthermore, the crate restricts the movements of the sow, preventing her, e.g. to choose a nest-site, to leave the lying area for defaecation and urination, to initiate and regulate social contact with the piglets and to choose a floor area that is more suitable for thermoregulation. With regard to individual crates, welfare consequences can be reduced by using housing systems with temporary crating, and the detrimental effects are less pronounced the shorter the crating period. After opening the crate, all welfare consequences described in Table 39 are similar to those observed in farrowing and lactating sows kept in individual pens and thus no longer classified as having high relevance. The comparison between the systems can be found in Appendix B (Table B.1).

5.4. Highly relevant welfare consequences for piglets: hazards, preventive, corrective and mitigation measures (Specific ToRs 4 and 5)

In the case of piglets, the systems that have been assessed are individual farrowing crates, individual farrowing pens, outdoor paddock systems and artificial rearing systems (see the beginning of Chapter 5).

5.4.1. Restriction of movement

Restriction of movement was classified as having high relevance in the artificial rearing systems due to the fact that large groups of piglets are housed in the same pen (up to 20–25 piglets) and limited space is available for each. High stocking rates do not allow freedom of movements nor possibility to move away from other piglets (high severity). Piglets are kept in this type of system from an early age until weaning (~ 28 days) (long duration). This welfare consequence was considered to have a high prevalence because it affects all piglets kept in these systems.

Hazards, preventive, corrective and mitigating measures

1) **Insufficient space**: Inadequate space is the main impediment of movement. In artificial rearing systems for piglets, space allowance is usually very low (see Section 3.3.4.1). There is a little opportunity to walk around because the floor area is busy with other piglets, lying or standing. It also leads to competition between piglets for the heating space and limits play-fighting. Moreover, the lying behaviour is also compromised because of the lack of space.
   The preventive measure is to offer a pen large enough to accommodate all piglets comfortably. The corrective measure is to decrease the number of animals in a group.
2) **Poor floor quality:** flooring should allow piglets to move easily and to rest comfortably.
   To prevent this hazard, it is important to select and maintain appropriate flooring, of a material that does not injure the legs of the piglets, which are very vulnerable at this early age. It is important to provide floors that are not slippery and having no risk of trapping claws. Corrective measures would include provision of a substrate material like straw or provision of rubber mats and ensure the proper temperature of the floor by, e.g. insulated walls, pens, heating panels, infrared lamps, etc.

5.4.2. Group stress

Group stress was classified as having high relevance in all four husbandry systems that were fully assessed for piglets (individual farrowing crates, individual farrowing pens, outdoor paddock systems and artificial rearing systems). In all group housing systems, there is a continuous interaction between siblings, i.e. because of competition for food, space and other resources. This can be stressful and can be more severe in large litters (high severity). Group stress is present throughout the whole lactation period (long duration) and affects virtually all piglets (high prevalence).

Hazards, preventive, corrective and mitigating measures

The main reason for group stress in suckling piglets is the competition for teats.

1) **Insufficient access to teats** (not relevant to artificial rearing systems): The competition for establishing the teat order within the first 24 h and afterwards maintaining it causes significant group stress. Weak piglets (e.g. with low birth weight) are subjected to a greater extent to this hazard, compared to stronger piglets. When there are more piglets than teats (prolific litters), milk supply by the sow is insufficient or not all the teats are functional (e.g. due to mastitis, young or old sows); thus, the hazard is increased. Group suckling pens could also be a source of group stress. In these systems, piglets have a possibility to get access to more teats, different from those of their mother sow (cross-fostering/suckling) and strong piglets can thus cause disturbance in the whole system. Moreover, teat fighting leads to facial injuries, as piglets are born with fully erupted 'needle teeth' that can be used to defend the position at a teat (for further details, see Section 6.1).
   Preventive measures would include improving the breeding strategy for optimising the litter size. Corrective measures would include: (i) moving of piglets between sows to balance litter sizes on commercial farms (cross-fostering) and also application of split suckling (a practice involving temporary removal of larger piglets to allow smaller piglets to have unimpeded teat access); and (ii) early provision of creep feed for piglets or additional milk supplementation in order to reduce the competition for teats.
2) **Insufficient access to resources** (relevant to artificial rearing systems): If piglets experience difficult access to water or creep feed, they could fight for these resources as well and it could cause group stress. The lack of space at the milk cups in the artificial rearing systems could increase the number of aggressive interactions.
   Preventive measures would include providing appropriate number of milk cups and drinkers for piglets and a place where creep feed could be spread. Regular checking of the flow rate, adjust the height of the drinkers to the weight of the piglets and ensuring enough milk are valuable corrective measures.
3) **Penmate directed behaviours** (relevant to artificial rearing systems): Early weaned piglets placed in artificial rearing systems typically develop 'belly nosing', which increases both in frequency and duration over the artificial rearing period (see Section 3.4.8 for details). As a result of this hazard, piglets could not rest properly because their rest is interrupted more often than normal and reduced comfort may occur.
   Preventive measures would include increasing the space for the piglets in the system. Corrective measures include decreasing the number of piglets in one system. Injured piglets may need to be removed for suitable treatment.

5.4.3. Separation stress

Separation stress occurs at weaning in any system but was classified as having high relevance in the artificial rearing systems because of the stressful effects resultant from separation from the sow (high severity). Piglets tend to be moved to this kind of housing system at a very early age and are kept until weaning (high duration). Separation stress affects all piglets kept in artificial rearing housing (high prevalence).

Hazard, preventive, corrective and mitigating measures

Separation from the sow. Piglets show intense activity and characteristic patterns of vocalisation in the first minutes and hours after separation, between 1 and 5 weeks of age (Weary and Fraser, 1997; Weary et al., 1999). Moreover, they try to run and jump across the walls of the pen, are very restless and may be aggressive towards their pen mates.

Separation stress cannot be prevented when using artificial rearing systems.

5.4.4. Inability to perform exploratory or foraging behaviour

Inability to perform exploratory or foraging behaviour was classified as having high relevance in piglets housed in individual farrowing crates and artificial rearing systems. The very limited space available in these systems and the frequent absence of bedding provide no opportunities for exploration or foraging (high severity). It tends to affect all piglets (high prevalence) throughout the time they are housed in these systems (whole lactation, up to 28 days) (long duration).

Hazard, preventive, corrective and mitigating measures

Lack of appropriate enrichment/foraging material (considered highly relevant to individual farrowing crates and artificial rearing systems): When no exploratory material or substrate is provided to piglets, exploratory behaviour can be redirected to pen mates.

Preventive and corrective measures include the provision of enrichment material of a nature and amount adequate to fulfil the requirements of piglets, i.e. investigable, manipulable, chewable (including deformable and destructible), edible, and that can be shared with other piglets (for further information, see Section 5.7.15). In systems with fully slatted floor, it is more difficult to provide appropriate enrichment materials as these easily fall through the slats, and therefore commonly only e.g. objects attached to pen features can be used. A preventive measure is to consider solid or partly slatted flooring when designing the system. As a corrective measure a rubber mat can be provided to allow provision of enrichment materials on the floor.

5.4.5. Inability to perform sucking behaviour

Inability to perform sucking behaviour was classified as having high relevance in the artificial rearing systems due to the fact that suckling is not possible in these systems due to separation from the sow and impossibility to suckle from the sow mammary gland (high severity). Even if artificial teats are provided these do not provide the same opportunities to perform full suckling behaviour (including udder massage). It affects all piglets (high prevalence) throughout the period they are housed in these systems (whole lactation, up to 28 days) (long duration).

Hazard, preventive, corrective and mitigating measures

Lack of a teat to suck. Early weaned piglets in artificial rearing systems typically develop an abnormal behaviour pattern termed 'belly nosing' (see Section 3.4.8). These rhythmic up-and-down movements with the snout directed to the body of a pen mate appear as a result of not satisfied suckling behaviour. This disturbance increases both in frequency and duration over the artificial rearing period.

The hazard can be prevented by supplying milk through a teat rather than in a dish, which reduces the prevalence of belly nosing (Widowski et al., 2005). However, some belly nosing still occurs because of the absence of udder massaging opportunities.

5.4.6. Prolonged hunger

Prolonged hunger was classified as having high relevance in all four husbandry systems that were fully assessed for piglets (individual farrowing crates, individual farrowing pens, outdoor paddock systems and artificial rearing systems). Genetic selection for large litter sizes means that often there is a high competition for milk between piglets; this can result in prolonged hunger for weaker and less dominant piglets (high severity). It can occur in all grouped-housed piglets, but it is more frequent in high litter sizes and affects weaker piglets mainly (medium prevalence) and have a continued effect during lactation (long duration). In artificial rearing systems, this is aggravated by the fact that the quality of artificial milk and colostrum is often lower than those produced by the sow.

Hazards, preventive, corrective and mitigating measures

1) **High litter size** (relevant to all four systems): Piglets with low birth weight and poor vitality may have difficulties to get access to teats, and they do not ingest sufficient amount of milk. They thus suffer from hunger and may die due to starvation. This is more likely to happen in bigger litters, compared to smaller ones. Breeding for large litters is discussed in Section 5.7.18.
   Preventive measures would include improving the breeding strategy for optimising the litter size. In the farrowing systems, corrective measures include cross-fostering to balance for litter size, and provision of supplementary milk. In the artificial rearing systems, it can be mitigated by providing an alternative source of nutrition which meets the needs of the group of piglets.
2) **Poorly designed or operated systems** (mainly related to artificial rearing): In artificial piglet rearing systems, piglets may struggle to become familiar with the functionality and location of the milk cup system.
   Preventive and corrective measure could include encouraging piglets to use the milk cup and a provision of milk replacer or creep feed.

3) **Poor milk yield of the sow** (relevant to all systems except artificial rearing). Mastitis and other health issues (e.g. teat lesions) may affect milk yield of sows as well as the age of the sow (very old or very young sows) and insufficient number of functional teats.
Preventive measure here is to reduce risk factors of mastitis (e.g. introduction of gilts into herd, feeding, pen hygiene and provide assistance around farrowing), but occurrence of mastitis cannot completely be prevented. Timely culling of older sows after weaning and regular monitoring of number of functional teats could be applied in the case of insufficient production of milk due to the sow age. Corrective measure at farm level could be an early recognition and treatment. They may include split suckling, supplying piglets in their home pen with artificial milk, 'targeted' early cross-fostering, use of nurse sows, early piglet feeding.

5.4.7. Prolonged thirst

Prolonged thirst was classified as having high relevance in piglets housed in individual farrowing crates, individual farrowing pens and outdoor paddock systems. Prolonged thirst in combination with low milk intake could lead to dehydration and later death of a piglet. The risk of dehydration is especially high in situations with both insufficient access to water and limited milk intake (high severity) and is also high in warm environment and cases of diarrhoea (high prevalence). Prolonged thirst could affect piglets during the whole lactation period (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Insufficient access to milk** (relevant to the three farrowing systems). If piglets have low weight gain, possibly indicating low milk intake, they are more inclined to drink water. Piglets with low birth weight and poor vitality could have difficulties to get access to teats, and they do not ingest sufficient amounts of milk. If they cannot reach the drinkers, this will worsen the situation.
Preventive measures include breeding strategies (for lower litter size). Corrective measure include supporting weak piglets in accessing teats or finding the milk replacer.
2) **Lack of supplementary water** (relevant to the three farrowing systems, and particularly for outdoor farrowing paddocks). Access to water is very important in particular when it is warm, and when piglets suffer from diarrhoea. In outdoor paddock systems, drinking facilities are not normally present in farrowing huts. Freezing of drinkers during the cold days can also result in prolonged thirst.
Preventive measures include providing sufficient number of drinkers with appropriate height and flow rate for suckling piglets. Preventive and corrective measures include encouraging piglets to drink water by making drinkers more attractive to them.

5.4.8. Cold stress

Cold stress was classified as having high relevance in piglets housed in outdoor paddock systems. Piglets are particularly susceptible to cold because of their small body size and poorly developed thermoregulation mechanism especially after birth. Limited capacity for thermoregulation, low energy reserves, a lack of brown adipose tissue and environmental conditions that are adverse for the piglet around the time of birth, including the absence of a microclimate, all contribute to difficulties in reaching thermal homeostasis in the first hours post-birth (Villanueva-García et al., 2021). Whilst indoor piglets are commonly provided with controlled thermal conditions, with supplementary heat, piglets kept in outdoor systems can be exposed to low temperatures and have difficulties in keeping a comfortable body temperature (high severity). This welfare consequence has a continuous effect (long duration) and affects many piglets (high prevalence) kept in outdoor housing in winter conditions (except perhaps those kept at lower latitudes).

Hazards, preventive, corrective and mitigating measures

1) **Low ambient temperature:** At low ambient temperatures, it may be impossible to provide adequate outdoor housing conditions to prevent cold stress.
The preventive measure is to only use indoor housing where heat can be provided in regions and seasons where very low temperatures regularly occur. The corrective measure would be to move piglets to indoor housing with heating possibility.

2) **Housing with poor insulating properties:** Piglets can better resist low temperatures if their housing aids conservation of body heat and allows a warmer microclimate to be established. This includes high insulation of walls and roof, prevention of draughts and deep bedding of dry straw.
   The preventive measure is to provide suitable insulated housing conditions. A corrective measure is to increase the depth of dry straw bedding.

5.4.9. Soft tissue lesions and integument damage

The welfare consequence 'Soft tissue lesions and integument damage' was classified as having high relevance in piglets housed in individual farrowing crates, individual farrowing pens and outdoor paddock systems. This welfare consequence may result from negative social interactions such as aggression or teat competition, from handling or from damaging environmental features or from mutilation practices (e.g. tail docking, if practised) and from piglet crushing by the sow. All types of lesions can be very painful (high severity); piglet crushing can result in death in some instances (high severity). Because any piglet can be affected by this type of lesions it was considered that the prevalence of this welfare consequence is high, and has a prolonged effect since the risk of suffering soft lesions or integument damage is continuous until weaning (long duration).

Hazards, preventive, corrective and mitigating measures

For all hazards, the most important measure to alleviate the welfare consequence is to treat the affected animals. If the consequence is serious, then the animals need to be isolated in hospital pens. In case of very serious situations, euthanasia might be also taken into consideration. Early detection of light soft tissue lesions and integument damage is important and allows corrective measures to be applied at a stage when it is likely to be more effective, consequently reducing the likelihood of chronic and serious problems.

1) **Competition for teats.** Soft tissue lesions and integument damage could occur in all three systems when piglets fight for teats and weaker animals cannot avoid aggressive interactions with stronger individuals. This could lead to facial injuries and skin lesions on the front limbs.
   Preventive measures include an appropriate breeding strategy to avoid large litter sizes and cross-fostering to equalise litters within a short period after birth. Corrective measures include removal of bullied individuals and treatment in the case of any injury.
2) **Poor floor quality and maintenance** (relevant to the three systems). Flooring should allow piglets to move easily and to rest comfortably. Piglets develop abrasion injuries on their front legs from contact with the floor during suckling.
   To prevent this hazard, it is important to select and maintain appropriate flooring, made of a material that does not injure the legs of the piglets, which are very vulnerable at this early age, with preference of solid floors instead of part-concrete, part round-weld-mesh flooring. Corrective measures consist in remedying injurious pen components (e.g. sharp edges) and provision of mats or a substrate such as straw.
3) **Crushing of suckling piglets by the sow** (relevant to the three systems). Crushing is accompanied with major trauma including soft tissue lesions. Most piglets are crushed when the sow moves from standing to lying or when she rolls over while already lying. Crushing results from failure of the piglet to avoid the sow or as a result of illness or behavioural problems in the sow which lead her to ignore the piglets.
   Preventive measures include the use of protective pen features such as rails or sloped walls or devices such as blow away units or hydraulic floors (dependent on housing system) to discourage piglets from moving underneath the sow each time she stands up. Farrowing crates should be adjusted for the size of the sow. Farrowing pens should have warm creeps to encourage piglets to lie separately from the sow. Attendance at farrowing may reduce crushing. Some protective features are visualised in Figures 1–4 (Section 3.3). A corrective measure consists in providing fine bedding, such as sawdust (Chaloupková et al., 2011).
4) **Insufficient access to and availability of resources** (relevant to all three systems): Soft tissue lesions and integument damage, including bitten tails, occur when animals compete to attain or protect limited resources. Aggression over resources may result from the limited access to the resource, or from limited availability of the resource.

Preventive measures include: providing appropriate number of milk cups, drinkers and creep feed, increasing lying space or enrichment and changing the breeding strategy to less prolific sows. Preventive and corrective measures are increasing limiting resources or access to resources. Removal of individual animals which are unable to compete successfully and treatment in the case of any injury can also correct the hazard.

5) **Lack of enrichment** (relevant to all three systems). Tail, ear and flank lesions caused by pig-directed behaviours are more prevalent when the environment provides few other opportunities for expression of exploratory behaviour.

   Providing additional environmental enrichment is both a preventive and corrective measure. Further corrective measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.

5.5. Outcome table on the welfare of piglets

Table 40 presents an overall outcome on the elements requested by the General ToRs on the welfare of piglets: identification of the relevant welfare consequences, welfare hazards, preventive and corrective measures or mitigating measures and related ABMs. This relates to the four husbandry systems for piglets that were fully assessed in the General ToRs (individual farrowing crates, individual farrowing pens, outdoor paddock systems and artificial rearing systems). Cross-reference to the sections describing the welfare consequences and related ABMs, and husbandry systems is provided.

Table 40: Welfare of piglets: outcome table linking the most relevant welfare consequences, ABMs, hazards, and preventive, corrective and mitigation measures in the four husbandry systems that have been fully assessed in the General ToRs (farrowing individual crates, farrowing individual pens, outdoor paddock systems and artificial rearing systems). Cross-reference to the sections describing the welfare consequences and related ABMs, and husbandry systems is provided

Welfare consequence	Husbandry system (s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure (s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Restriction of movement **(overall description: Section 3.4.1; details in Section 5.4.1)**	Artificial rearing systems (Section 3.3.4.1)	– Insufficient space	– Offer a large enough system	– Decrease the number of piglets	**(Table 12 – Section 3.4.1)** – Locomotory behaviour – Play-fighting – Lying behaviour – *Posture changes*
		– Poor floor quality	– Select and maintain appropriate flooring	– Provision of rubber mats or substrative material (straw, sawdust) – Ensure proper temperature of the floor	
Group stress **(overall description: Section 3.4.3; details in Section 5.4.2)**	All four systems: – Individual farrowing crates (Section 3.3.3.3) – Individual farrowing pens (Section 3.3.3.5) – Outdoor farrowing paddocks (Section 3.3.3.8) – Artificial rearing systems (Section 3.3.4.1)	– Insufficient access to teats (no artificial rearing systems)	– Changing the breeding strategy to less prolific sows	– Supplying piglets in their home pen pen, e.g. with artificial milk; – Cross-fostering (or split suckling)	**(Table 16 – Section 3.4.3)** – Agonistic behaviour – Facial injuries – Belly nosing – Skin lesions – Body condition
		– Penmate directed behaviours (artificial rearing systems)	– Increase the space for the piglets in the system	– Decreasing the number of piglets in the system; – Removal of the injured piglets and suitable treatment	
		– Insufficient access to resources (artificial rearing systems)	– Providing appropriate number of milk cups, milk replacer or creep feed	– Regular checking of the flow rate – Adjust the height of the drinkers to the weight of the piglets – Assuring enough milk	

Welfare consequence	Husbandry system (s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure (s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Separation stress **(overall description: Section 3.4.5; details in Section 5.4.3)**	Artificial rearing systems (Section 3.3.4.1)	– Separation from the sow	None	None	**(Table 18 – Section 3.4.5)** – Increased activity – *Vocalisations*
Inability to perform exploratory or foraging behaviour **(overall description: Section 3.4.6; details in Section 5.4.4)**	– Individual farrowing crates (Section 3.3.3.3) – Artificial rearing systems (Section 3.3.4.1)	Lack of appropriate enrichment/foraging material (relevant to both systems)	– Providing foraging material in adequate amount (straw, sawdust, peat, shredded newspaper)* – Provide part solid floor when offering loose materials (all systems)	– Provide a rubber mat to allow provision of enrichment materials on the floor	**(Table 20 – Section 3.4.6)** – Exploratory behaviours directed at enrichment material – Exploratory behaviour directed to pen-fittings – Re-directed exploratory behaviour, towards pen mates – *Tail lesions* – *Ear lesions* – *Skin lesions on other body parts*
Inability to perform sucking behaviour **(overall description: Section 3.4.8; details in Section 5.4.5)**	Artificial rearing systems (Section 3.3.4.1)	– Lack of a teat to suck	– Supplying milk through a teat	None	**(Table 22 – Section 3.4.9)** – Belly nosing
Prolonged hunger **(overall description: Section 3.4.9; details in Section 5.4.6)**	All four systems: – Individual farrowing crates (Section 3.3.3.3) – Individual farrowing pens (Section 3.3.3.5)	High litter size (relevant to all systems)	– Changing the breeding strategy to less prolific sows (all systems)	– Cross-fostering (farrowing systems) – Supplying piglets in their home pen, e.g. with artificial milk (farrowing systems) – Provision of an alternative source of nutrition which meets the needs of the group of piglets	**(Table 24 – Section 3.4.9)** – *Runt pigs* – *Facial injuries* – *Live-born mortality*

Welfare consequence	Husbandry system (s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure (s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
	– Outdoor farrowing paddocks (Section 3.3.3.8) – Artificial rearing systems (Section 3.3.4.1)	– Poorly designed or operated systems (mainly artificial rearing system)	– Encouraging piglets to use the milk cup* – Provision of milk replacer or creep feed*		
		– Poor milk yield of the sow (three farrowing systems)	– Reduce the risk of mastitis – Timely culling of old sows – Regular monitoring of the number of functional teats	– Early mastitis recognition and treatment – Split suckling – Supplying piglets e.g. with artificial milk – Cross-fostering – Use of nurse sows – Early piglet feeding	
Prolonged thirst **(overall description: Section 3.4.10; details in Section 5.4.7)**	– Individual farrowing crates (Section 3.3.3.3) – Individual farrowing pens (Section 3.3.3.5) – Outdoor farrowing paddocks (Section 3.3.3.8)	– Insufficient access to milk (relevant to all three systems)	– Changing the breeding strategy to less prolific sows	– Provide easily accessible milk replacer – Check-up regularly on newborn piglets – Encourage piglets to use sow teats – Show piglets where to find drinkers	**(Table 25 – Section 3.4.10)** – Increased drinking attempt – Skin pinch test
		– Lack of supplementary water (mainly for outdoor farrowing paddocks)	– Providing sufficient number of drinkers with appropriate height and flow rate; – Making drinkers more attractive to piglets*		

Welfare consequence	Husbandry system (s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure (s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Cold stress **(overall description: Section 3.4.12; details in Section 5.4.8)**	Outdoor farrowing paddocks (Section 3.3.3.8)	– Low ambient temperature	– Use indoor housing for piglets in cold seasons	– Move piglets to indoor housing with heating possibility	**(Table 28 – Section 3.4.12)** – Rectal temperature – Skin temperature – Shivering – Huddling behaviour – Ratio of lying in sternal position/lying laterally – *Colostrum intake* – *Live-born mortality*
		– Housing with poor insulating properties	– Provide suitable insulated housing conditions	– Increase amount of dry straw bedding	
Soft tissue lesions and integument damage **(overall description: Section 3.4.14; details in Section 5.4.9)**	– Individual farrowing crates (Section 3.3.3.3) – Individual farrowing pens (Section 3.3.3.5) – Outdoor farrowing paddocks (Section 3.3.3.8)	– Competition for teats (all three systems)	– Changing the breeding strategy to less prolific sows – Cross-fostering	– Removal of bulled individuals and treatment of the injuries	**(Table 32 – Section 3.4.14)** – Facial injuries – Skin lesions on the front limbs – Tail lesions – Body lesions – Leg injuries – Ear lesions – Bursitis – *Live-born mortality*
		– Poor floor quality and maintenance (all three systems)	– Selection and maintenance of appropriate flooring – Preference of solid floors	– Remedying injurious pen components – Providing mats or straw	
		– Crushing of suckling piglets by the sow (all three systems)	– Adjusting farrowing crates to the size of the sow – Providing warm creeps at farrowing – Attendance at farrowing – Use of protective pen features	– Providing fine bedding like sawdust	
		– Insufficient access and availability of resources (all three systems)	– Providing of appropriate number of milk cups	– Removal of uncompetitive individuals	

Welfare consequence	Husbandry system (s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure (s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
			drinkers and creep feed; – Increasing lying space or enrichment – Changing the breeding strategy to less prolific sows – Increasing limiting resources or access to resources*	– Treatment of injured animals	
		– Lack of enrichment (all three systems)	– Providing additional environmental enrichment*	– Removal of any persistently disruptive animals – Treating lesions	

*: The preventive measures that may also be used to correct an ongoing problem have been marked with a star key (*).
**: The ABMs considered neither sensitive nor specific (see Section 3.4) are presented in 'Italics' but for information purposes only and are not recommended to be used in practice.

5.6. Comparison of the systems for piglets

The welfare aspects of the four housing systems for piglets (individual farrowing crates, individual farrowing pens, outdoor farrowing paddocks and artificial rearing systems) can be compared based on the information in Section 5.4 and Table 40. Some of the highly relevant welfare consequences, such as group stress and prolonged hunger are common for all four systems. Changing the breeding strategy to move away from increased litter sizes will benefit several aspects of piglet welfare. Other welfare consequences like restriction of movements, separation stress and inability to perform suckling behaviour are observed mainly when piglets are separated from their mother and have their own preventive and corrective measures. Some of the welfare consequences are more influenced by the housing conditions and were typical for outdoor paddocks (cold stress). The full comparison between the systems can be found in Table B.1, in Appendix B.

5.7. Assessment of Specific ToRs 2 and 3: welfare of sows and piglets in different farrowing house systems offering different degrees of behavioural freedom

5.7.1. Combining two Specific ToRs

This Section deals with two Specific ToRs described in the Mandate from the European Commission:

Specific ToR 2: The welfare of gilts and dry pregnant sows 1 week before farrowing in different housing systems offering different degrees of behavioural freedom;

Specific ToR 3: The welfare of sows and piglets from farrowing to weaning in different housing systems offering different degrees of behavioural freedom.

The two ToRs deal with different pig categories according to the European Commission Mandate, however they are both housed in the same farrowing accommodation and therefore the discussion of these Specific ToRs is combined in this Section.

Please note that for the purpose of this assessment only individual sow housing systems were included; group suckling systems were not considered, as the design of such systems is diverse and they are currently not widely used in commercial practice (for further information, see Section 3.3.3.6).

The improvement in sow and piglet welfare in farrowing systems is strongly related to two aspects which are not related to the design of the system and warrant further investigation. They are (1) the time needed for animals and caretaker to adapt to the new system, and (2) the size of the litter. These two aspects are addressed in Sections 5.7.17 and 5.7.18.

5.7.2. Relevant 'exposure variables' and how to assess them

There are a range of factors that determine animal welfare differences between farrowing crates and pens. Important factors or 'exposure variables' are the amount of space available to sows and piglets, the timing of extra available space, the level of environmental enrichment and the possibilities for nest-building. They will be addressed in the following sections. There are also other variables that can be considered to affect welfare in farrowing systems.

One group of such exposure variables involves the type of floor. It includes the materials used and also the ratio between solid and slatted floors and other aspects that determine the functional areas of the farrowing accommodation. As described in Section 3.3.1.3, a partly solid floor is required to allow the piglets to rest comfortably. It must be solid or covered with a mat or be littered with straw or any other suitable material to allow piglets to rest together in a thermally comfortable area and suckle without obstructions. Inappropriate floor design may result in wet lying areas for piglets or lying areas in which piglets are insufficiently protected from crushing. This may lead to cold stress (Section 3.4.12) or mortality due to overlying (Section 3.4.14). For sows, a properly drained dunging area and a dry and comfortable lying area is important to avoid poor hygiene and resting problems (Section 3.4.2).

Another highly relevant set of exposure variables is the experience, skills and attitude of the farmer towards the farrowing system. Waiblinger and Spoolder (2007) describe the activities in the farrowing house which involve some degree of pig-human contact: checking the sow before, during and after parturition, drying off piglets, making sure colostrum is taken up by the whole litter, cross-fostering, teeth clipping and iron injecting, all involve handling of the animals by the caretaker. Several handbooks (e.g. Brent, 1982) address how these activities should technically be carried out, to improve piglet survival as well as the productivity of the unit. Most of the welfare consequences which are described in 3.4 are affected by the way the farmer operates. The combination of technical skill and attention to detail is crucial, or as Hemsworth et al. (1995) call it: a 'motivation to observe departures from normal'. Good supervision in the farrowing rooms not only improves sow and piglet welfare but does so in an economically viable way: extra time spent in the farrowing room pays for itself (Holyoake et al., 1995).

Appropriate climate control in the farrowing house avoids problems related to cold stress (3.4.12) and heat stress (3.4.11). The requirements for climate control are more complex than in other pig buildings, as the temperature requirements of the piglets are considerably higher than for the sows. This means that whilst the sow lying area should not be too hot for her to produce milk for the piglets and cooling may be required, additional heating may be needed for piglets in the creep area through, e.g. heating lamp and floor heating.

Quantification of the effects of these exposure variables need experimental studies or monitoring of a wide range of systems. For all of them, we found that corresponding references relating them to space allocation are sparse and lacking standardisation. However, for three relevant exposure variables quantifiable relations to animal welfare were identified in the scientific literature. They are:

- Effects of the temporal availability of access to space (i.e. temporary crating).
- Effects of the quantity of space (in terms of m^2 accessible to the sow).
- Effects of the quality of space (in terms of environmental enrichment).

For each of these exposure variables, ABMs were chosen that allow a degree of quantification of the welfare impact of the variable. To be able to do this, extensive literature searches (ELS) were carried out to identify scientific evidence reporting welfare implications of the exposure variables and associated ABM(s). Details of the approach and results of the literature searches can be found in Appendix B.

Relevant data on ABM(s) with a strong relationship to the exposure variables were extracted and analysed. In the following paragraphs, the reasons for choosing these ABMs as well as the outcomes of the impact assessments are presented. Table 41 provides an overview of these ABMs for quantification of the effect of the exposure variables both pre-farrowing and post-farrowing. The table also indicates where a non-quantitative/narrative approach was chosen to assess the welfare impact.

Table 41: ABMs used in this Scientific opinion to quantify the effects of three exposure variables on sow and piglet welfare in the farrowing accommodation. An X indicates that a non-quantitative/narrative approach was used

Exposure variable	Timing		
	Pre-farrowing	Post-farrowing	
		Sow	Piglets
Temporal availability of space	X	X	preweaning mortality (EKE 1)
Quantity of space	Inter-piglet birth interval (EKE 2)	locomotory behaviour (EKE 3)	preweaning mortality (EKE 4)
Quality of space	Nest-building behaviour	X	X

5.7.3. Temporal availability of space: temporary crating of the sow

The first of the three exposure variables affecting the behavioural freedom of sows concerns the timing and duration of temporary crating a sow in a farrowing pen situation. For the purpose of this assessment, the description of temporary farrowing crates (see Section 3.3.3.4) was used as a starting point. The total space occupied in these pens is usually between 5.5 and 7.5 m^2, offering ~ 4.3–6.3 m^2 to the sow when the crate is opened as the area reserved for the piglets in this SO is estimated to be 1.2 m^2.

Because insufficient data are available to do a quantitative assessment, the effects of temporary crating from the perspective of the sow (both pre- and post-farrowing), are discussed based on scientific evidence in a narrative text (see Section 2.2.2). The effect of temporary crating post-farrowing on total preweaning mortality of the piglets is assessed through an EKE approach (EKE 1).

5.7.4. Pre-farrowing crate closing time

5.7.4.1. Evaluation of the scientific evidence

As discussed in the General TORs, when sows are confined in a farrowing crate in the period prior to farrowing they experience the welfare consequence of 'restriction of movement' (see Section 3.4.1) and, because they are unable to carry out the full repertoire of highly motivated nest-building behaviours, they also experience the welfare consequence of 'inability to express maternal behaviour' (see Section 3.4.7). However, farrowing crates are widely used because of concerns about the increased risk of piglet mortality in non-confinement housing. In order to balance these conflicting considerations, systems in which the period of confinement for the sow is reduced (temporary crating systems) have been developed (Section 3.3.3.4). If such systems are adopted, it is pertinent to consider at what point relative to the time of farrowing that confinement of the sow should be imposed. In order to minimise the number of handling occasions, some farmers choose to confine the sow immediately at the time of moving into the farrowing accommodation (typically around 5 days prior to expected farrowing). A second option is to allow the sow to initially be loose in the pen, and only close the crate shortly prior to farrowing. The closer to farrowing this is carried out, the more possibility the uncrated sow has to fully express elements of nest seeking and nest-building behaviour. However, since the exact time when farrowing will occur is uncertain, it is most common to close the crate 1–2 days before expected farrowing to avoid the risk of earlier parturition. This means that some sows are confined for a longer period before giving birth. The third option is to leave the crate open until the end of parturition, typically closing it on the first occasion that the sow is seen to have completed farrowing. For sows which farrow overnight, this may be several hours after the last piglet is born. The available information regarding these different options has recently been the subject of a detailed scientific review (Goumon et al., 2022), where the pertinent scientific references can be found. The key evidence is summarised in the following sections.

When first moved into a farrowing crate, animals may experience acute stress as a response to confinement particularly for gilts kept in groups during pregnancy (Boyle et al., 2002b). This was clearly shown for gilts by an increase in blood cortisol (Lawrence et al., 1994) but the limited evidence for multiparous sows indicates that they do not experience acute stress when moved into the farrowing crate possibly because they have experience of them (Boyle et al., 2002). It is also uncertain how much this acute stress is associated with the handling and change of environment involved in transfer to the farrowing accommodation, rather than confinement per se, and to what extent it is mitigated by previous experience of confinement, e.g. in gestation feeding stalls. When moved into their farrowing accommodation (either loose pens or crates) at a very late stage of gestation (1–2 days before expected farrowing), both gilts and sows showed increased restlessness before farrowing in comparison with animals which were given more time to adapt to their new accommodation (Lawrence et al., 1994). However, no increase in salivary cortisol could be detected when sows previously moved into a loose farrowing pen were subsequently confined in a temporary crate at 2 days prior to expected farrowing. These findings suggest that environmental novelty and handling stress are the main hazards associated with the acute response. Since elevated cortisol can antagonise the action of oxytocin, any acute stress associated with placing sows in confinement at a time shortly before or during farrowing might adversely affect farrowing progress and increase the risk of stillbirths. There is good evidence for this in gilts, but it is less clear in the case of multiparous sows. Clearly, confinement in a crate impairs the sow's ability to move around. This may result in frustration at a motivational level, without being detectable in stress hormone concentrations.

As highlighted in Section 3.4.1 on restriction of movement in farrowing systems, confinement of sows which includes the 24-h period prior to the onset of farrowing will disrupt nest-building behaviour. The duration of nest-building and the time active during the nest-building phase are reduced in sows confined 1–2 d before expected farrowing, in comparison with sows confined after completion of farrowing or never confined, and their nest-building behaviour is more fragmented. The effect of frustrating nest-building on stress physiology is less marked in multiparous sows than in gilts, but may still be present. Mayer et al. (2016) suggested that the sows which are confined 1 day before expected farrowing have lower heart rate variability (and thus an increased stress level) compared to those confined after farrowing. The effect on salivary cortisol is less clear (as described above): it is difficult to interpret measures of cortisol at this time because of the natural changes associated with increased activity during nest-building and the farrowing process. Recent studies suggest no increase in cortisol for sows subject to temporary crating prior to farrowing compared to loose-housed sows.

The consequences of the time at which temporary crating is imposed for the farrowing process are also inconsistent. Most recent studies report no difference in farrowing duration (5/7 studies; see Goumon et al., 2022) or the number of stillborn piglets (6/9 studies) when sows were confined for 1 or more days before expected farrowing in comparison to animals not confined for the period before and during farrowing.

Successful performance of nest-building behaviour is associated in some studies with more careful behaviour of sows towards their offspring, improved nursing behaviour and colostrum ingestion in neonatal piglets. Two out of 3 published studies (see Goumon et al., 2022) suggest better nursing outcomes when sows remained unconfined until the completion of farrowing. However, the possible benefits of improved maternal behaviour in unconfined sows may be countered by the increased risk of crushing with unrestricted movement of sows in the neonatal period. The majority of published studies carried out in temporary crating systems (7/9, see Goumon et al., 2022) report an increase in mortality prior to first piglet processing or on the first day of life (i.e. the period covering the duration of farrowing and time before likely human intervention) when comparing sows where the crate remained open until at least the completion of farrowing with those crated from one or more days before farrowing. This adverse outcome is more pronounced in the case of hyperprolific breeds (total born > 16 piglets; Goumon et al., 2022).

5.7.5. Post-farrowing crate opening time: sow welfare

5.7.5.1. Evaluation of the scientific evidence

As discussed in the General TORs, when sows are confined in a farrowing crate they experience several welfare consequences (see Section 3.4). However, farrowing crates are widely used because of concerns about the increased risk of piglet mortality in non-confinement housing. In order to balance these conflicting considerations, systems in which the period of confinement for the sow is reduced (temporary crating systems) were developed (description in Section 3.3.3.4). If such systems are adopted, it is pertinent to consider for what period after parturition that confinement of the sow should continue before she is given greater freedom of movement. This question has recently been the subject of a detailed scientific review (Goumon et al., 2022), where the relevant scientific references can be found that are referred to in the following text.

Both in semi-natural conditions and in different farm housing conditions, sows are predominantly inactive in the nest during the first 2 days after farrowing. This would suggest that confinement in a crate during this period has few welfare consequences.

However, after this time the sow in semi-natural conditions spends increasing periods of time active and away from the nest, finally abandoning the nest after 6–9 days. The motivation to leave the nest might include foraging for food, maintaining nest hygiene, exercise, environmental exploration and social reintegration. Remaining confined in a crate frustrates all of these except obtaining food, and also prevents the normal social interactions between the sow and her piglets. Moreover, confinement prevents the sow from circumventing the piglets' attempts to suckle frequently once the natural weaning process starts. Although logic would suggest that the less time spent in a crate the better the welfare for the sow, there are relatively few scientific studies which compare sow welfare outcomes for different days of crate opening. Most publications report only a comparison between a specific temporary crating regime and either zero confinement or permanent crating throughout the full farrowing and lactation period.

Published experimental comparisons do suggest that sows may benefit in the short term from a reduction in confinement compared to permanent crating, as they show increased activity, greater exploratory behaviour and more interactions with piglets immediately following crate opening. It is unclear whether this is simply a short-term response to the novelty of a new environment, since some studies failed to show that differences persist into later lactation. However, there is still a lack of studies on these longer term behavioural consequences and the influence of different aspects of the pen environment.

Attempts to assess the welfare impact of release from confinement in early lactation by measurement of the stress hormone cortisol yielded inconclusive results in relation to both the period immediately following release and the situation in later lactation. Comparisons of crated sows with those in pens sometimes showed higher cortisol towards the end of lactation, when the parent-offspring conflict over control of suckling starts to take effect. A similar result is suggested by the finding of a positive correlation in a retrospective analysis of the duration of confinement (ranging from 3 days post farrowing to the complete lactation) and hair cortisol concentrations in sows in a temporary crating system. However, a controlled experimental comparison found no late lactation difference in salivary cortisol concentrations between a temporary crating and permanent crating system.

In accord with a possible detrimental effect on the crated sow of being unable to escape vigorous piglet suckling attempts in late lactation, four different papers reported a lower incidence of teat and udder lesions in the third and fourth weeks of lactation when sows were released on day 2 or day 4 after farrowing in comparison with permanent crating. However, the available data present conflicting results regarding the prevalence of lesions of the integument and lameness, with no clear beneficial effect of an earlier crate opening time compared to permanent crating. The design of the crate appears to be a more important factor for this outcome. Moreover, effects of the duration of temporary crating on lesions of the integument and lameness may be masked by the housing conditions during lactation, and the low number of days the sows are crated during lactation may not be sufficient to induce such consequences.

The release of the sow from crating does not change the physical environment for the piglets but has a significant effect on their social environment. Five studies investigated sow–piglet interactions after crate opening at some point during the first week of lactation, and four of these reported an increase in sow–piglet interactions after removal of confinement. The possible longer term benefits of a more enriched social environment in a temporary crating system have received little investigation, despite the awareness that early-life experience can play a major role in shaping behavioural and physiological responses to future challenges. Three studies that compared the consequences of rearing in a system with either temporary or permanent crating of the mother for post-weaning behaviour, response to challenge situations and even transgenerational maternal behaviour suggested possible benefits, but data are currently inadequate to draw conclusions on this aspect.

Opening of the crate also increases the accessibility of the udder which might benefit suckling behaviour. Although 3 studies reported improvement in some parameter of nursing/suckling behaviour in either the short- or long-term following crate opening, 3 other studies reported no differences. Evidence for a benefit of opening the crate to piglet growth rate is similarly inconsistent. While 6 papers have reported an improvement in growth, 13 found no effect and one a deterioration.

From the perspective of the piglets, the most significant welfare outcome is preweaning survival, which is indicative of the manifestation of the chilling-starvation-crushing complex which leads to mortality and is thus an iceberg ABM for several different welfare consequences. The effect of crate opening time on this ABM was explored in a structured EKE (EKE 1).

5.7.6. Post-farrowing crate opening time: piglet welfare

5.7.6.1. Choice of ABM

For a quantitative assessment of the effects, total live-born mortality was chosen. There are two important reasons for this choice: the availability of data to support the assessment that resulted from the ELS (see Section 2.2.1.2), and the direct relationship between the ABM (which is strongly related to crushing incidences) and the crate opening time. The other ABMs could not be used to assess the welfare advantages or disadvantages of the crate opening time, mainly because data were insufficiently available or insufficiently standardised to allow quantification.

Live-born mortality is an ABM of combined welfare consequences of soft tissue lesions and integument damage (see Section 3.4.14), cold stress, (Section 3.4.12) and prolonged hunger (Section 3.4.9). It is also related to the inability of the sow to express maternal behaviour described in Section 3.4.7, which is the outcome of a set of complex interactions between the sow, the piglet and the environment. Crushing by the sow is the main ultimate cause of piglet death, which is why farrowing crates were introduced with the aim to reduce piglet mortality attributed to overlying by the sow (Edwards, 2002). As described in Section 3.4.14, in conventional (crated) farrowing accommodation crushing is associated with more than half of all preweaning mortality and is estimated to result in 3–7% mortality of live-born piglets (Kamphues, 2004). Farrowing crates are designed to reduce or slow down sow postural changes and prevent sudden drops or sudden rolling over of the sow whilst the piglets are in close proximity. This gives piglets more time to move away from the area under the sow. Keeping lactating sows and their piglets in a pen system without such protective measures increases the risk of crushing.

Piglet mortality can be expressed in a number of ways: 'preweaning mortality', 'total mortality', (including or excluding number of stillbirths), 'proportion of total mortality due to overlying', 'total mortality excluding stillbirths and due to crushing'. However, in the literature that was analysed, the cause of death is often not reported or determined, which excludes many of the possible indicators listed. Furthermore, the general ABM 'Pre-weaning mortality' includes stillbirths which were not deemed relevant for the lactation situation. It was therefore agreed to go for 'total mortality from birth to weaning (including crushing)', summarised as 'live-born piglet mortality'. This reflects survival of the piglets during the suckling phase.

5.7.6.2. EKE 1: live-born piglet mortality in relation to the time the sow is crated

The effect on piglet preweaning mortality was assessed through an Expert Knowledge Elicitation (EKE 1), based on literature evidence (see Section 2.2.1.2). The EKE procedure is described in EFSA AHAW Panel, 2022.

The EKE model components for this assessment are summarised in Table 42.

Table 42: Summary of EKE 1 model components

Pig category	Piglets, from birth until weaning
Husbandry system	Temporary crate
Welfare Consequences	Soft tissue lesions and integument damage, prolonged hunger, cold stress
Animal Based Measure	'Live-born piglet mortality'. The proportion of piglets in a litter from birth to weaning that die before weaning.
Exposure variable	Crate opening time (in days).
Unrestricted population	The unrestricted situation is when there is no exposure to a free moving sow (i.e. a fully crated system).

As the movement of the sow is the risk factor for the piglets, a fully crated system is where piglets are at least risk of being crushed by the sow. Piglet mortality in conventional fully crated systems is reported in the InterPig Study (AHDB, 2021a) for European Countries, including UK. The experts estimated **the live-born piglet mortality of a fully crated sow as 14.2% (with a 90% certainty range from 12.4% to 17.0%)**. The uncertainty is because of the unknown influence of the litter size, the limited representation of all EU countries, and possible reporting biases due to the selection of farms.

Some non-aggregated datasets were available to judge on the between-farm variation. The Irish InterPig data show a coefficient of variation of 24%, while two sets of Dutch data indicate 22% and 19%, respectively (Robert Hoste, Wageningen Economic Research, personal communication, 2021). The experts estimated a between-farm coefficient of variation of 22%. This implies approximately that **80% of the farms will show a preweaning mortality of live-born piglets of a fully crated sow from 10.2% to 18.3%.**

Several authors (Salaün et al., 2004; Moustsen et al., 2013; Chidgey et al., 2015, 2016; Lambertz et al., 2015; Condous et al., 2016; Mack et al., 2017; Singh et al., 2017; Gouman et al., 2018; Höbel et al., 2018; Spindler et al., 2018; King et al., 2019; Caille et al., 2010; Choi et al., 2020; Loftus et al., 2020; Lohmeier et al., 2020; Ceballos et al., 2021; Kinaine et al., 2021) investigated the relationship between live-born piglet mortality and number of crating days. Data from studies assessing the piglet mortality when opening the crate after several days (day 0 means no crating of the sow) compared to permanently crated sows were extracted. The study of Mack et al. (2017) was not considered in the elicitation because the sample size was small and its very high mortality in the temporary crated treatment might be explained by the very small pen size used.

To adjust for additional effects between the studies, e.g. different management practises, the relative change in the piglet mortality between 'opening at day x' and 'permanently crated' were calculated (Figure 11). The variation between studies assessing the same opening day is considerable but looking to the mean over all studies at the same opening day indicated decreasing mortality. The experts judged that opening at day 7 (with a 90% certainty range from 3.4 to 16 days) will not result in a higher preweaning mortality than for permanently crated sows on farms with crates and equipment of good commercial standards, standard thermal environment for the piglets, and a typical parity profile of the sows. It reflects the specific need of care of the piglets in the first days. The uncertainty reflects the variability between studies and, more specifically, confounding factors such as the effect of larger litter sizes and consequently weaker piglets.

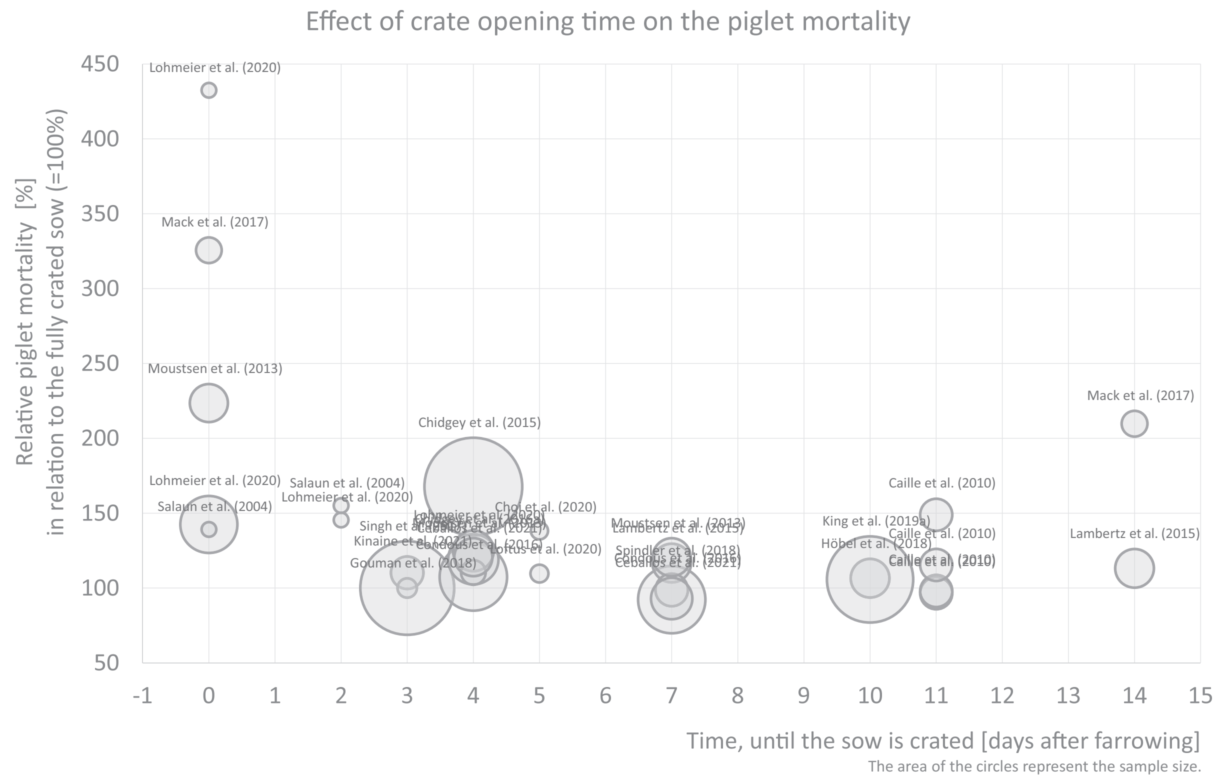


Figure 11: Effect of crate opening time on the piglet mortality expressed relative to the mortality of fully crated sows (= 100%). The area of the circles represents the sample size (all studies). (Further information on the supporting literature is available upon request)

Finally, data on preweaning mortality from countries with non-crated sows (Sweden: InterPig (AHDB, 2021a) Switzerland: Weber et al. (2020), and Norway: Ingris (2020)) were used to estimate the relative change in preweaning mortality between non-crated (= opening at day 0) and permanently crated sows. The ratios were between 95% and 129%. Additional experimental studies show an average ratio of 165%, up to 231%. **The experts judged that mortality increases by 24% (with a 90% certainty range from 3% to 59%) for non-crated sows compared to crated ones.** The uncertainty is mainly caused by lacking representativeness of the selected countries for the whole of Europe. A strong management effect is assumed for the experimental studies, where management of non-crated sows may not reflect standard practises after transformation of the systems.

Assuming a standard farm situation with good practise in non-crated sow management of this type of temporary confinement pen, the experts estimate a preweaning piglet mortality of 18% (with a 90% certainty range from 14% to 24%) if the sow is not crated. The increase is comparable to a badly performing farm with crated sows.

A linear interpolation (Figure 12) was assumed to connect the results of non-crated sows (opening day = 0) to a crating time of 7 days (opening day = 7). Following mortality rates can be predicted for crating times between 0 and 7 days:

- After 2 days of crating (opening on day 2) the piglet mortality is on average 16.5% (90% certainty range between 13.5% and 21.7%)
- After 4 days of crating (opening on day 4) the piglet mortality is on average 15.6% (90% certainty range between 12.7% and 20.0%)

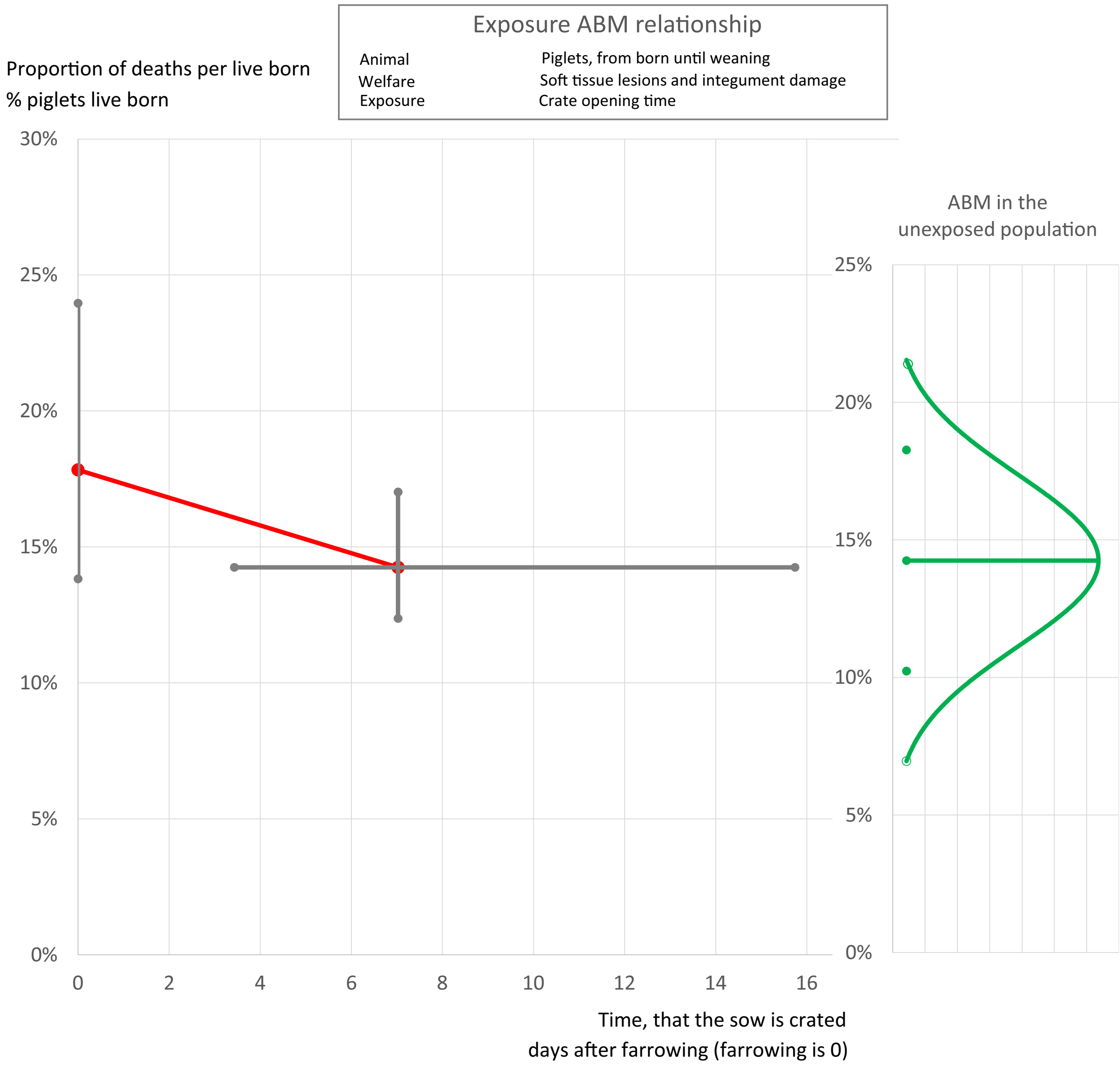


Figure 12: Relation between the time a sow is crated and the piglet mortality. The red line interpolates between the mortality observed for non-crated sows and the crating time large enough to have no further decrease on the mortality. Grey bars indicate the 90% certainty ranges, while the green curve indicates the variation in piglet mortality between litters without exposure to the sow (fully crated sows) (green dots indicate the 5th, 50th (median), and 95th percentile)

5.7.7. Summary Conclusions on farrowing systems: temporal availability of space

5.7.7.1. Summary Conclusions on pre-farrowing crate closing time

1) Initial confinement in a farrowing crate is stressful, but less so if animals have prior experience of the farrowing accommodation or of close confinement (e.g. feeding stalls) and to human interaction.
2) Confinement imposed prior to farrowing restricts the sows' possibility to move around and prevents the functional performance of highly motivated nest-building behaviour. This is detrimental to sow welfare.
3) It has been shown that delaying the crate closing time until farrowing is completed, results in increased neonatal piglet mortality. This adverse outcome is more pronounced in the case of hyperprolific breeds.

5.7.7.2. Summary Conclusions on post-farrowing crate opening time (sow perspective)

1) Highly relevant welfare consequences for the sow (restriction of movement, resting problems, group stress, inability to perform exploratory or foraging behaviour, inability to perform maternal behaviour, heat stress, soft tissue lesions and integument damage, see Sections 3.4 and 5.1) can be mitigated with early opening times after farrowing. Intuitively this benefits sow welfare although objective evidence from ABMs to confirm this is lacking.
2) The possibility of longer term benefits for the piglets from improved sow–piglet interaction following maternal release from confinement requires further investigation.

5.7.7.3. Summary Conclusions on post-farrowing crate opening time (piglets' perspective)

1) Any change in farrowing system is likely to need a transition period for people and animals to adapt to the new situation before the stable results in the following conclusions are achieved.
2) A temporary crating system with an average space for the sow of 4.3–6.3 m^2 can achieve the same piglet survival as a permanent crating system. The minimum confinement time of a sow in a temporary crating system to achieve this is 7 days after farrowing (90% certainty range between 3.4 and 16 days).
3) A situation where the sow is never crated in a pen designed for temporary crating will increase piglet mortality relative to permanent crating by 24% (with 90% certainty range from 3% to 59%).
4) The estimated mortality in a permanent crating system or a temporary crating system with a minimum of 7 days of confinement is 14% (with 90% certainty range from 12% to 17%) and a temporary crating system where the crate is never closed is 18% (with 90% certainty range from 14% to 24%).

5.7.8. Quantity of space: sow space allowance

The second of the three exposure variables affecting the behavioural freedom is the amount of space a sow has for herself. Before discussing different amounts of space available to the sow, it is important to put space requirements into perspective by considering the physical dimensions of the sow. Petherick (1983) pioneered this way of thinking and introduced the 'k-value', which is presented and discussed elsewhere in this opinion (Section 7.2). The k-value connects the weight of an animal with the floor surface area it requires, through the equation:

$$A = k \times W^{2/3}$$

in which W is the body weight of the animal (kg) and A is the space required (in m^2).

The constant k differs according to e.g. body posture: animals lying in sternal position require less space than animals lying laterally recumbent. Petherick (1983) considers a k-value of 0.019 to represent sternal lying, whereas k = 0.047 is needed for lateral recumbent lying. For a sow of 250 kg (approximate length = 1.85 m), this means a floor space of 0.75 and 1.82 m^2, respectively. In both cases, a static posture is assumed. For standing, the same floor area is needed as for sternal lying (k = 0.019).

To be able to move in a given space, not just the total floor area, but also the length and the width of a space is relevant. Leonard et al. (2020) considers how much 'dynamic space' sows physically need, and for a 250 kg sow they estimated that for getting up without touching any walls they need 1.99 × 1.04 m, and for lying down 1.79 × 0.86 m. According to them, for dynamic space the pen width should be 52 and 48% (respectively) of her body length.

For turning around, more space is needed. Bøe et al. (2011) looked at turning movements of sows and found that the frequency decreased from almost 200 times per 24 h in a pen with a width of 2.4 m, to less than 36 times in a pen with a width of 60% of the sow's length. Sows turned on average less than two times when width was reduced to 50% of sow length. The authors report that 'all sows turned around several times daily, even when pen width was reduced to 60% of sow length. However, when pen width was reduced to 50%, only 7 of 16 sows turned around'. Based on this, Bøe et al. (2011) concluded that below 60% turning around becomes difficult, and below 50% turning can hardly be performed. They also noted that at and below 50%, sow lying times are increased considerably compared to unrestricted width.

It has to be noted that at the pen dimensions above where width equals 100% of body length (so ~ 1.85 × 1.85 = 3.42 m^2 in our example), a sow may be able to turn around freely, but will not be able to walk more than 1 step in any direction without touching a wall.

For farrowing pens that are fitted with dedicated functional areas (to physically separate lying, feeding and dunging behaviour), they would need a minimum feeding area to stand in of 0.75 m^2, plus a similar area for defecation, plus a lying area (nest) in which they can turn around of 3.42 m^2. Such an unpartitioned pen would require at least 4.92 m^2.

Finally, for a partitioned pen with a lying area as well as a dunging/feeding area in which the sow can turn around unhindered, 3.42 m^2 × 3.42 m^2 = 6.84 m^2 is the estimated physical requirement.

It is important to note that the space allowances presented above are not the same as the total space required for the farrowing pen. In this SO, the latter is assumed by the EFSA experts to be equal to space available to the sow plus 1.2 m^2 of space available only for the piglets.

In addition to the above considerations based on sow body dimensions, the EFSA experts proceeded to relate sow space allowance to welfare consequences and ABMs in three blocks: (1) pre-farrowing, and post-farrowing (2) regarding the welfare of the sow and (3) regarding the welfare of the piglets. In the next paragraphs, we will describe for each block the ABMs that were chosen, and how they relate to the exposure variable. Any evidence related to other ABMs for the quantity of space is also presented. At the end of this section, the results across all ABMs are summarised.

5.7.9. Pre-farrowing quantity of space

5.7.9.1. Choice of ABM

There are several indicators potentially useful to assess welfare consequences related to space allowance in the farrowing accommodation in the week before the piglets are born (see Section 3.5.2). The most important part of this pre-farrowing week are 1–2 days prior to farrowing, when the sow performs nest-building. In Section 3.4.7 on 'Inability to express maternal behaviour and related ABMs', the various stressors on the sow during this period are described. These stressors may affect a number of ABMs, e.g. the farrowing duration, still births, piglet mortality, nest-building behaviour, postures, locomotion, exploration, the sow's response to humans etc.

For the purpose of quantifying the effects of this exposure variable on welfare, the ABM 'farrowing duration' (expressed as inter-piglet birth interval (IBI)) was chosen. IBI is discussed below.

The ELS procedure (see Section 2.2.1.2) yielded a range of other relevant ABMs.

Lack of space is an important factor influencing the sow's ability to show **nest-building behaviour**, and the amount and type of nest-building behaviours are often considered when comparing pen and crate housing (e.g. Pedersen and Jensen, 2008; Damm et al., 2003; Thodberg et al., 2002). Sows are highly motivated to build a nest prior to farrowing. However, there are only a few studies documenting the behaviours involved and to what extent they are performed under different space allowances. The results are difficult to compare as the pen designs as well as the ABMs differ considerably. For example, for the seemingly simple ABM of nest-building time, Pedersen and Jensen (2008) calculated the time spent in nest-building defined generally as any rooting, pawing, carrying straw in the mouth, and arranging straw in the nest from 16 h before birth of first piglet (BFP) until 48 h after BFP. Meanwhile, Damm et al. (2003) identified eleven behaviours associated with nest-building as rooting and restlessness and set specific criteria for the start, termination, duration and quantity of each in relation to the onset of farrowing. Furthermore, the space requirements of the sow may actually vary depending on the phase of the nesting period, with sows needing more space at the beginning of the nesting phase (phase of gathering material) and less space towards the end (e.g. 9 m^2 more than sufficient in this period). Hence, it is impossible to quantify nest-building behaviour in relation to available space, based on existing data (see also Section 5.7.12 below, for an assessment of the type of nest-building materials).

The same applies to another likely set of ABMs, related to posture. **Lying and postural changes** were investigated by several authors, but there is no general consensus on how they relate to space allowance. Zhang et al. (2020) found a decrease in lying behaviour of penned sows (at 4 m^2) compared with crated sows 12 h pre-farrowing, but an increase at 6 days prepartum. The timing of the assessment and the way in which lying behaviour is scored seem to play an important role, and the ELS procedure yielded insufficient data to quantify the relationships. Only 7 papers reported on the number of posture changes (Jarvis et al., 2001; Thodberg et al., 2002; Petersen and Jensen, 2008; Baxter et al., 2015; Hansen et al., 2017; Nowland et al., 2019; Yun et al., 2019). Postural changes increased when sows were penned instead of crated (e.g. Yun et al., 2019), but they also decreased (e.g. Thodberg et al., 2002). Fewer posture changes could result from sow's complete inability to move due to the lack of space, but equally a higher number of posture changes in close confinement could reflect discomfort and an associated need to change posture frequently. Therefore, we did not consider this ABM further.

Standing and locomotory activities were investigated by e.g. Botto et al. (2000), Jarvis et al. (2001), Koller et al. (2014), Yun et al. (2019) and Zhang et al. (2020). When comparing crates vs. pens, sows in pens spent more time standing compared to sows in crates during the preweaning phase (Botto et al., 2000; Yun et al., 2019; Zhang et al., 2020). In penned sows, the effects of space allowance on standing and lying are less clear: Koller et al. (2014) reports less standing with increasing pen space. It is likely that the amount of nest-building behaviour that can be performed affects these outcomes but the arguments presented for lying behaviour and postural changes equally apply to standing behaviour.

A large number of studies (n = 29) investigated the relationship between the **number of stillborn piglets** and the space that is available to the pre-farrowing sow (e.g. Cronin et al., 2000; Oliviero et al., 2008; Bolhuis et al. 2018; Zhang et al., 2020; Choi et al., 2020). According to Condous et al. (2016) the mechanism behind this relationship is referred to as the confinement-stillbirth hypothesis. The hypothesis suggests that crated sows exhibit an increased level of cortisol prior to farrowing (Lawrence et al., 1994), and a post-expulsion reduction in oxytocin pulse (Olivero et al., 2008). At the same time, an extended farrowing duration and inter-piglet birth interval is observed in confined sows (Olivero et al., 2010), which may give rise to an increased number of piglets dying before being born. This theory is not undisputed: free farrowing sows have higher salivary cortisol levels without any increases in stillbirths (Hales et al., 2016). The evidence collected through the ELS procedure (see Section 2.2.1.2) allowed for a crude assessment of the effect of the available space to the sow on stillbirths. A large data set on stillbirths (from over 60,000 farrowings) was available for Switzerland as the country moved from crates to farrowing pens following implementation of new legislation (Weber et al., 2009). There were lots of pen designs and sizes included in the data set, so average values were used as opposed to stillbirth rates for specific pen types. An initial evaluation of the raw data indicated a trend for lower rates of stillbirths in relation to higher space allowances in the nest-building period. However, once standardised against data for farrowing crates this relationship was no longer evident. Importantly a major constraint to the use of stillbirths as an ABM was identified that obviated any further consideration of this ABM. Stillbirths are often recorded as the number of piglets found dead behind the sow and which are therefore assumed to have been born dead. However, some piglets found behind the sow may be born alive but die shortly afterwards. It is relatively easy to differentiate the two by opening the chest to evaluate whether the pig breathed. Piglets that die shortly after being born will have pink, fresh and normal looking lungs. The lungs of the true stillborn pig are a dark plum colour, showing none of the pink areas associated with breathing. Pigs that attempt to breath during the process of farrowing will show evidence of mucous obstructing the windpipe. Absolute confirmation of stillbirth is possible by inflation of the lung tissue (e.g. Hales et al., 2015). These authors categorised piglets as stillborn if their lungs would not float in water. Similarly, Pedersen and Jensen (2008) necropsied all dead piglets to accurately determine the number that were stillborn. However, numerous studies indicate that the data were collected from standard technical recordings that may or may not have conducted confirmatory assessments (e.g. Oliviero et al., 2008; Choi et al., 2020; Zhang et al., 2020). Meanwhile, Bolhuis et al. (2018) counted stillbirths from video recordings.

Numerous studies report the **duration of farrowing**. It is expressed as total duration (time in minutes from birth of first to birth of last piglet) or as inter-piglet birth interval (IBI, mean time in minutes between birth of each piglet, including stillborn). When the total litter size and the total duration of farrowing are known, the IBI is easily calculated.

5.7.9.2. EKE 2: farrowing duration

The effect on farrowing duration (via the IBI) was assessed through an EKE (EKE 2), based on literature evidence (see Section 2.2.1.2). The EKE procedure is described in EFSA AWAH Panel (2022).

The EKE model components for this assessment are summarised in Table 43.

Table 43: Summary of EKE 2 model components

Pig category	Farrowing and lactating sows (although this EKE only related to farrowing sows)
Husbandry system	Indoor individual pens
Welfare Consequence	Inability to express maternal behaviour
Animal-Based Measure	Farrowing duration [min/piglet]: This is the time required for the sow to deliver the litter of piglets. It is expressed in inter-piglet birth interval (mean time in minutes between birth of each piglet including stillborn).
Exposure variable	Space allowance [in m^2 per sow], available to the sow to walk/stand on. Not included in the space is the area reserved for the piglets, including the creep area.
Unrestricted population	A sow in a very large indoor pen, in which the space is not restricted.

Several studies (Verhovsek et al., 2007; Oliviero et al., 2008, 2010; Pedersen and Jensen, 2008; Gu et al., 2011; Condous et al., 2016; Hansen et al., 2017; Bolhuis et al., 2018; Nowland et al., 2019; Yun et al., 2019) compare farrowing durations of gilts and sows in crates with sows in pens of different sizes. Studies considering only parts of the litter (e.g. first 5 piglets) were excluded.

The IBI of crated gilts and sows in the studies range from 14 to 29 min per piglet, which reflects different ages/parities and breeds of the sows and conditions of the crates/pens and farm. Each study was reviewed on the additional factors. For the description of the effect of space allowance on the farrowing time, good commercial conditions are assumed, including typical parity profiles, the current European genetic distribution, healthy sows in thermo-neutral conditions, feeding according typical standards, none or minimal nest-building material due to the restrictions of the farming system, and a minimal crate size, which restricts movement and precludes the turning/walking of the sow. The sows will be crated at least 2 days before farrowing. Under these conditions the experts estimated **the average IBI of crated gilts and sows as 22 min per piglet** (with an 90% certainty range from 15 to 29 min/piglet).

The studies showed large variation in the inter-piglet birth interval between individual sows. The coefficient of variation calculated from the studies is between 80% and 100%. Considering additional variation between the sows due to high parity in commercial situations compared to experimental studies, a log-normal distribution with **a coefficient of variation of 100% is assumed to describe the variation between individual sows.**

None of the studies investigated the farrowing duration for different pen sizes. To compare the results between the studies the relative change in the inter-piglet birth interval from crated sows to sows in pens were calculated. Figure 13 shows this relative change (with the crated treatment set at 100%) for different studies comparing the crated situation with the penned situation at different pen sizes.

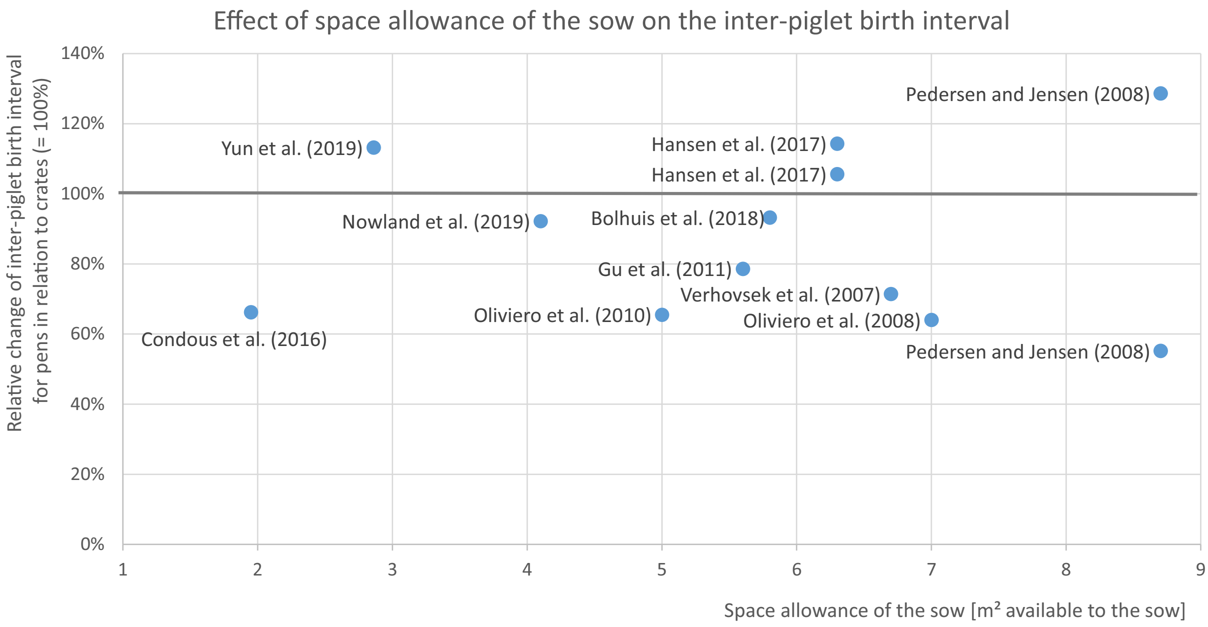


Figure 13: Effect of space allowance of the sow on the inter-piglet birth interval (IBI) in pens expressed relative to the IBI of crated sows (= 100%). Every point represents one treatment in the mentioned study

While many individual studies showed a significant effect of space allowance on the inter-piglet birth interval a clear trend for increasing space allowance is absent. **The average reduction of the IBI from crated to non-crated systems is estimated as 18% (90% certainty range from 3% to 36%).** Non-crated systems allow the sows to walk and turn, this increases their ability to perform maternal behaviour and reduces the IBI.

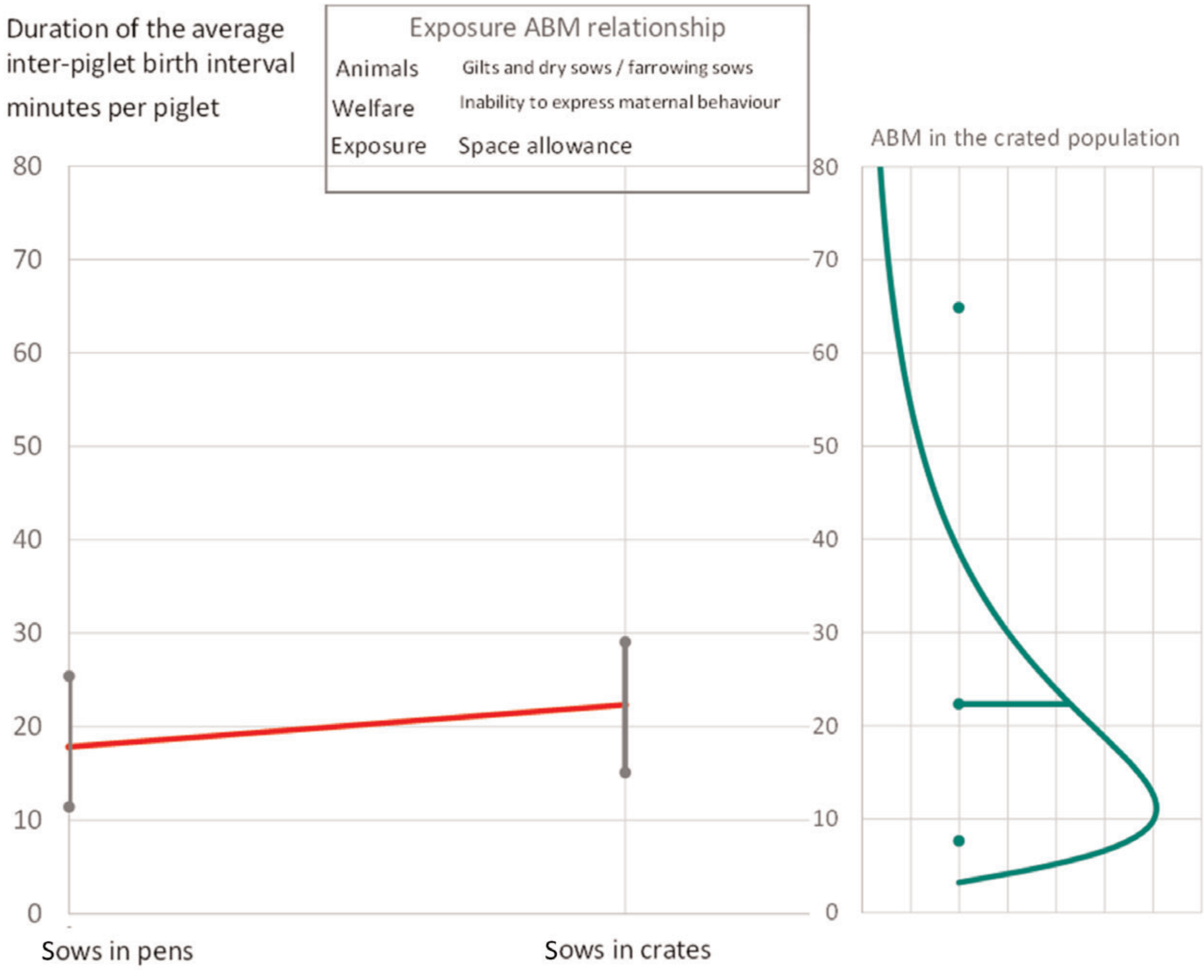


Figure 14: Comparison of the inter-piglet birth interval (IBI) of sows in pens with crated sows. The grey bars indicate the 90% certainty ranges, while the green curve indicates the variation between crated sows (green dots indicate the 5th, 50th (Median), and 95th percentile)

Combining the results (Figure 14) gives **an average IBI of sows in pens in good commercial conditions of 18 min per piglet** (with a 90% certainty range from 11 to 25 min/piglet). It was concluded that the average farrowing duration per piglet expressed as inter-piglet birth interval is lower in pens than in crates. The reduction is on average 4 min per piglet.

Other factors, e.g. the management practise of the farm, may have a larger influence on the IBI, as well as the variation between sows induced by e.g. age/parity or breed. The between sow variability is estimated from 8 min per piglet (10th percentile) to 65 min per piglet (90th percentile) for the individual **IBI** for crated sows.

5.7.10. Post-farrowing quantity of space: sow welfare

5.7.10.1. Choice of ABM

Several ABMs reflect welfare consequences to the sow of different space allowances post farrowing (see Section 5.2). In Section '3.4.1 Restriction of movement and related ABMs', the following were mentioned: locomotory behaviour, lying behaviour, posture changes, atypical lying down movements.

For the purpose of this EKE, the indicator chosen to quantify the impact of the space available to the sow is the average proportion of time from birth to weaning an animal spends in 'Locomotory behaviour', e.g. walking and changing location/position, by moving from an old to a new position. This ABM will be the subject of the analyses below.

The ELS procedure yielded a range of other relevant ABMs.

The effect of lactating sow space allowance on **postures** (e.g. sternal and recumbent lying, sitting and standing) and **posture changes** were reported in several studies, but the data are inconclusive.

Increased sternal lying could be a reflection of insufficient space to lie laterally, and thus be an indicator of restriction of movements. However, an increase in sternal lying could also be due to the sow avoiding the attention of her piglets. Too much sternal lying can also be indicative of boredom, e.g. through lack of enrichment. The data in the literature are equally ambiguous. The amount of sternal lying was lower in sows kept in farrowing crates compared with pens according to some authors (Nicolaisen, 2019a), and higher according to others (Baumgartner et al., 2005). When comparing different pen sizes, Koller (2014) did not find a difference between 3.3 m^2 and 4.3 m^2, whereas Baumgartner et al. (2005) saw a 20% increase comparing 4.4–4.9 m^2.

The amount of lateral lying may say something about the welfare of the sow: it is present both when the sow is resting and when she is nursing the piglets. Therefore, it could reflect welfare differently. An important confounding factor is the temperature in the room, which affects the time spent in a lateral position as a way to lose heat. Other confounders are the floor type and the bedding material, both linked to resting comfort. The effects of space allowance on lateral lying are more or less the reverse of sternal lying described above (Baumgartner, 2005; Nicolaisen, 2019a).

Standing was higher in penned sows compared to crates (Nicolaisen, 2019a; Zhang, 2020), and increased slightly with pen size (Baumgartner, 2005). This parameter is almost completely complementary to the combined lying behaviours. Increased standing could either indicate an uncomfortable lying area or an interesting environment.

Finally, the frequency of posture changes as an indicator of resting problems was not usable. A decrease in posture changes due to changing space allowances could either indicate a more comfortable lying area or be associated with discomfort when changing posture.

Another group of ABMs relate to the **interactions between sow and piglets**. EFSA experts discussed the available literature, and found that nursing frequency, is higher in pens compared to crated sows (e.g. Botto, 2000; Loftus, 2020). Botto (2000) also found other maternal behaviours ('sniffing, licking and driving away piglets') were higher in a 7.2 m^2 pen compared to a farrowing crate situation. It can be expected that increased space allowance during the lactation phase positively effects the ability to move and to regulate contact with piglets, and the number of sow-piglet interactions. However, there are insufficient data to quantify this effect.

Other ABMs that were considered include **oral stereotypies**, with a study by Zhang (2020) suggesting that crated sows perform much more sham chewing behaviour (9.2%) compared to penned sows (3.2%, at 4.1 m^2). **Injuries of sow teats, legs or her back** were also considered, but the effects of space allowance were inconclusive (Baumgartner et al., 2005; Koller, 2014). Finally, **hygiene indicators** were also discussed, but insufficient scientific papers were found to relate space allowance and parameters such as level of hygiene and the effectiveness of distinguishing functional areas.

5.7.10.2. EKE 3: sow locomotory behaviour

The effect on sow locomotion was assessed through an EKE (EKE 3), based on literature evidence (see Section 2.2.1.2). The EKE procedure is described by EFSA (EFSA AHAW Panel, 2022).

The EKE model components for this assessment are summarised in Table 44

Table 44: Summary of EKE 3 model components

Pig category	Farrowing and lactating sows
Husbandry system	Indoor individual pen
Welfare Consequence	Restriction of movements
Animal-Based Measure	Average proportion of time from birth to weaning an animal spent with 'Locomotory behaviour', e.g. walking, changing location/position by moving (e.g. walking, running, turning) from old to new position. This includes locomotion that occurs when foraging, exploring. This does not include 'Standing'. [in % per total time]
Exposure variable	Space allowance [in m^2 per sow], available to the sow to walk/stand on. Not included in the space is the area reserved for the piglets, including the creep area*. Only usable area for the sow.
Unrestricted population	A sow in a very large indoor pen: the space is not restricted.

*: The area reserved for the piglets in this Scientific opinion is estimated in 1.2 m^2.

To estimate the locomotory behaviour of sows without restrictions in space, studies on sows in group suckling systems were used (Bussemas and Weißmann, 2011; Bohnenkamp et al., 2013), which provided between 7 and 12 m^2/sow or 40–70 m^2 in total (per group). The reported observations were standardised to the average proportion of time during birth and weaning a sow is walking. For this, additional evidence on the relation of walking to, e.g. standing was considered. It was assumed that sows walk less after farrowing than during lactation. The results were checked for their plausibility with results from outdoor farming (Stangel and Jensen, 1991; Buckner et al. 1998) taking into account that outdoor studies overestimate the walking time due to additional exploration behaviour. Other aspects that were taken into consideration when evaluating the data were possible effects of boredom, the absence or presence of enrichment and that lying behaviour (or locomotory activity) may change on the basis of group size.

The experts estimated that **sows without restrictions in space will spend on average 13.4% of their time between birth and weaning (with a 90% certainty range from 8.6% to 21.8%) walking**. This corresponds to 3 h and 12 min per day (24 h). The uncertainty is caused by limitations in the study designs, e.g. observations only on parts of the day, only few days after farrowing, and different classification of activities (e.g. combined measuring of standing and walking). The inter-sow variation was estimated by a coefficient of variation of 27% derived from the study of Buckner et al. (1998). This means that ~ **80% of sows under these conditions will walk between 8.7% and 18% of their total time.**

Restricting the space of the individual sow may reduce the time spent walking. Studies for sows in pens with restricted space reporting mainly walking and standing together (Baumgartner et al., 2005; Heidinger et al., 2017), only standing (Koller, 2014; Nicolaisen, 2019; Zhang, 2020), and only once walking (Botto, 2000). Using the detailed data of Buckner et al. (1998), the ratio between standing and walking was determined to convert the study results to a common ABM, namely locomotory behaviour. Other factors like the equipment of the pens were taken into account, e.g. enrichment material, multiple feeders etc. For studies on group housing, it was assumed that the larger total space and additional social interactions will further increase the time spent walking. Considering all factors, the experts judged that **a pen with a size of 47 m^2 for an individual sow (with a 90% certainty range from 12 m^2 to 179 m^2) will not limit the walking behaviour of the sow**.

A linear relationship (Figure 15) was used to extrapolate from the unrestricted space (47 m^2/sow with 13.4% walking) and the crated situation without ability of walking (2 m^2/sow with 0% walking). To check, if especially for lower space allowances a super-linear relation exists, the literature was screened for pen sizes of about 5 m^2/sow. The experts estimated, that **sows in individual pens with available space for the sow of 5 m^2 will show on average 2.2% (32 min/24 h) of the time from birth to weaning with locomotory behaviour (with a 90% certainty range from 0.8% to 4.8%)**. This is slightly above the linear extrapolation.

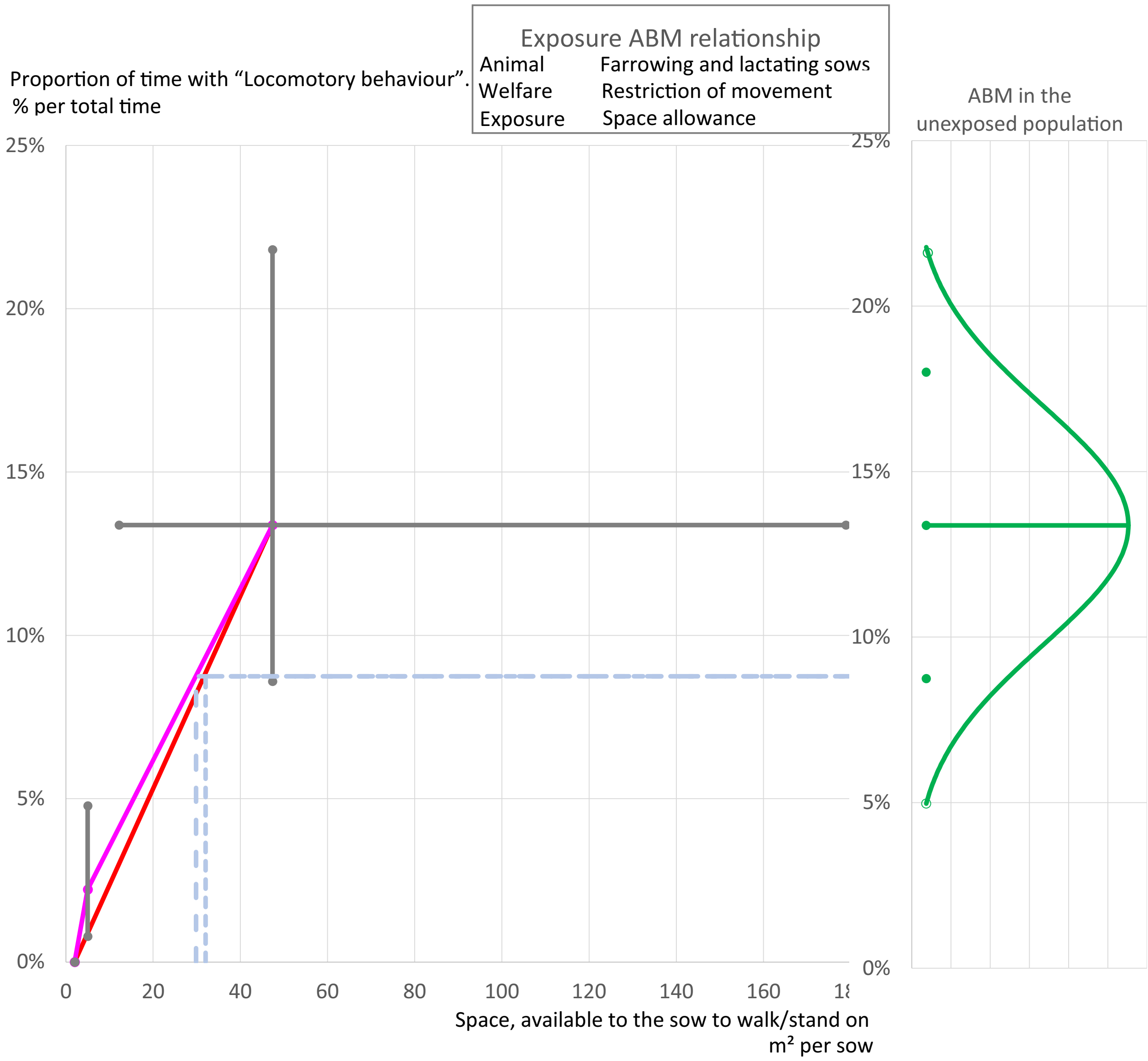


Figure 15: Relation between space allowance of the sow and proportion of time the sow is showing locomotory behaviour. The red line shows the interpolation between fully crated sows and sows experiences no restriction in space. For an intermediate space of 4 m^2/sow, an additional estimate is included to show a super-linear relationship (pink line). Grey bars indicate the 90% certainty ranges, while the green curve indicates the variation between unrestricted sows (green dots indicate the 5th, 50th (Median), and 95th percentile)

Using the linear interpolation between 5 m^2/sow and 47 m^2/sow it is possible to calculate the proportion of locomotory behaviour also for intermediate pen sizes, like 6.6 m^2 (favourable for piglets see Section 5.7.11.2). Here the sow would spend 2.6% of their total time walking (with a 90% certainty range **from 1.2% to 6%). This corresponds to 23% of the behaviour of the sow** shown under unrestricted conditions.

5.7.11. Post-farrowing quantity of space: piglet welfare

5.7.11.1. Choice of ABM

There are a number of indicators to assess the impact of lactating sow space allowance on the welfare of suckling pigs. The EFSA experts chose **total live-born mortality**, because it integrates a number of highly relevant welfare consequences for the piglets (soft tissue lesions and integument damage, prolonged hunger, cold stress (see Section 5.4). This ABM will be the subject of the analyses below.

The ELS procedure yielded a small number of other potentially relevant ABMs.

They include ABMs related to the additional space available to the piglets. **Locomotory behaviours, exploration and play behaviour** may all increase for piglets, when space for the sow is increased (e.g. Baumgartner et al., 2005). Others are related to highly relevant welfare consequences in piglets such as soft tissue lesions and integument damage, assessed by **skin lesions, aggressive interactions or crushing and trapping events** (e.g. Weber and Schick, 1996; Baumgartner et al., 2005; Yun et al., 2019). However, there were no standardisable data in the literature to allow a quantitative assessment.

The welfare consequences associated with crushing and preweaning mortality are described in Section 5.7.4.1.

5.7.11.2. EKE 4: live-born piglet mortality in relation to space allowance

The effect of sow space allowance on live-born piglet mortality was assessed through an EKE (EKE 4), based on literature evidence (see Section 2.2.1.2). The EKE procedure is described in EFSA AHAW Panel (2022).

The EKE model components for this assessment are summarised in Table 45.

Table 45: Summary of EKE 4 model components

Animals	Piglets, from birth until weaning
Husbandry system	Indoor individual pen
Welfare Consequence	Soft tissue lesions and integument damage, prolonged hunger, cold stress
Animal Based Measure	Live-born piglet mortality: The proportion of live-born piglets in a litter from birth to weaning that will die before weaning.
Exposure variable	Space allowance [in m^2 per sow], available to the sow to walk/stand on. Not included in the space is the area reserved for the piglets, including the creep area.*
Unrestricted population	The unrestricted situation is when there is no exposure to a free moving sow (i.e. a fully crated system).

*: The area reserved for the piglets in this Scientific opinion is estimated in 1.2 m^2.

As described above, the movement of the sow is the risk factor for the piglets. In that section, the experts estimate the preweaning mortality of live-born piglets of a fully crated sow as 14.2% (with a 90% certainty range from 12.4% to 17.0%). They also estimated a between-farm coefficient of variation of 22%. This implies approximately that 80% of the farms will show a preweaning mortality of live-born piglets of a fully crated sow from 10.2% to 18.3%.

Several papers compared the piglet mortality of crated sows with those of sows in pens (Collins et al., 1987; McGlone and Blecha, 1987; Cronin and Smith, 1992; Lou and Hurnik, 1994; Weber and Schick, 1996; Morris et al., 1997; Cronin et al., 2000; Marchant et al., 2000; Friedli, 2004; Salaün et al., 2004; Baumgartner et al., 2005; Pavicic, 2005; Weber, 2007; Payne et al., 2009; Kampheus, 2014; Baxter et al., 2015; Morrison and Baxter et al., 2015; Nicolaisen, 2019a; Baxter and Edwards, 2020; Loftus, 2020; Zhang, 2020). The space available for the sows in the pens varies between 2.5 m^2/sow (Morris et al., 1997) and 9.36 m^2/sow (Payne, 2009). Other differences were in the bedding material provided to the sows, and the equipment of the pens with functional areas. Please note that we assume additional 1.2 m^2 of the pen reserved for the piglets and not accessible for the sow.

To analyse the effect of the space allowance on the preweaning piglet mortality the relative change compared to the crated situation was calculated. Figure 16 shows the relationship between space allowance for the sow and the relative change in the mortality between fully crated sows and sows in pens of different sizes. The area of the dots corresponds to the sample size of the study.

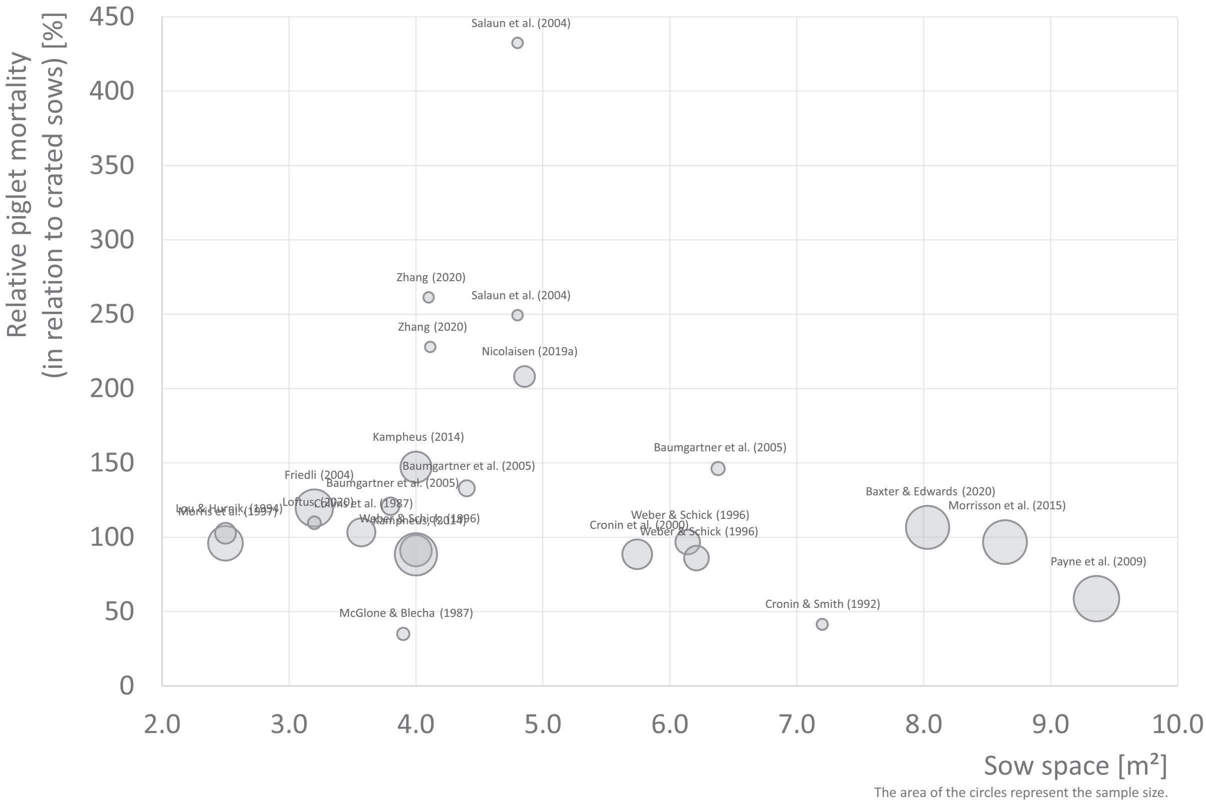


Figure 16: Effect of space allowance of the sow on the piglet mortality in pens expressed relative to the mortality in farrowing crates (= 100%). The area of the circles represents the sample size. (Further information on the supporting literature is available upon request).

A pen of size below 4 m^2 available for the sow is considered as restricted, as the sow will not be able to turn around or lay down without leaning on sides of the pen. Above 4 m^2 is a slight trend of decreasing mortality. Additional bedding material may confound the piglet mortality rate.

For farms with typical equipment, and associated flooring of good commercial standard, a typical parity profile of the sows, and standard thermal environment for the piglets, the experts judged that **from a space allowance of 6.6 m^2 (with a 90% certainty range from 4.5 m^2 to 9.8 m^2) available for the sow the preweaning mortality of the piglets will be no more different from the mortality of crated sows** (see Figure 17).

Focussing on the studies looking at pen sizes of about 4 m^2 available for the sows (Baumgartner et al., 2005; Kamphues, 2014; Zhang, 2020) the experts judged a 42% increase in piglet mortality (with a 90% certainty range from 3% to 122%). The high uncertainty reflects the differences between the studies possibly explained by different management practises. **A pen size of 4 m^2 available for the sow will result in a preweaning piglet mortality of 20% (with a 90% certainty range from 14% to 33%).**

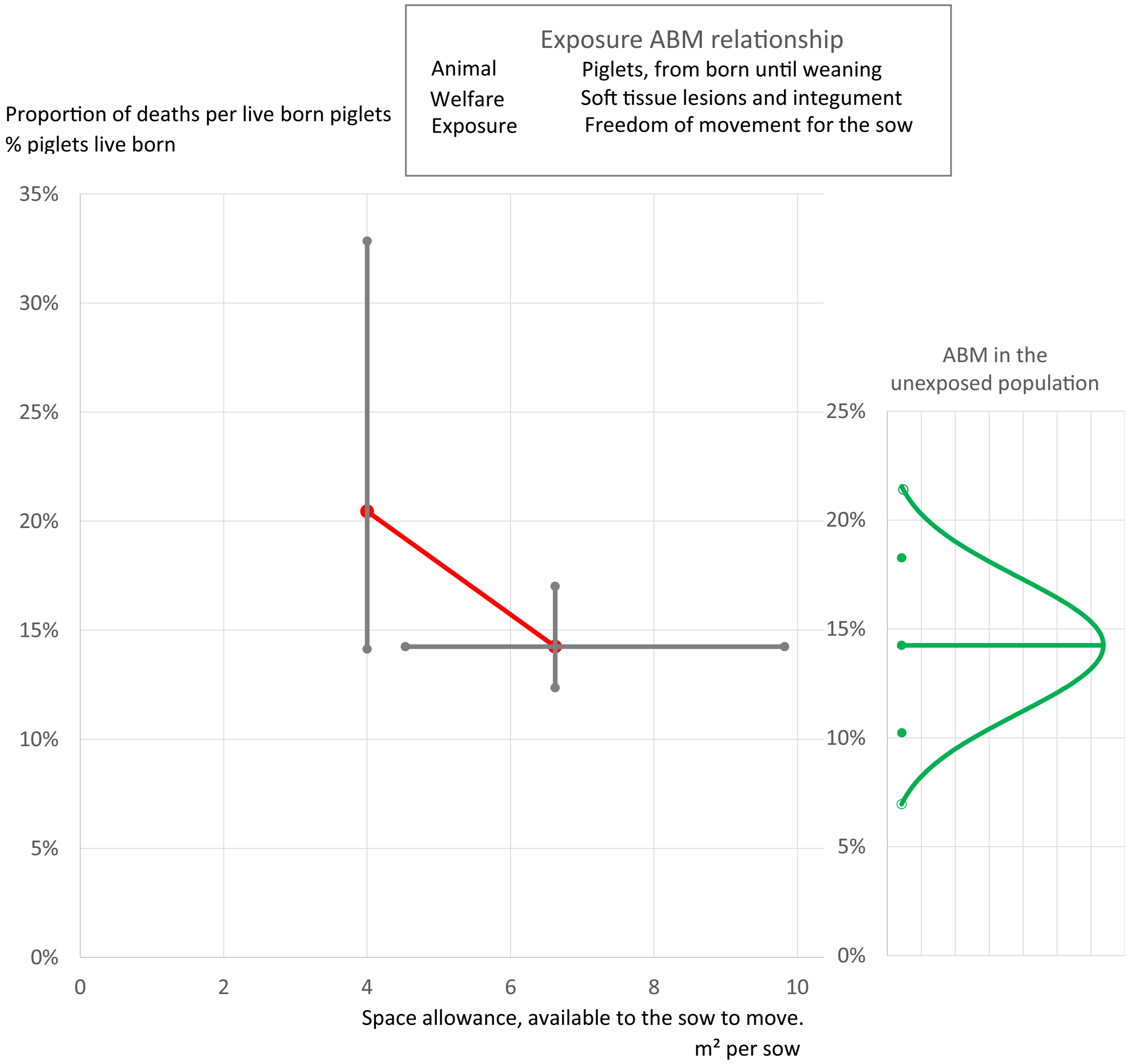


Figure 17: Relation between space allowance of the sow and the piglet mortality. The red line interpolates between the mortality observed at the minimal space for the sow to turn (4 m^2) and the pen size large enough to have no further decrease on the mortality for increased space. Grey bars indicate the 90% certainty ranges, while the green curve indicates the variation in piglet mortality between sows without restriction of space (green dots indicate the 5th, 50th (Median), and 95th percentile). The area reserved for the piglets in this SO is estimated to be 1.2 m^2

5.7.12. Summary conclusions on the quantity of space in farrowing systems

Increasing the available space in farrowing systems has several effects on the welfare of sows and piglets, as described in the previous paragraphs.

5.7.12.1. Summary conclusions on the amount of sow space pre-farrowing

1) The farrowing duration per piglet expressed as Inter-piglet birth interval (IBI) is lower in pens than in crates. The IBI in a pen was estimated as 82% of that in a crate, with a 90% certainty range from 64% to 97%.
2) The effect on the estimated IBI can be quantified as a reduction of 4 min per piglet when comparing the average sow in an individual crate (22 min/piglet, with 90% certainty range from 15 to 29 min/piglet) to a pen (18 min/piglet, with 90% certainty range from 11 to 25 min/piglet) in good commercial conditions.

3) Although IBI was affected by crating, for uncrated sows there was no consistent effect of the pen size. This suggests that being able to turn around is positive for IBI, but not the amount of space in which the sow can turn around.

5.7.12.2. Summary conclusions on the amount of sow space post-farrowing (sow perspective)

1) The minimum space required to allow a sow to express the same time in locomotor behaviour as shown in an unrestricted environment is much higher than that currently offered in any indoor individual farrowing pen. A space allowance of at least 47 m^2 (with a 90% certainty range of 12.2–179 m^2) is needed for a sow to show the full extent of locomotory behaviour, estimated as 13.4% of 24 h (193 min per 24 h) (with a 90% certainty range of 8.6–22%).
2) In a pen allowing 6.6 m^2 of space for the sow (as subsequently shown to optimise piglet survival, see Section 5.7.11.2), the time spent walking is estimated as 2.6% (with a 90% certainty range of 1.2–6.0%). This would roughly equate to 23% of the locomotory behaviour a sow would express when not space restricted (with a 90% certainty range of 11–53%).
3) Each additional square meter of available space is associated with a predicted increase in locomotory behaviour of 0.3% (= 4 min per 24 h).

5.7.12.3. Summary conclusions on the amount of sow space post-farrowing (piglets' perspective)

1) Experimental studies suggested that with appropriate pen size, it is possible to achieve the same piglet mortality in a system where the sow is never crated as with permanent crating.
2) It is estimated that farrowing pens that provide at least 6.6 m^2 available space to the sow (with a 90% certainty range from 4.5 m^2 to 9.8 m^2) can achieve the same mortality as in a permanent crate. This roughly equates to a total pen space of at least 7.8 m^2 (with a 90% certainty range from 5.7 m^2 to 11 m^2).
3) Reducing the pen space from 6.6 m^2 available space to the sow will lead to higher piglet mortality if the sow is not crated.
4) It is estimated that a pen with 4 m^2 available for the sow (which roughly equates to 5.2 m^2 of total pen size) will lead to 1.42 times the mortality of that in a permanent farrowing crate (with an 90% certainty range from 1.03 times to 2.22 times).
5) The use of a temporary farrowing crate systems cannot be advised as a step in a farm's transition from using farrowing crates to farrowing pens, unless the size of the temporary farrowing crate system is the same as that of the future free farrowing pen.

5.7.12.4. Summary conclusions on the combination of sow and piglet ABMs post farrowing – quantity of space

Pens (in which the sow can turn around) provide more behavioural freedom for sows compared to farrowing crates (in which she is fixed between bars). They allow her some degree of locomotion, a more comfortable lying space with less obstacles when getting up and lying down, possibly reducing stress and resulting in a quicker farrowing process. The latter was quantified in Section 5.7.6 above.

The amount of space available to the sow in a farrowing pen does not appear to affect the time it takes to farrow her litter. However, increasing space allowance will further benefit locomotory behaviour, the development of 'functional areas' (for feeding, dunging, resting), exploration, and withdrawal from piglets in between suckling periods. For the piglets, the absence of a farrowing crate puts them at greater risk of being crushed. At the same time, an increase in sow pen space allowance will reduce piglet mortality and also offer them a larger area for play, locomotion and exploration.

In this opinion, an attempt was made to quantify the optimum space allowance offered to the sow in a farrowing pen. The minimum space required to allow a sow to express the same time in locomotor behaviour as shown in an unrestricted environment is much greater than that currently offered in any indoor individual farrowing pen. Therefore, we considered the welfare implications for both sow and piglets of providing different space allowances available to the sow in a lower space range (see Table 46).

Table 46: Activities a sow can perform in a given space. This table considers individual sow farrowing and lactating systems, not group suckling systems. The calculations are based on a sow of 250 kg live weight, with a body length of ~ 1.85 m

Area available to the sow	Length × width	Behaviour that can be expressed	Total pen size*
0.75 m^2 (k = 0.019)	1.85 × 0.41 m	**Lying sternally:** the sow can only stand, dog-sit or lie on her belly. She cannot change posture without touching the walls, turn around or walk (Petherick, 1983). See Section 5.7.8.	1.95 m^2
1.82 m^2 (k = 0.046)	1.85 × 0.98 m	**Lying laterally:** the sow can lie on her side with her legs stretched (Petherick, 1983). It is just possible to lie down without touching pen walls, but getting up without touching walls is problematic (Leonard et al., 2020). The pen width is 53% of the sow's body length. Below 60% turning around becomes difficult, and below 50% it can hardly be performed. At and below 50% sow lying times are increased compared to unrestricted width (Bøe et al., 2011). (See Section 5.7.8).	3.02 m^2
3.42 m^2	1.85 × 1.85 m	**Unhindered turning:** the pen width is the same as body length and the sow is not hindered in her behaviour to turn around (Bøe et al, 2011), or to lie down and get up. She cannot walk more than 1 step in any direction. (See Section 5.7.8).	4.62 m^2
4.92 m^2	Feeding area = area for standing/lying sternally: 0.75 Nesting area = unhindered turning: 3.42 Defecating area = lying sternally: 0.75	**Establishing functional areas** in an unpartitioned pen**. In theory, the sow can walk a few steps and has the ability to dung and rest in different places of the same pen: there is sufficient space for her to make a separate dunging area, feeding area and nesting area. (See Section 5.7.8). At this space allowance the estimated piglet mortality is 18.1%, (with a 90% certainty range from 11.9% to 23.3%), which is 1.27 times higher than in a crated system. A linear interpolation between high and low exposed piglets (4 m^2 or 6.6 m^2) is used for the estimation. (See Section 5.7.11.2 – EKE 4).	6.12 m^2
6.6 m^2		**Piglet survival:** The minimum space needed for a lactating sow to achieve similar preweaning piglet mortality to a crated sow. At lower space allowances mortality increases, at greater space allowances mortality does not decrease further (with 90% certainty range from 4.5% to 9.8%). (See Section 5.7.11.2 – EKE 4). At this space allowance sows will theoretically express 23% **of locomotory activity reported for unrestricted situations.** (See Section 5.7.10.2. EKE 3).	7.8 m^2
6.84 m^2	Feeding area + defecation area = unhindered turning: 3.42 Nesting area = unhindered turning: 3.42	**Establish functional areas** in a partitioned pen**. The functional areas are present, and there is a barrier between the nest and the feeding/defecating area. Sows have the possibility to turn around both in the nesting area and in the feeding/defecating area. (See Section 5.7.8).	8.04 m^2
22 m^2		**50% of locomotory activity reported for unrestricted situations:** In theory, a sow will perform 96 min of locomotor activity per 24 h, which equates to 50% of what she would do if there were no space restrictions. (See Section 5.7.10.2 – EKE 3).	23.2 m^2

Area available to the sow	Length × width	Behaviour that can be expressed	Total pen size*
47 m^2		**100% of locomotory activity reported for unrestricted situations:** Possibility to express locomotory behaviour at a level equal to if the sow had unrestricted space allowance: 124 min of locomotor activity per 24 h. (See Section 5.7.10.2 – EKE 3)	48.2 m^2

*: The total pen size is assumed to be the area required by the sow plus 1.2 m^2 for the separated piglet area.
**: Functional areas are separate areas for feeding, nesting and defecating.

The following summary conclusions are based on the effects of increasing space allowance to the sow and will be further elaborated with evidence related to other aspects of the design and management of the farrowing facilities.

1) Lactating sows can be offered more behavioural freedom by housing them in farrowing pens as opposed to farrowing crates, without increasing preweaning piglet mortality.
2) In a pen, reducing the space available to the lactating sow below 6.6 m^2 will reduce her freedom of movement and increase the mortality of her piglets. Above 6.6 m^2, the behavioural freedom of sows and piglets is increased, but piglet mortality does not further improve.

5.7.13. Quality of space: provision of enrichment materials

The third of the three exposure variables affecting the behavioural freedom of sows concerns the availability of materials that enrich the farrowing environment. The effects of enrichment on nest-building behaviour prior to parturition are discussed on the basis of scientific evidence (ELSs, see Section 2.2.1.2) in a narrative text, and a semi quantitative EKE. The effects of post farrowing enrichment are discussed through an evaluation of the available scientific evidence.

5.7.14. Pre-farrowing enrichment

5.7.14.1. Evaluation of the scientific evidence

Based on evidence provided in the scientific literature, 'nest-building behaviour' was identified as the most suitable ABM to assess the effect of different nest-building materials on the welfare consequence 'inability to express maternal behaviour'. Hazards, preventive, corrective and mitigation measures for this welfare consequence are addressed in Section 5.1.5. In most experimental studies, the duration of this behaviour was measured in relation to the quality of nest-building material provided in the pre-farrowing period.

5.7.14.2. Description of nest-building behaviour

On the day before farrowing, sows are highly motivated to perform nest-building behaviour. If provided with adequate nest-building material, they carry this material to a selected nest-site, where they arrange it by performing pawing and rooting behaviour. Typically, such behaviour is shown for several hours (Arey et al., 1991). The behaviour is very strongly motivated: nest-building behaviour is performed as rooting, sniffing and pawing directed to the floor even though there was no nesting material on the part of the floor the sow was touching (e.g. Jarvis et al., 2002; Edwards et al., 2019a; Aparecida Martins et al., 2021). This behaviour is intrinsically motivated, i.e. it does not require cues from the environment to trigger it. Therefore, sows in crates will also attempt to perform it (Jarvis et al., 2002).

In the following sections the materials that are best suited to allow such behaviour are described and compared.

5.7.14.3. Description of nest-building material

Nest-building material can be provided in different ways. Long-stemmed or long-cut straw may be offered in a straw rack or straw feeder that is refilled on a daily basis (Thodberg et al., 1999; Damm et al., 2010). In pens containing a resting area with solid floor, this area may be covered with a layer of such material (Damm et al., 2000; Jarvis et al., 2002). In experimental studies, a variety of other materials were offered to sows and gilts on the floor and in different amounts, such as short-cut or chopped straw (Burri et al., 2009; Westin et al., 2015; Swan et al., 2018), lucerne hay (Edwards et al., 2019a), peat (Rosvold et al., 2018), wood shavings (Swan et al., 2018), sawdust (Yun et al., 2014), shredded newspaper (Yun et al., 2014), sisal ropes (Yun et al., 2014) and branches (Yun et al., 2014). As an alternative to materials provided in a dispenser or directly on the floor, Hessian bags (jute sacks) fastened to the front bars of a farrowing crate have been investigated for their suitability as a nest-building material (Plush et al., 2021). In the experimental studies, sows and gilts were moved into farrowing crates or loose housing farrowing pens about 1 week before the expected farrowing. To measure the effect of different nest-building materials on nest-building behaviour, sows and gilts were observed during the last 24 h or during the last 12 h before the birth of the first piglet. Nest-building activity was quantified either in total or for different behavioural elements, such as carrying, manipulating, rooting and pawing. Unfortunately, there is no uniformity in the ethogram or observation methodology used in different studies (e.g. Jarvis et al., 2002; Edwards et al., 2019a; Aparecida Martins et al., 2021).

5.7.14.4. Comparison of nest-building materials

In studies comparing the duration of nest-building behaviour of sows or gilts kept in farrowing crates or pens, the animals provided with material showed significantly more nest-building behaviour than those without (e.g. Thodberg et al., 1999; Bolhuis et al., 2018; Rosvold et al., 2018; Edwards et al., 2019a; Aparecida Martins et al., 2021). Conversely, abnormal behaviour (biting the crate equipment or sham chewing) was more prevalent in animals without nest-building material (e.g. Jarvis et al., 2002; Edwards et al., 2019a; Aparecida Martins et al., 2021).

The quality and the quantity of nest-building material provided to the sows and gilts was variable in different experimental studies. Consequently, it is difficult to make comparisons between studies. Moreover, several studies (e.g. Damm et al., 2000; Burri et al., 2009) did not show any statistical difference in the amount of nest-building behaviour, when comparing different materials. It is, therefore, not possible to rank (or group) different nest-building materials unambiguously with regard to their positive effect on nest-building behaviour. In a few studies only, significant differences were detected in the duration of nest-building behaviour between housing conditions with different types of nesting material. Chaloupková et al. (2011) reported that sawdust elicited more nest-building behaviour compared to straw. However, the particle size of the straw provided in that study was not described in the methods. Yun et al. (2014) provided sows with a combination of sawdust (2 full buckets), shredded newspaper, chopped straw (3 full buckets), 7 branches of a tree and 3 natural sisal ropes of 50 cm length and measured more nest-building behaviour compared to sows offered sawdust only. Caille et al. (2016) observed more nest-building behaviour in sows provided with a Hessian bag compared to dried seaweed. Rosvold et al. (2018) reported that 2–2.5 kg of long-stemmed straw induced more nest-building behaviour (total time), less pawing, less rooting, more arranging material and more straw carrying behaviour than 4 kg of peat. Swan et al. (2018) found more nest-building behaviour in sows offered newspaper (3–6 full or half pages) compared to 2–3 l of chopped straw and to 2–3 l of wood shavings. Finally, Westin et al. (2015) reported an effect of the quantity of chopped straw provided to sows in that 15–20 kg elicit more nest-building behaviour than 0.5–1 kg. Whereas high quality nesting materials offered in sufficient quantity are expected to result in a high frequency and long duration of nest-building behaviour, the effects of nesting materials with low quality and/or offered in small amounts could be diverse. Such materials may either be unattractive, resulting in a low frequency and short duration of nest-building behaviour, or induce prolonged nest-building activity, as they fail to provide feedback to downregulate the sows’ motivation to show such behaviour. However, low quality nesting materials will generally reduce the diversity of nest-building behaviours performed (Rosvold et al., 2018).

5.7.14.5. Semi-quantitative assessment of the suitability of different nest-building materials

The above shows that although pair wise comparisons of the functionality of nest-building materials are in the scientific literature, there is insufficient evidence to make a full ranking based on a complete pairwise comparison of the various materials.

Therefore, a semi quantitative assessment was performed using expert opinion, and the outcome is presented in Table 47.

EFSA experts identified four Functional Behavioural Elements (FBE) of nest-building behaviour that sows and gilts typically engage in.

- FBE1: to root and paw the material on the ground to make a depression,
- FBE2: to find the material and carry it back to the nest site,
- FBE3: to bite and tear of the material to give it the correct structure,
- FBE4: to arrange the material by carrying (picking the material up and depositing it with the mouth), rooting and pawing it to accumulate the material into a heap at the nest-site (see Table 47).

These four FBEs were then used to score the suitability of different materials for building a nest.

Each material was scored against the possibility of the behaviour to be expressed and to be fully functional. Score 0 means that the behaviour is not possible; score 1 that the behaviour can be observed but it is not fully functional; and score 2 that the behaviour is typically shown, and it is functional. A behaviour was considered functional when it allowed the sow to meet the goal of the behaviour, e.g. to carry the material to the nest site or to accumulate it into a heap.

To assess the effect of different quantities of nest-building material on sow behaviour, examples of the amount of material, representing the two extremes of deep layer and minimal supply, were considered when assigning scores to the four FBEs.

Table 47: Suitability of different nest-building materials to enable the functional behavioural elements (FBE) of nest-building behaviour (score 0 = the behaviour is not possible; score 1 = the behaviour can be observed but it is not fully functional; score 2 = the behaviour is typically shown, and it is functional

Nest-building materials (examples of the amount of material are indicated for methodological purposes only)*	Functional behavioural elements (FBE) of nest-building behaviour				Sum of scores regarding behavioural possibility and functionality
	FBE1: to make the depression	FBE2: to carry	FBE3: to bite and tear	FBE4: to arrange	
Material with longer structures, (e.g. long-stemmed or long-cut straw, hay, haylage) – deep layer	2	2	2	2	8
Paper sheets or long shreds – deep layer	2	2	1	1	6
Material with longer structures, (e.g. long-stemmed or long-cut straw, hay, haylage) – minimal supply	0	2	2	1	5
Branches**	0	2	2	1	5
Loose destructible material (e.g. large diameter rope, hessian bag or jute bag)	0	2	2	1	5
Material with larger particles, (e.g. wood chips, wood shavings, coarse peat, chopped straw) – deep layer	2	1	0	1	4
Paper sheets or long shreds – minimal supply	0	2	1	1	4
Fixed destructible material (e.g. large diameter rope, hessian bag or jute bag)	0	1	2	1	4
Material in small particles (e.g. fine peat, sawdust, fine chopped straw) – deep layer	2	0	0	1	3
Material with larger particles (e.g. wood chips, wood shavings, coarse peat, chopped straw) – minimal supply	0	1	0	1	2
Material in small particles (e.g. fine peat, sawdust, fine chopped straw) – minimal supply	0	0	0	1	1
Fixed indestructible material (e.g. wooden pole, chain)	0	0	1	0	1

*: Deep layer: e.g. above a depth of approx. 5 cm; minimal supply: e.g. not covering the floor or up to a depth of approx. 1 cm; values are not to be considered as exact figures.
**: In the case of branches, the indicative amount is not necessary because even 1 single branch can elicit the behaviour.

The following considerations were used by experts to build Table 47.

By definition, the sow can only make a depression at the nest site if there is a deep layer of nesting material. Similarly, a depression cannot be made when branches as well as loose or fixed (in) destructible materials are provided.

Material with longer structures is suitable to be gathered with the mouth and carried to the nest site (long-stemmed or long-cut straw: Burri et al., 2009; Damm et al., 2010; hay: Edwards et al., 2019a). With regard to shredded paper, Swan et al. (2018) mentioned only pawing and rooting/arranging in the ethogram used to record nest-building behaviour. In that study, however, nesting material was provided to sows housed in a farrowing crate, and carrying shredded paper is likely to occur when offered in a loose farrowing system. Experimental results indicate that the smaller the particles of nesting material the more difficult it is for the sows to carry such material to the nest site. Rosvold et al. (2018) reported that carrying material was performed only with long-stemmed straw but not with peat and wood shavings. However, Westin et al. (2015), providing sows with 15–20 kg of chopped straw 2 days prior to expected farrowing, mentioned carrying straw in mouth as an element of nest-building behaviour. Damm et al. (2000) found no significant difference in the total number of 5-min intervals in which sows collected (defined as taking the material from a rack or floor and carrying it in the mouth while taking at least two steps) straw and branches in a loose farrowing pen. EFSA experts considered that carrying probably also occurs when hessian bags are provided as loose destructible material. Plush et al. (2021), however, included only nosing (back and forth movements with nose on ground) and pawing (front legs used to dig at ground in a sweeping motion) in the ethogram used to describe nest-building behaviour in sows with access to a hessian bag fastened to the front bars of the farrowing crate. Taking this into account EFSA experts gave score 1 for FBE2 performed with a hessian bag.

EFSA experts discussed that materials with small particles, such as fine peat or sawdust, do not elicit biting and tearing behaviour to change the structure of the material. Therefore, a score 0 was given for FBE3. With (shredded) paper, biting and tearing is possible, but not fully functional once the material is wet or chewed (score 1 for FBE3). Also, biting fixed indestructible material (e.g. wooden pole, chain) is not functional in terms of nest-building. Conversely, material with longer structures (e.g. long-stemmed or long-cut straw, hay), branches and loose as well as fixed destructible materials, such as ropes and hessian bags, are suitable to elicit biting and tearing that is functional (score 2 for FBE3). For example, Bolhuis et al. (2018) chose jute bags as nesting material to allow for fluffing.

FBE4 is only possible with material with longer structures (e.g. long-stemmed or long-cut straw, hay) and offered in large quantity (deep layer). In this situation, the sow can create a heap and arrange the material in a circle (score 2 for FBE4). Nesting material with small particles (e.g. sawdust) is also arranged by sows, but the behaviour is not fully functional to accumulate the material into a heap (score 1 for FBE4). Rosvold et al. (2018) offered sows either 2 kg of long-stemmed straw or 4 kg of peat as nesting material. They found that sows performed more arranging behaviour (collect material with the mouth, deposit and move collected material without walking) with long-stemmed straw, whereas pawing (digging movements in material with a forefoot) and rooting (digging movements in material with the snout) occurred more frequently with peat. Burri et al. (2009) observed more rooting (snout movement directed to the straw bedding) and arranging (all straw-directed behaviour other than rooting and carrying straw) in sows provided with long-cut compared to short-cut straw (2 kg each, replenished every morning and evening), whereas pawing occurred at a similar level in the two treatments. In both studies, however, the amount of nesting material was not sufficient for a deep layer. Sows also arrange branches (Damm et al. 2000) and jute bags (Bolhuis et al. 2018) by rooting and pawing, but the behaviour is not fully functional (score 1 for FBE4). When offered fixed indestructible material (e.g. wooden pole, chain), however, sows are not able to arrange such material at the nest site (score 0 for FBE4).

5.7.15. Post-farrowing enrichment – welfare of sows and piglets

5.7.15.1. Evaluation of the scientific evidence

Enrichment materials provided to sows and piglets prevent stress and/or negative affective states such as frustration and/or boredom resulting from the thwarting of the motivation to investigate the environment (see Sections 5.1.4 and 5.4.4). A welfare consequence associated with absence or inadequate access to appropriate enrichment is the 'inability to perform exploratory or foraging behaviour', which is described in Section 3.4.6 together with the related ABMs. Hazards, preventive, corrective and mitigation measures for this welfare consequence are addressed in Section 5.1.4 for lactating sows and Section 5.4.4 for piglets. In the following sections, the effects of different enrichment materials used in experimental studies on sow and piglet behaviour are assessed to identify recommendations regarding the characteristics of suitable materials. These studies were carried out with sows kept in housing systems offering different degrees of behavioural freedom, i.e. conventional farrowing crates as well as loose farrowing pens.

5.7.15.2. Description of behaviour directed at enrichment material

During the lactation period, provision of enrichment material elicits explorative behaviour in both the sow and the piglets. With piglets, such behaviour includes rooting, biting, chewing, sniffing, nosing, touching and manipulating the material (Lewis et al., 2006; Munsterhjelm et al., 2009; Oostindjer et al., 2011; Vanheukelom et al., 2011; Telkänranta et al., 2014b; Brajon et al., 2017).

With sows, explorative behaviour during lactation has not been analysed in detail. Salaün et al. (2004) recorded exploration as a behavioural category but did not describe the behavioural elements the sows used to manipulate the straw provided as litter. To quantify exploration in sows, Valros et al. (2017) measured weight reduction of a piece of wood offered as enrichment material without describing animal behaviour. However, all behavioural elements expressed by piglets (e.g. rooting, biting, chewing, etc.) can also be used to describe explorative behaviour in sows during lactation. In addition, Swan et al. (2021) mentioned pawing with the front foot as a manipulative behaviour observed in sows. In the studies found in the literature search, data collection focused on the duration (or frequency) of explorative behaviour directed to enrichment material in sows and piglets. However, there is no uniformity in the ethogram, the observation methodology or the data collection period (e.g. weeks after farrowing) used in different studies.

5.7.15.3. Description of enrichment material

Different types of enrichment material were offered to sows and piglets from farrowing to weaning in experimental studies (Table 48). In some studies, several materials were offered in combination (Pedersen et al., 2003; Munsterhjelm et al., 2009; Oostindjer et al., 2011; Telkänranta et al., 2014b; Yang et al., 2018; Luo et al., 2020). For example, Middelkoop et al. (2019) attached canvas clothes, cotton ropes and PVC spiral tubes to the piglet feeder in the farrowing pen and observed that this enrichment stimulated feeder exploration and attracted more piglets to the feeder. In most cases, the enrichment materials were accessible to both sows and piglets, with the exception of ropes and plastic balls provided to the piglets only, as these were fixed out of reach of the sow kept in a crate (Lewis et al., 2006; Telkänranta et al., 2014b; Yang et al., 2018).

Table 48: Enrichment materials provided to sows and piglets from farrowing to weaning in experimental studies

Enrichment materials	Publications
Chopped straw provided on the floor	Munsterhjelm et al. (2009); Westin et al. (2014, 2015); Brajon et al. (2017)
Chopped straw provided in a dispenser	Bulens et al. (2014)
Short-cut straw offered on the floor	Burri et al. (2009)
Long-cut straw provided in a feeder	Thodberg et al. (1999)
Long-cut straw provided on the floor	Martin et al. (2015); Rosvold et al. (2019)
Lucerne hay	Edwards et al. (2019a)
Peat	Pedersen et al. (2003); Oostindjer et al. (2011); Vanheukelom et al. (2011); Rosvold et al. (2019); Luo et al. (2020)
Shredded paper	Lewis et al. (2006)
Newspaper	Telkänranta et al. (2014b)
Ropes	Lewis et al. (2006); Telkänranta et al. (2014b); Yang et al. (2018)
Sawdust	Chaloupková et al. (2011); Oostindjer et al. (2011); Luo et al. (2020)
Wood shavings	Munsterhjelm et al. (2009); Oostindjer et al. (2011); Telkänranta et al. (2014b)

Enrichment materials	Publications
Branches	Pedersen et al. (2003); Oostindjer et al. (2011)
Plastic balls	Telkänranta et al. (2014b); Yang et al. (2018)

Both with sows and piglets, the majority of studies included a comparison of experimental treatments with and without a given type of enrichment material. None of the studies identified in the literature search with observations on sow behaviour compared the amount of explorative behaviour between different materials, whereas three studies focusing on piglet behaviour did so (Lewis et al., 2006; Oostindjer et al. 2011; Telkänranta et al., 2014b).

In studies quantifying sow behaviour, the enrichment materials available during lactation were offered to the animals already in the pre-farrowing period as nesting material (i.e. long-cut or chopped straw, lucerne hay, peat, branches or sawdust), with data collection continuing into the farrowing and lactation period. Explorative behaviour directed at these materials could thus also be considered as nest-building behaviour, especially when shown during parturition (Thodberg et al., 1999).

5.7.15.4. Assessment of enrichment material

In studies comparing the explorative behaviour of sows and piglets kept in farrowing crates or pens with and without (control) any kind of enrichment material, the animals typically show significantly more explorative behaviour in the treatments with enrichment material. Salaün et al. (2004) reported that sows kept in crates as well as those in loose housing pens showed significantly more exploration on days 1–4 post-partum when provided with straw on the floor. Valros et al. (2017) offered lactating sows a piece of fresh willow (30 cm long and 6 cm in diameter) attached to the front part of the farrowing crate and observed that this object was used more on days 23–27 compared to days 1–22 postpartum. Moreover, Swan et al. (2021) found that the frequency and duration of object manipulation (directed at newspaper or pen structures) in sows did not differ between the second and third week of lactation.

With regard to piglets, Brajon et al. (2017) found that percentage of animals showing exploration on days 6, 12 and 20 prior to weaning at 22 days of age was significantly increased in enriched farrowing pens (chopped straw bedding) compared to standard farrowing crates with fully-slatted flooring. Similarly, Luo et al. (2020) observed that piglets raised in enriched pens, containing a mixture of straw, sawdust and peat, spent more time exploring at 3 weeks of age compared to piglets in a barren pen. Vanheukelom et al. (2011) measured significantly more such behaviour (i.e. manipulating peat or feed with the snout) until weaning at 4 weeks of age, if piglets had access to a tray of peat from about 5 days of age. Contrary to these results, Munsterhjelm et al. (2009) reported that general exploratory behaviour, as well as exploration of specific pen components such as the floor or the substrate did not differ between piglets raised in pens that either were or were not moderately bedded with wood shavings and chopped straw during the lactation period (0–4 weeks of age). However, piglets kept in barren pens explored fixtures (i.e. any part of the pen except the floor, drinking nipple or inside the feeder or trough) significantly more in this study. In line with this, piglets in a barren environment spent significantly more time with pen-directed exploration (i.e. exploring any part of the pen (wall, floor), feeder, objects, drinking nipples) at 3 weeks of age in the study of Luo et al. (2020).

In a pairwise comparison, Lewis et al. (2006) found that piglets observed on days 14, 18, 22 and 26 after farrowing spent significantly more time interacting with shredded newspaper presented in two boxes than with two natural fibre ropes (length 1 m). Conversely, the time spent exploring pen-fittings (i.e. rooting, biting and sniffing, directed to fixtures and fittings) was significantly lower in the treatment with shredded paper. Similarly, Oostindjer et al. (2011) reported that piglets raised either in a farrowing crate system or a loose housing pen spent more time exploring the floor (i.e. sniffing, touching, scraping the leg or rooting (substrate on) floor) on days 7, 14, 21 and 28 of lactation when the floor was covered with straw, peat and wood shavings (with some branches on top of these substrates) in the enriched treatment, compared to the barren treatment with only a small amount of sawdust provided in the first 24 h after farrowing. Moreover, time spent exploring fixtures (i.e. sniffing, touching, chewing or rooting part of the pen above floor level) as well as manipulative behaviour directed at pen mates (i.e. nibbling, sucking or chewing part of the body of a pen mate) were significantly reduced in the enriched treatment in that study. Finally, Telkänranta et al. (2014b) compared the behaviour of piglets kept in farrowing crates furnished with 10 pieces of sisal rope and one plastic ball suspended on the wall, and given newspaper and wood shavings twice a day, to that of piglets in a control treatment with a plastic ball and wood shavings, and observed significantly more object-directed oral-nasal manipulation in the enriched housing condition in weeks 2 and 3 of lactation.

In a few studies on sow behaviour, the quality of enrichment material was related to sow-piglet social interactions, aspects of nursing behaviour, crushing risk or piglet mortality. However, as the enrichment materials studied were identical to the nest-building materials provided to the sows before farrowing, it is possible that the effects observed in these ABMs are due to differences in nest-building behaviour in the pre-farrowing period rather than differences in the quality of enrichment material provided during and after parturition.

In most studies measuring piglet behaviour, enrichment material was provided only after parturition and in an attempt to elicit explorative behaviour. Besides exploration, effects of enrichment material on play behaviour were reported in some studies (Chaloupková et al., 2007; Oostindjer et al., 2011; Vanheukelom et al., 2011; Martin et al., 2015; Brajon et al., 2017; Yang et al., 2018).

The number of studies measuring explorative behaviour in sows and piglets from farrowing to weaning is low. Moreover, the quality (and quantity) of enrichment material offered to the animals differs considerably between the studies. Consequently, it is difficult to make comparisons between studies. Given that only three studies made pairwise comparisons between enrichment materials, there is insufficient scientific evidence to make a full ranking of the various materials. Finally (and different to the situation regarding the suitability of different nesting materials to enable specific elements of nest-building behaviour in sows), data on the proportion of time sows and piglets spend with specific elements of explorative behaviour when offered different enrichment materials are not available. It is, thus, not possible to do a semiquantitative assessment of the suitability of different categories of enrichment material in this specific scenario. However, it can be assumed that the material characteristics which are preferred by other pig categories (e.g. weaners and rearing pigs) are also likely to be preferred by sows and piglets during lactation (see Section 7.7.4).

5.7.15.5. Effects of enrichment during lactation on pig behaviour after weaning

There are studies showing that provision of enrichment material from farrowing to weaning has positive effects on the behaviour of the pigs after weaning. For example, in a case–control study, Moinard et al. (2003) found that increased provision and replenishment of straw in the farrowing pen was significantly associated with a reduced risk of tail biting in growing pigs. Telkänranta et al. (2014b) recorded tail damage in weaned piglets in week 9 after birth and reported that severe tail damage (part of tail missing or wounds with inflammation) was significantly less prevalent in pigs that had access to paper and ropes as enrichment materials before weaning. In line with this, Schmitt et al. (2020) observed that piglets provided with diverse enrichment (one piece of hessian and one bamboo stick) during the lactation period performed less biting (chewing or biting the tail, ear or snout of another pig) in the first 2 weeks after weaning than piglets with access to one type of enrichment material only (two pieces of hessian fabric).

Access to enrichment material during lactation may also make piglets better prepared for weaning. Luo et al. (2020) reported that enriched housed piglets were better able to cope with weaning transition, as they gained more weight and had a higher feed intake during the first 5 and 18 days after weaning. Similarly, enrichment of the creep feeder in the farrowing pen was found to increase piglets' feed intake and growth between days 0–15 post-weaning (Middelkoop et al., 2019), and provision of peat as enrichment material during the lactation period led to a higher weight gain in piglets after weaning and a higher weight at the end of the weaning period (Vanheukelom et al., 2011). Moreover, Munsterhjelm et al. (2009) observed that the number of days pigs had diarrhoea was reduced on days 0–18 after weaning in piglets raised in farrowing pens with some bedding as compared to barren housing.

5.7.16. Summary Conclusions on quality of space in the farrowing systems

5.7.16.1. Summary Conclusions on pre-farrowing enrichment materials

1) On the day before farrowing, sows and gilts are intrinsically motivated to perform nest-building behaviour. Even without access to suitable nest-building material they will redirect (non-functional) nest-building behaviour to the floor or the pen fixtures.
2) Nest-building material is typically manipulated by sows and gilts during several hours on the day before farrowing.
3) Sows kept in crates face difficulties to perform nest-building behaviour, because any loose material provided may get out of reach due to their manipulatory behaviour.

4) The suitability to enable specific nest-building behaviours varies between materials and also depends on the amount of the materials.
5) There is little evidence to allow a complete pairwise comparison of the suitability of all nest-building materials used in practice.
6) In the absence of sufficient scientific evidence, a semiquantitative analysis based on expert opinion allowed to identify materials such as long-stemmed or long-cut straw, hay, haylage as the most suitable for nest-building. However, these materials need to be provided in an amount which allows all behavioural elements of nest-building to be performed at a functional level.

5.7.16.2. Summary Conclusions on post-farrowing enrichment materials (sow and piglets perspective)

1) Both sows and piglets are motivated to explore enrichment material during the whole period from farrowing to weaning.
2) Both sows and piglets without access to suitable enrichment material will redirect explorative behaviour to pen fixtures and pen mates.
3) Sows kept in crates face difficulties performing exploratory behaviour, because any loose enrichment material provided may get out of reach due to their manipulatory behaviour.
4) Provision of enrichment material to piglets during the lactation period reduces the risk for tail biting in weaners and growing pigs.
5) Piglets with access to enrichment material in the farrowing pen are better able to adapt to the weaning transition.
6) The evidence found in literature does not allow a complete pairwise comparison of the suitability of all enrichment materials used in practice.
7) Given the limited amount of evidence measuring explorative behaviour in sows and piglets from farrowing to weaning, a preference for specific enrichment materials cannot be determined scientifically. However, it can be assumed that lactating sows and piglets prefer the same material characteristics as other pig categories.

5.7.17. Time needed for adaptation from crate to free farrowing system

There is very little information available on the time it takes a farm to adapt to a free farrowing system. However, according to practical experience, there are at least three factors affecting this adaption time.

Staff experience and learning process. Farm staff needs to learn new routines to optimise things in the unfamiliar systems (PigProgress website[27]; TuVa, 2022). How long this takes is likely to depend on the background experience of the staff with loose sows, their understanding of pig behaviour, their motivation and the training they receive. Farmers in Finland, with at least one years´ experience of free farrowing (TuVa, 2022) suggested it might be beneficial for farmers and staff to practice in another farm before rebuilding their own. There is some limited data to indicate that it might take at least four to six farrowing batches to adapt to a new system (Baxter and Edwards, 2021; Andersen and Ocepek, 2020). Depending on batch size and farrowing rotation, this suggests a period of 1–3 months. These data, however, should be considered with care as they are from farms that received support from researchers to adapt to free farrowing. They also show success is not always guaranteed: in the Andersen and Ocepek (2020) study, the number of weaned piglets did not increase over time, even though they reported a decrease in mortality of live-born piglets.

Adaptation of existing sows to the new system. When changing to a free farrowing system, most sows will never have farrowed in this system before. There is some evidence that sows do less well in an unfamiliar system (King et al., 2019). According to Finnish farmers (TuVa, 2022), old sows who are already used to farrowing in crates have more challenges in adapting to free farrowing systems as they are often less careful with their piglets than gilts. It will take ~ 5 months for all sows to go through the new system once.

Optimising the herd for free farrowing. There is a need to carefully select the animals to be used in the free farrowing systems (TuVa, 2022). Therefore, time is needed for culling poorly performing sows and sows with poor leg health, aggressive sows or sows which are not careful towards their piglets before reaching an optimal sow herd. Typically 40–50% of sows are replaced

[27] https://www.pigprogress.net/specials/reducing-piglet-mortality-in-free-farrowing-systems/

each year, thus a complete herd change would take 2–3 years, with an increasing proportion of 'suitable' sows. If the culling and replacement policy is adapted for free farrowing starting only at the time the system changes, it will take 4 months until all sows already inseminated have farrowed in the new system. This is regardless of their suitability, and it would take 5 months to replace all sows found to be unsuitable based on their first performance in the new system. Genetic selection by breeding companies for sows with traits better suited to free farrowing will progressively benefit performance on individual farms.

Expert opinion from researchers who have worked extensively with free farrowing suggest that it takes from about 6 months to a year, or even longer, before a free farrowing system can reach mortality figures comparable to a previous crated system (Vivi A. Moustsen, SEGES Danish Pig Research Centre, Emma M. Baxter, Scotland's Rural College and Anna Valros, University of Helsinki, personal communication, 2022). This seems to be in line with the above reasoning.

5.7.17.1. Summary Conclusions on the time needed for adaptation

1) The adaptation of staff and animals to a change from crated to free farrowing is likely to take at least six months.
2) Longer term optimisation of the system will occur with the incorporation in genetic selection of traits focused on free farrowing.

5.7.18. Effects of litter size on sow and piglet welfare

5.7.18.1. Background

Changing the breeding strategy to less prolific sows is one of the preventive measures to the hazards 'insufficient milk' (in all systems), 'insufficient access to teats' (in all systems except in artificial rearing systems), 'competition for teats' (not artificial rearing systems) and 'insufficient access to resources' (not artificial rearing systems) reported in the common ToRs for piglets in relation to the welfare consequences: group stress, prolonged hunger, prolonged thirst and soft tissue lesions and integument damage and also for tooth reduction.

Genetic selection has led to a steady increase in litter size over the last 20 years (see Section 3.3.4.1), but EU legislation on pig welfare does not yet specifically address the welfare of highly prolific sows and their piglets. Based on evidence showing that piglet mortality rapidly increased when litter size was larger than 11–12 piglets, EFSA (2007b) recommended that genetic selection for litter size should not aim at exceeding having an average of 12 piglets born alive in a litter. In 2020, however, the average number of piglets born alive in EU InterPIG countries amounted to 14.9 (AHDB, 2021b). Due to the progress in the selection for litter size, it is increasingly likely that the number of piglets born alive in a given litter exceeds the sow's number of functional teats. It will be difficult in herds with highly prolific sows to move piglets between the sows to balance litter sizes (cross-fostering), because the average number of piglets born alive will be close to or above the number of functional teats available in all sows farrowing at the same time in a batch.

5.7.18.2. Rearing surplus piglets of highly prolific sows

To resolve this problem, surplus piglets can be raised by supplying them with artificial milk in their home pen (Kobek-Kjeldager et al., 2020b), moving them to artificial piglet rearing systems (Rzezniczek et al., 2015; Schmitt et al., 2019) or the use of nurse sows (Sørensen et al., 2016).

However, all three management interventions have negative implications for piglet and sow welfare (Baxter et al., 2013, 2020). Kobek-Kjeldager et al. (2020b) standardised litters to 14 or 17 piglets at day 1 postpartum and provided them with or without milk replacer in the farrowing pen. They found that piglet mortality was significantly higher in larger litters, irrespective of access to milk cups, and concluded that piglets in litters with more piglets than functional teats were not able to drink sufficient milk replacer. Moreover, the milk replacer was mainly used by the larger piglets within-litter and as a supplement to increase growth of piglets who had access to a teat (Kobek-Kjeldager et al., 2020c). When surplus piglets are raised in artificial piglet rearing systems, they redirect massaging behaviour (belly nosing) to their pen mates resulting in group stress. Rzezniczek et al. (2015) also observed that, compared to piglets reared by the sow, the average resting bout length was shorter in artificially raised piglets, and Schmitt et al. (2019) reported that artificially reared-piglets had a lower growth rate and a higher incidence of diarrhoea, compared to sow-reared piglets. Nurse sows raise two litters in succession and thus have a prolonged lactation period. In a cross-sectional study including 57 sow herds in Denmark, Sørensen et al. (2016) found that nurse sows had a significantly higher risk of swollen bursae on legs and udder wounds than non-nurse sows. In addition, carpal abrasions were more prevalent in foster litters, possibly due to teat order fighting eventually reinforced by hunger experienced during the transfer period.

5.7.18.3. Welfare implications of large litter size on the piglets

Rutherford et al. (2013) reviewed several detrimental animal welfare consequences of large litter size **for the piglets**. These included intra-uterine crowding leading to piglets with reduced birth weight and increased within-litter birth weight variation, an increase in stillbirth prevalence associated with increasing litter size, an increase in peri-natal mortality and morbidity especially in piglets with low birth weight, and increased competition for access to teats during suckling bouts (see also Section 6.1.4 on tooth reduction). Piglets without access to a functional teat will suffer from prolonged thirst and hunger and typically starve to death before they are 4 days old. In addition, piglets with a low birth weight have an increased risk of chilling due to poorer thermoregulatory abilities and an increased risk of being crushed by the sow. In the long term, they show compromised growth, carcass quality and reproductive performance, as they exhibit impaired digestive, cardiac, endocrine and neuromuscular function (Edwards et al., 2019b).

As selection for litter size is associated with increased within-litter variation of piglet birth weight and increased piglet mortality, selection on birth weight uniformity would be a relevant approach to improve piglet survival (Quesnel et al., 2008). Damgaard et al. (2003) estimated maternal genetic variance and heritability for within-litter variation in birth weight and concluded that genetic improvement of this trait by selective breeding is possible. Similarly, Matheson et al. (2018) found that selection against intrauterine growth retardation is possible at the maternal level and would result in an increase in the survival of piglets to 24 h of age.

5.7.18.4. Welfare implications of large litter size on the sows

Rutherford et al. (2013) reviewed detrimental animal welfare consequences of large litter size **for the sows**. They mentioned challenges sows with large litters face in late pregnancy, such as energetic and nutrient demands of growing fetuses, general discomfort and restriction of movement, and an increased risk of heat stress due to the increased metabolic loading during pregnancy. The prolonged farrowing duration associated with large litter size and increased numbers of stillborn piglets could also lead to increased pain in the parturient period. During lactation, demands for milk production increase with litter size. If a sow cannot maintain a high feed and water intake, she will start to lose body condition and is at greater risk of developing injuries such as shoulder sores.

Litter size has also been shown to be related to sow longevity. Andersson et al. (2016) analysed the impact of first parity litter size on sow longevity and removal reasons in 28 Swedish herds. They found that among sows giving birth to 9–16 piglets in their first parity, a higher proportion had a second litter, and a higher proportion was able to stay $\geq$ 4 L, compared to sows giving birth to $\leq$ 8 or $\geq$ 17 piglets. Moreover, sows having $\geq$ 14 piglets had the largest proportions of sows removed due to udder problems. Andersson et al. (2016) thus concluded that there is a maximum to the number of piglets a sow should give birth to in order to be sustainable, and that this maximum is around 12–14 piglets.

5.7.18.5. Number of functional teats in European sow breeds

The number of teats in pigs shows a considerable variability among and within breeds, is influenced by many different quantitative trait loci (QTL) and has a medium/high level of heritability (Bovo et al., 2021). For example, Rohrer and Nonneman (2017) reported a genomic heritability of 0.23 for total teat number and Lundeheim et al. (2013) calculated an estimated heritability of 0.31 for the number of functional teats. With regard to litter size at birth, heritability values are typically lower and in the range of 0.08–0.1 (Lundeheim et al., 2013; Putz et al., 2015; Sell-Kubiak, 2021). Lundeheim et al. (2013) did not find significant genetic correlations between litter size at birth and the total number of teats or the number of functional teats. Selection for larger litters will thus not automatically result in more teats. With regard to animal welfare, the number of functional teats is crucial, and this number is typically lower than the total number of teats. Ocepek et al. (2016), e.g. found that the proportion of non-functional teats varied between 9.4% and 20.7% in three Norwegian breeds. In recent studies, there are different average numbers of functional teats presented. These numbers varied between 14.2 and 15.1 in sows of a Danish breed (Kobek-Kjeldager et al., 2020b), between 12.8 and 14.2 in sows of a German breed (Pustal et al., 2015), between 12.6 and 15.9 in sows of three Norwegian breeds (Ocepek et al., 2016) and was 14.2 in a genetic analysis using a Swedish-Finnish breed (Lundeheim et al., 2013).

5.7.18.6. Summary Conclusions on the effects of litter size on sow and piglet welfare

1) Selection for increasing litter size is associated with negative welfare consequences for both the piglets and the sows.
2) The use of artificial rearing systems as a structural consequence of large litters provides challenges to piglet welfare that can only be mitigated by adapting the herd's average litter size to the physical capabilities of the sow, by genetic selection.
3) In large litters, the number of piglets born alive typically outnumbers the number of functional teats, and selection for litter size does not concomitantly result in an increase in the number of functional teats.
4) Increasing litter size is characterised by increased within-litter birth weight variation, increased perinatal mortality and longer term detrimental effect for low birthweight piglets.
5) Genetic selection for reduced within-litter variation in birth weight is feasible and will result in improved piglet survival.

5.8. Summary Conclusions on the welfare of farrowing and lactating sows and piglets

5.8.1. Summary Conclusions from the General ToRs

1) The highly relevant welfare consequences experienced by **farrowing and lactating sows housed in farrowing crates** are restriction of movements, resting problems, group stress, inability to perform exploratory or foraging behaviour, inability to express maternal behaviour, heat stress and soft tissue lesions and integument damage. Hazards leading to these highly relevant welfare consequences and ABMs that can be used to assess them are presented in Section 5.2.
2) There were no highly relevant welfare consequences identified for **farrowing and lactating sows housed in farrowing pens or outdoor farrowing paddocks**. However, other welfare consequences may negatively affect the welfare of farrowing and lactating sows, but these were classified as less or moderately relevant (see Appendix B).
3) The highly relevant welfare consequences experienced by **piglets housed in farrowing crate** systems are group stress, inability to perform exploratory or foraging behaviour, prolonged hunger, prolonged thirst and soft tissue lesions and integument damage. Other welfare consequences may negatively affect the welfare of farrowing and lactating sows, but these were classified of minor or moderate relevance (see Appendix B). Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 5.5.
4) The highly relevant welfare consequences identified in the case of **piglets housed in farrowing pen systems** are group stress, prolonged hunger, prolonged thirst and soft tissue lesions and integument damage.
5) The highly relevant welfare consequences experienced **by piglets housed in outdoor farrowing paddocks** are group stress, prolonged hunger, prolonged thirst, cold stress and soft tissue lesions and integument damage.
6) The highly relevant welfare consequences experienced by **piglets housed in artificial rearing systems** are restriction of movement, group stress, separation stress, inability to perform exploratory or foraging behaviour, inability to perform sucking behaviour and prolonged hunger.

5.8.2. Summary Conclusions from Specific ToRs 2 and 3

1) When converting from a system with farrowing crates to a system with farrowing pens, an adaptation period for individual sows, the herd as a whole and the stockperson will be needed before piglet survival levels will be similar or better than before the conversion.
2) **Temporary farrowing crate systems** can be effective in maintaining piglet survival whilst (temporarily) offering a higher degree of behavioural freedom to the sow, at space allowances below those that can be recommended for pen systems. However, they will not allow a similar level of welfare for sow and piglets compared to a well-functioning pen system.

3) The use of a temporary farrowing crate system cannot be advised as a step in a farm's transition from using farrowing crates to farrowing pens, unless the size of the temporary farrowing crate system is the same as that of the future free farrowing pen.
4) The use of artificial rearing systems as a structural consequence of large litters provides challenges to piglet welfare that can only be mitigated by adapting the herd's average litter size to the physical capabilities of the sow, by genetic selection.
5) Breeding goals resulting in litter sizes that consistently exceed the number of functional teats of the sow will not result in adequate welfare for sows or piglets.
6) Traits relevant to piglet survival and sow longevity which could be incorporated in breeding goals are, e.g. optimal litter size, good piglet viability, low birth weight variability, good maternal behaviour, good leg conformation and good udder quality.

5.9. Recommendations on the welfare of farrowing and lactating sows and piglets

5.9.1. Recommendations from the General ToRs

1) Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for weaners, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 7.2).
2) Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **piglets**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 7.5).

5.9.2. Recommendations on Specific ToRs 2 and 3: space allowance on farrowing systems

1) For animal welfare reasons, periparturient and lactating sows should not be housed in farrowing crates but in farrowing pens.
2) When housing a lactating sow and her piglets in a farrowing pen, the minimum available space for the sow should be around 6.6 m2 in order to achieve comparable piglet mortality to a farrowing crate system. This equates to ~ 7.8 m^2 total pen size.
3) A larger pen size than referred to in the recommendation above is recommended to improve the locomotory possibilities for the sow.
4) Training to farm staff should be offered to minimise welfare compromises during the transition period away from farrowing crates.

5.9.3. Recommendations on Specific ToRs 2 and 3: pre-farrowing enrichment materials

1) To satisfy their intrinsic motivation to build a nest, sows and gilts should be provided with material enabling nest-building behaviour at least on the day before farrowing.
2) Materials such as long-stemmed or long-cut straw, hay and haylage should be offered to sows and gilts, as these are suitable to enable a variety of functional behavioural elements of the nest-building behaviour. These materials should be provided in an amount which will allow all behavioural elements of nest-building to be performed at a functional level.
3) Further studies are needed to identify what amount of such materials is deemed to be functional.

5.9.4. Recommendations on Specific ToRs 2 and 3: post-farrowing enrichment materials

1) Sows and piglets should be provided with enrichment material that allows them to perform exploratory behaviour in the period from farrowing to weaning.
2) Suitable enrichment material should be provided and replenished in an amount which will allow the sow and the piglets to perform explorative behaviour at all times in order to allow them to express the behaviour when they are motivated to.
3) Future research should investigate the kind and amount of enrichment materials which elicit explorative behaviour in lactating sows and piglets and reduce the incidence of behaviours

that are detrimental to animal welfare (such as tail biting). This would enable the definition of characteristics required by enrichment materials offered specifically in this period to elicit frequent and diverse exploratory behaviours.

5.9.5. Recommendations on the time needed for adaptation

1) Staff should receive training in appropriate management of free farrowing system to facilitate rapid adaptation.
2) Temporary crating systems should not be used as interim step for farms that want to convert from crates to complete free farrowing, if the total floor surface area they occupy is insufficient to allow for a well-functioning pen system.
3) Genetic selection to improve pig welfare in free farrowing systems should be addressed by breeding organisations. Such traits include good piglet viability, low birth weight variability, good maternal behaviour, good leg conformation, good udder quality.

5.9.6. Recommendations on the effect of litter size to sow and piglet welfare

1) To avoid excessive competition for access to teats and significantly increased piglet mortality in large litters, the average number of piglets born alive in a given sow breed or line should not exceed, and preferably be lower than, the average number of functional teats in the population of this breed or line.
2) For breeding to be sustainable in terms of sow longevity, selection for litter size should be limited to an average number of 12–14 piglets born alive.
3) Selection for litter size should be supplemented to a larger extent with selection for low birth weight variation within litters and other traits resulting in low piglet mortality before weaning.

6. Assessment of the welfare of piglets in the context of the practice of mutilations

Mutilations are listed in Specific ToR 4 of the mandate on the welfare of weaners and rearing pigs. However, in the context of this SO, they are assessed when discussing the welfare of the piglets, which is the pig category they are applied to. Nevertheless, it is recognised that long-term welfare consequences of these practices may last also in older pigs.

The mutilations that will be assessed in the following sections are tooth reduction, castration and tail docking.

6.1. Tooth clipping

6.1.1. Introduction

In this SO, tooth reduction is assessed instead of tooth clipping as it also includes other methods for reduction and is therefore considered more appropriate. 'Tooth reduction' is the term used to refer to practices such as 'tooth clipping' and 'tooth grinding'. An overview of welfare risks related to tooth reduction was provided by SVC (1997) and Prunier et al. (2021). In the current document, an updated review of the scientific literature on methods of tooth reduction and welfare implications for piglets and for the sow is presented. Mitigation and preventive measures are then presented, and finally conclusions and recommendations are given.

Tooth reduction is carried out on farms because piglets' milk teeth are sharp and can cause lesions of the sows' udder and extensive facial injuries in other piglets when piglets fight to establish the teat order just after birth and to access teats later on (Fraser and Thompson, 1991; Torrison and Cameron, 2019). The goal of tooth reduction is to prevent or reduce the prevalence and severity of such lesions. However, while the effect of tooth reduction in reducing facial injuries is well documented (e.g. Hutter et al., 1993), the reduction of udder and/or teat lesions is less clear (e.g. Hay et al., 2004; Gallois et al., 2005; Menegatti et al., 2018). Also, there is little understanding of the effect of tooth reduction on piglet mortality or weight gain with inconsistent effects being reported in the literature (Holyoake et al., 2004; Marchant-Forde et al., 2009; Sinclair, 2022).

The problem of facial injuries is especially associated with milk shortages, either in large litters (when there are more piglets than functional teats, according to Hansson and Lundeheim, 2012) or due to insufficient milk supply by the sow (e.g. in very young or old sows, or if they suffer from mastitis).

Epidemiological data are scarce. However, there is considerable anedoctal evidence indicating that tooth reduction is a frequent practice on EU farms (Chou et al., 2020a). It appears that shortening of suckling piglets' teeth within the first day(s) of life is carried out in many countries worldwide (e.g. Fredriksen et al., 2009), and there is little reason to believe that this has recently changed (Prunier et al., 2020a). For instance, 80% of farms surveyed in Norway performed tooth grinding (Rosvold et al., 2017). In fact, in a recent online survey of 75 respondents from 17 countries (including countries outside the EU) ~ 50% of the respondents reported not to carry out teeth reduction, from which a majority stated that lesions of piglets and sows were manageable (Chou et al., 2020a; Chou et al., under review). For instance, 80% of farms surveyed in Norway performed tooth grinding (Rosvold et al., 2017). In a study on organic piglet producing farms in Austria (Bernardi, 2015), 40% were carrying out tooth reduction whilst claiming not to do it on a routine basis, and 60% were never doing it.

In the current document, an updated review of the scientific literature is presented. A description of the current procedures, providing details on the effect of different methods and age of piglets is carried out. The welfare consequence and ABMs are addressed of piglets undergoing teeth reduction, as well as the welfare consequence for piglets and the sow if teeth reduction is not performed. Mitigation measure to reduce the welfare consequence are also considered. Finally, conclusions and recommendations are given.

6.1.1.1. Description of the procedure of tooth reduction

Tooth reduction is commonly carried out in the first days of life (Prunier et al., 2021). The procedure involves the shortening of the upper and lower third incisor and the canines (total of 8 teeth) to remove the sharp part of the teeth without opening of the dental pulp. However, as teeth can have different length this can easily go wrong. A maximum removal of the top third of each tooth is generally recommended, but in practice this varies considerably, from a small fraction to the whole tooth above the gum line being removed (Gallois et al., 2005; Fu et al., 2019).

Traditionally, either manual clipping (performed using side-cutting pliers, called 'clippers') or electronic grinders (tooth abrasion with a stone) are used. Data of the actual distribution of both practices are missing.

6.1.1.2. Welfare consequences of tooth reduction

Welfare consequences of piglet tooth reduction will include soft tissue lesions and integument damage and handling stress, causing the overarching welfare consequences of pain and fear. As the dentin is affected, the welfare consequence 'bone lesions' also needs to be considered.

6.1.1.3. Welfare consequence due to handling related to the whole procedure

The tooth reduction procedure is stressful for both the piglet and farmer. The practices of tooth clipping and tooth grinding in piglets involves intensive handling of piglets (e.g. catching, restraint, application of grinder or clipper) leading to handling stress that can be measured by escape attempts and vocalisations (Marchant-Forde et al., 2009). Behavioural indicators (e.g. piglets struggling) can be observed as a reaction to tooth reduction (von Borell and Schäffer, 2005). However, the effect of teeth reduction on these ABMs is difficult to measure as the procedure implies the opening of the mouth (see Table 49: 'escape attempts' and 'squeals'). The exposure to handling stress for the whole procedure was ~ 27 sec/piglet in both grinding and clipping in a study by Hutter et al. (1993), while in another study, grinding took longer than clipping (56.3 vs. 38.6 s) (Marchant-Forde et al., 2009).

6.1.1.4. Welfare consequence due to tooth reduction and comparison between methods

Independent from the method applied, tooth reduction can cause lesions to diverse tissues of the teeth; these are bone (dentin) lesions, opening of the dental pulp with development of soft tissue lesions which may result in pulpitis and gingivitis.

Differences in teeth lesions have been reported to be linked with the method used: it appears there is less teeth damage when using grinding compared to clipping (Table 49). Grinding always leads to a smooth surface (Hutter et al., 1993) and a low percentage of fractured teeth: 3% was reported by Hay et al., 2004. In contrast, clipping causes a ten times higher percentage of splintered teeth (Hutter et al., 1993; Hay et al., 2004).

Furthermore, opening of the dental pulp possibly leading to pulpitis can occur in both methods, but it was reported to be higher when clipping (48.2% with grinding vs. 91.7% with clipping; Hutter et al., 1993).

Lastly, splintered teeth can provoke gum lesions (Lewis et al., 2005b) and subsequently inflammation (gingivitis). The gingival inflammation was reported to be higher with clipping (20.4%) compared to grinding (2.7%) according to Hutter et al. (1993).

The practices of grinding and clipping cause also acute pain and long-term pain. Acute pain is associated with the short-term effect of the procedure of teeth reduction, while long-term pain is caused by subsequent inflammatory processes of the tissues involved. This is explained in the following.

Acute pain in piglets after tooth reduction was assessed looking at behavioural indicators of pain. Piglets with reduced teeth were more inactive after the procedure than those with intact teeth after a sham-procedure, which was suggested as an indicator of reduced welfare, and was interpreted as sickness behaviour (Lewis et al., 2005b). Champing (or chomping) behaviour was also considered an indicator of pain by e.g. Sinclair et al. (2019) and Lewis et al. (2005b). This behaviour is described as the repeated opening and closing of the jaws, with empty mouth. Following tooth reduction through teeth clipped piglets showed the highest percentage of teeth champing (in 80% of piglets) as compared to sham-processed piglets (45% of piglets), while piglets receiving grinding showed intermediate champing (60% of piglets) (Sinclair et al., 2019).

The effects of acute pain on physiological indicators were less consistent. For example, tooth reduction had no effects on plasma cortisol, ACTH nor glucose (Prunier et al., 2005; Marchant-Forde et al., 2009), however increased heart rate and decreased body surface temperature were found in piglets who received tooth reduction as compared to control groups which were handled without teeth reduction (Moya et al., 2006; Fu et al., 2019; Sinclair et al., 2019).

Long-term detrimental effects can be caused by the inflammation of the labial and palatine mucous membranes, pulpitis and gingivitis (Hutter et al., 1993; Lewis et al., 2005b). A study comparing grinding with clipping reported higher concentrations of proteins indicative of inflammatory processes in the latter group (i.e. teeth clipped piglets) almost 30 days following tooth reduction (Moya et al., 2006). Similarly, expression of *CXCL8* pro-inflammatory cytokine within the dental pulp indicated a prolonged inflammatory state (up to 6 weeks) in both methods. However, tooth grinding showed lower gene expression of *CXCL8* during the whole period, as compared to tooth clipping (330-fold change vs. 558-old change at 6 weeks).

Table 49: Overview of the specific welfare consequences and related ABMs comparing the effect of no tooth reduction (or sham treatment), grinding and clipping, considering acute and long-term effect

Welfare consequence	ABMs (units)	No Treatment (or 'Sham' if stated)	Grinding	Clipping	Reference
Handling stress	Escape attempt (Number of escape attempts/sec.)	0.68[a]	0.46[b]	0.49[b]	Marchant-Forde et al. (2009)
	Squeals (No/s)	0.57[a]	0.24[b]	0.40[ab]	Marchant-Forde et al. (2009)
Pain	Chomping (% of pigs)	45[a]	60[ab]	80[b]	Sinclair et al. (2018)
	Chomping (relative duration in s)	0[a]	0.7[ab]	1.95[b]	Lewis et al. (2005b)
Bone lesions – Impact on teeth	Teeth surface smooth (%) *(significance level not indicated)*		100	52.7	Hutter et al. (1993)
	Split/fractured Teeth (%) *(significance level not indicated)*		0	26.1	Hutter et al. (1993)
	Number of teeth at Day 6 (8 teeth per group): fractured teeth	0[a]	0[a]	4[b]	Hay et al. (2004)

Welfare consequence	ABMs (units)	No Treatment (or 'Sham' if stated)	Grinding	Clipping	Reference
Soft tissue lesions (and integument damage)	Open dental pulp (%)	0[a]	45[b]	NA	Hessling-Zeinen (2014)
	Open dental pulp (%)		41.7[a] (10.3[b] cup grinding)	NA	Ellert (2017)
	Number of teeth at Day 6 (8 teeth per group): opening of pulp cavity	0[a]	3[b]	4[b]	Hay et al. (2004)
	open dental pulp (% of teeth) (*significance level not indicated*)	0.8	65.8	85.8	Sinclair et al. (2018)
	Pulpitis (%) day 3		48.2[a]	91.7[b]	Hutter et al. (1993)
	Pulpitis (%) day 56 (*significance level not indicated*)		66.0	90.4	Hutter et al. (1993)
	Number of teeth at Day 6 (8 teeth per group): Haemorrhaging	0[a]	3[b]	4[b]	Hay et al. (2004)
	Number of teeth at Day 6 (8 teeth per group): Infiltration	0[a]	4[b]	4[b]	Hay et al. (2004)
	CXCL8 in the dental pulp after week 1 (fold change relative to Sham piglets) ($p < 0.001$)	Ref value (Sham)	333-fold increase	483-fold increase	Sinclair et al. (2018)
	Idem after week 6 ($p < 0.001$)	Ref value (Sham)	330-fold increase	558-fold increase	Sinclair et al. (2018)
	Gingivitis (%) Day 3	1.4[a]	2.7[a]	20.4[b]	Hutter et al. (1993)
	Gum lesions Day 1 (% of piglets with at least 1 gum lesion) $p < 0.05$	~ 0.02	~ 0.39	~ 0.34	Lewis et al. (2005b)
	Idem Day 4 $p < 0.05$	~ 0.01	~ 0.10	~ 0.28	Lewis et al. (2005b)
	Idem Day 27 $p < 0.05$	~ 0.02	~ 0.15	~ 0.33	Lewis et al. (2005b)
Prolonged hunger	Body weight gain from birth to day 14 (g/day) $p < 0.1$	250	201	239	Marchant-Forde et al. (2009)

a,b: Numbers with different superscript statistically differs ($p < 0.05$). If only overall treatment effects are known, this is stated in the ABM column.

6.1.2. Welfare consequences of leaving teeth intact

6.1.2.1. Effect on piglets

When tooth reduction is not performed, some welfare consequences can occur. The major welfare consequences are soft tissue lesion and integument damage, such as facial injuries in piglets due to competition for teats among the litter (Hutter et al., 1993; Baxter et al., 2013).

The effects of no tooth reduction on mortality and weight gain of piglets are not conclusive. In some studies, piglets with intact teeth performed better (Menegatti et al., 2018), the same (Marchant-Forde et al., 2009) or worse (Hutter et al., 1993) as compared to those with shortened teeth. When tooth clipping was performed selectively within litters, piglets with reduced teeth length performed worse, especially in large litters (Fraser and Thompson, 1991).

6.1.2.2. Effect on sows

Intact teeth have been also considered as causing teat and udder lesions in the sow. However, this link is not clear. While fewer teat/udder lesions were reported in litters with clipped teeth compared to intact teeth (Fu et al., 2019), other risk factors for udder/teat lesions not related to piglet's teeth, such as type of flooring, injurious slats, floor material and lack of bedding were reported. Udder lesions can also be caused by the sow's claws when she stands up (Edwards and Lightfoot, 1986). Those lesions could thus overestimate the damaging effect of teeth on sow's udder.

Concerning sow behaviour, more sows were observed dog sitting (a posture which limits piglets' access to udder) when teeth were left intact (Lewis et al., 2005c). In other studies, no effect on sow posture was observed, but increased avoidance behaviour was found (Fu et al., 2019). Sucking with intact teeth can provoke interruption of nursing bout by the sow (Holyoake et al., 2004; Hansson and Lundeheim, 2012).

6.1.2.3. Preventive and corrective measure to reduce the practice of tooth reduction

In Table 50, a list of risk factors from literature is reported by animal category involved: piglet, sow and piglet + sow. For each risk factor, preventive and corrective measures are provided.

Generally, a risk assessment exercise will help to identify individual litters that require tooth reduction. However, it is important that before carrying out the tooth reduction, preventive and corrective measures are considered. These measures can be implemented at the population level (i.e. breeding strategies) or at farm level.

At population level, the increased risk of teat/udder and facial lesions due to large litters (Baxter et al., 2013) can be addressed by breeding organisations to optimise litter size according to teat number of sows and uniformity of piglets within a litter (see also Section 5.7.18).

Changes of the husbandry system (moving towards free farrowing systems) may contribute to improving the situation (Lohmeier et al., 2019). In free-farrowing systems, sows are better able to avoid piglets which fight for milk. However, a fully effective escape from piglets is only possible in outdoor systems. Although this appears to facilitate intact teeth, care needs to be taken in outdoor systems to prevent excessive avoidance of the litter by the sow, especially during periods with hot temperatures.

At farm level, measures to reduce competition at the udder include targeted early cross-fostering, nurse sows, split suckling and extra feeding of milk to piglets. In a survey from Chou et al. (2020a; under review), the most common management measures applied by pig farmers were cross-fostering (49 respondents, 65.3%), nurse sows (49, 65.3%), split suckling (41, 54.7%) and milk supplementation (31, 41.3%). The use of piglet management strategies did not differ between farms where teeth reduction was applied or not.

According to Chou et al. (2020a; under review), farmers that did not perform teeth reduction reported 'large litters' as a top risk factor, while for those applying teeth reduction, the lack of this practice was reported to be the reason for injuries. This result suggests that the perceived need of teeth reduction is a key motivation for farmers to perform this mutilation. It can be argued that increased farmer awareness and understanding of the alternatives to tooth reduction, as well as training to do risk assessment are needed to address this issue.

Table 50: Risk factors of tooth reduction, preventive and corrective measures to reduce the need to perform tooth reduction, at the level of the sow, piglet or both

Category	Hazards/risk factors	Preventive measures	Corrective measures at farm/ litter level	Reference
Piglet	Large litter size	Change breeding strategy (less and more even piglets) Choose less prolific sows	• Split suckling • Supplying piglets in their home pen with artificial milk; • 'Targeted' early cross-fostering; • Use of nurse sows; • Early piglet feeding	Baxter et al. (2013) Kobek-Kjeldager et al. (2020a,b) Hutter et al., (1993) Hansson and Lundeheim (2012)

Category	Hazards/risk factors	Preventive measures	Corrective measures at farm/litter level	Reference
	Use of cross-fostering	Change breeding strategy (less and more even piglets) Choose less prolific sows	• Ensure correct timing and management of cross-fostering	Baxter et al. (2013)
Sow and piglet	Small size farrowing unit (crates/free farrowing pen)	Consider larger pens when constructing new farrowing accommodation	na	Lohmeier et al., (2019); Anna Valros, University of Helsinki, personal communication, 2021
Sow-related (adequate management)	Mastitis	Reduce risk factors (e.g. introduction of gilts into herd, feeding, pen hygiene and provide assistance around farrowing)	• Early recognition and treatment, but occurrence of mastitis cannot completely be prevented	Gerjets et al. (2011)
	Insufficient milk due to age/insufficient number of functional teats	Timely culling of older sows Monitoring of number of functional teats	• Split suckling • Supplying piglets in their home pen with artificial milk; • 'Targeted' early cross-fostering; • Use of nurse sows; • Early piglet feeding • cull sow after weaning	Baxter et al. (2013)
	Insufficient milk (due to other reasons)	Improve water supply Improve sow nutrition Improve climate control Breeding strategies	• Split suckling • Supplying piglets in their home pen with artificial milk; • 'Targeted' early cross-fostering; • Use of nurse sows; • Early piglet feeding • Alleviate heat stress • cull sow after weaning	Baxter et al. (2013)

6.1.3. Measures to mitigate the welfare consequences of tooth reduction

Tooth reduction may be needed in some circumstances. Measures to reduce the welfare consequences of tooth reduction include:

Grinding instead of clipping. When preventive measures have been ineffective (see above) and the procedure is considered necessary, grinding is recommended. However, because the incisor and the canine have different lengths, even a correctly applied procedure can lead to opening of the dental pulp of the longer tooth during grinding (Ellert et al., 2018). There is also evidence that prolonged grinding of one tooth (6 s rather than the normal 2–3 s) can lead to considerable heat development (Redaelli et al., 2011). Tooth clipping on the other hand is associated with an increased occurrence of tooth fractures, gingivitis, open pulp and pulpitis (see Section 6.1.2). These damages can cause long-term inflammation and pain, as indicated also by the higher expression *CXCL8* (Sinclair et al., 2018).

Therefore, properly carried out grinding should be preferred over clipping. If only the very sharp part of the teeth is removed the damage will be limited, and will not cause teeth fractures.

Alternative grinders methods were proposed in literature, e.g. with a 'teacup' formed grinder, which is applied on each tooth individually and resulted in less opened pulp cavities than the conventional grinder (10.3% compared to 41.7%), but double time was needed (Ellert et al., 2018).

Few pain mitigation strategies were tested in experiments (Sutherland, 2015). Based on a systematic literature review on the effect of pain mitigation strategies (Dzikamunhenga et al., 2014) it was concluded that no recommendations could be drawn due to the limited number of studies (O'Connor et al., 2014). However, in a few countries (e.g. Austria and Israel), analgesia (Meloxicam) is required by law (Pozzi and Alborali, 2016).

Training of farmers (e.g. regarding grinding procedure) is important, as a 'farm-effect' was found in a study looking at the prevalence of opened pulpa (Ellert et al., 2018).

6.1.4. Summary conclusions on tooth reduction

1) Tooth reduction is a stressful procedure that if performed incorrectly causes short- and long-term pain. In particular, clipping is inherently injurious.
2) Grinding to only blunt the sharp tip of the tooth does not injure sensitive tissue when correctly performed.
3) Risk mitigation measures to reduce the necessity for teeth reduction include sow management measures to promote optimal milk supply, and balancing the number of piglets with the number of teats.
4) In individual litter situations where tooth reduction can be justified, the most effective measure to prevent and mitigate welfare consequences is training of staff in correct procedures.
5) Although current legislation highlights teat damage as evidence to justify tooth reduction, facial damage to litter mates is a more related animal-based measure.

6.1.5. Recommendations on tooth reduction

1) Measures to prevent the need for tooth reduction should be implemented (Table 50).
2) Tooth reduction should only be done after a litter level risk assessment (Table 50).
3) Only well-trained staff judged to be competent should perform tooth reduction by correct grinding procedure that does not injure sensitive tissue.
4) Tooth clipping should not be used.

6.2. Castration

6.2.1. Introduction

A previous EFSA SO thoroughly discussed the topic of castration of piglets (EFSA, 2004). Additional considerations on welfare implications of castration were described in a technical Report submitted to EFSA (Spoolder et al., 2011a,b), as well as in final reports of three main European projects: EU Framework programme number 6 specific support action PIGCAS (Attitudes, practices and state of the art regarding piglet castration in Europe) in Fredriksen et al. (2009), ALCASDE (2009), and CASTRUM consortium (2016). This section considers the previous conclusions and recommendations from EFSA and updates them with the latest scientific evidence available.

Castration is a traditional practice in many countries and is still practiced in the majority of EU pig farms. It aims at reducing aggressive and sexual behaviour in adult male pigs and avoiding boar taint (an offensive odour resulting from androstenone, skatole and indol compounds) in pork and pork products. On farm, the procedure usually involves rapidly cutting the skin (using a scalpel) and the spermatic cords (using a scalpel or an instrument called 'emasculator' which cuts and squeezes the spermatic cord) without administration of anaesthesia nor analgesia in piglets under 7 days (here considered the 'surgical castration' method). Castration by tearing the spermatic chords, even if not allowed in Europe, is still being performed in some cases (Schmid et al., 2021).

In the current document, an updated review of the scientific literature is presented, with a focus on welfare consequences for piglets when surgically castrated. This is followed by a description of possible alternatives to surgical castration, description of the current surgical methods and measures to mitigate pain. Finally, conclusions and recommendations are given.

6.2.2. Welfare consequences of surgical piglet castration

Welfare consequences of piglet castration include soft tissue lesions and integument damage and handling stress, causing the overarching welfare consequences of pain and fear.

A recent scientific review on invasive procedures in piglets summarised the negative implications of this practice to piglet welfare, confirming that there is now neural (observed via brain electric activity), hormonal, metabolic and behavioural evidence of pain that can last well after the procedure (Prunier et al., 2021). There is an increasing number of studies demonstrating that the neural pain pathways in pigs and humans are very similar and that a strong homology between porcine and human nociceptive neuron exist (Prunier et al., 2021), suggesting that castration can result in severe pain to piglets. These results align with previous studies reporting pain in piglets during (Taylor and Weary, 2000; Taylor et al., 2001; Kluivers-Poodt et al., 2012; Viscardi and Turner, 2018) and after the castration procedure (Prunier et al., 2006; Kluivers-Poodt et al., 2007).

Given these negative implications on the welfare of piglets, there is a need for alternatives to surgical castration (Bonneau and Weiler, 2019). The alternatives to surgical castration fall into four main categories: avoiding castration by leaving the males entire, with adequate implementation of management strategies, application of immunocastration, surgical castration with anaesthetic and analgesic to mitigate pain and discomfort from castration. Sex sorting of semen to increase the number of female:male ratio is common in cattle but it is unlikely to become available for swine in the near future due to associated costs and technological difficulties (Fàbrega et al., 2021).

6.2.3. Keeping entire male pigs

Raising intact males has clear welfare benefits comparing to traditional surgical castration, however husbandry, genetics, feeding and management need to be adapted. On the other hand, entire males develop specific behaviours, such as aggressive interactions and mounting behaviour, when reaching sexual maturity (around 5–7 months, see Section 3.2.7.1). These can lead to skin lesions, penile injuries and lameness (Prunier et al., 2006; von Borell et al., 2009; Ebschke et al., 2014; Weiler et al., 2016). Furthermore, when sexually mature, intact male pigs tend to develop a specific 'boar taint', described as an unpleasant odour in fat and meat that decreases consumer acceptance of the products. The main compounds responsible for boar taint are androstenone, skatole and to a lesser extent indole (Claus et al., 1994; Annor-Frempong et al., 1997; Rius and García-Regueiro, 2001).

However, it should be noted that the chemical background to boar taint is not yet fully understood. The combinations of different breeds, housing, nutritional and management strategies cannot be predicted and there is no single solution to raise entire male pigs without boar taint.

Keeping intact male pigs requires rethinking the organisation of the entire pig production chain, so that boar taint is minimised in live animals and carcasses are sorted and used according to their boar taint level to avoid rejection by markets and consumers (Parois et al., 2018).

Boar taint can be reduced through the implementation of certain management practices when raising entire male pigs. This topic has been thoroughly discussed by Fábrega (2021), and the key points of this review are summarised below. The full list of scientific references supporting the key points described below can be found in Fàbrega (2021).

6.2.3.1. Nutritional strategies

Recent research concluded that certain dietary ingredients minimise bacterial degradation of tryptophan in the large intestine leading to reduced skatole production. The full list of dietary ingredients was provided by IPEMA COST action.[28]

Additional feeding strategies to reduce skatole include ensuring maximum feed intake by promoting ad libitum feeding, ensuring lysine requirements are met (Quiniou et al., 2010; Dunshea et al., 2013), and provision of sufficient feeding space. These practices will likely also have a positive impact on welfare (Backus et al., 2016). It has also been suggested that providing proper water supply may also reduce skatole production (Fàbrega, 2021). While further studies are needed to establish the optimal combinations of feedstuff, dosages and durations of feeding, nutritional strategies appear to be a promising option to ensure welfare of entire male pigs and at the same time to reduce boar taint.

[28] http://www.ca-ipema.eu/#:~:text=The%20aim%20of%20the%20COST,Immunocastration

6.2.3.2. Management strategies

Stress related hormones were suggested to affect androstenone, skatole and indole in earlier studies (Claus et al., 1994). Certain management practices may help reducing mounting and aggression and therefore reducing stress and boar taint on meat.

Group composition: Different options, such as keeping siblings together until slaughter (Fredriksen, 2006, 2008), single sex groups (Backus et al., 2016) or early socialisation of litters when piglets are still with their mother (Fàbrega et al., 2013; Rydhmer et al., 2013) have been suggested, but there is no sufficient evidence on the most effective strategy. Mixed sex groups can result in premature pregnancies when fattening pigs reach sexual maturity. However, there is also evidence that the presence of gilts delays the onset of puberty (Salmon and Edwards, 2006), suggesting that visual contact of male pigs with gilts might be beneficial.

Group size: Past research concluded that lower group size (15 pigs/pen) resulted in lower levels of boar taint and less skin lesions compared to a larger group (30 pigs per pen) (Wagenberg et al., 2013; Backus et al., 2016; Thomsen et al., 2016).

Environmental conditions (hygiene, floor type, light): While past studies mentioned hygiene condition and cleaning schedule as important influencing factor for increased skatole levels (e.g. Hansen et al., 1995), recent evidence indicated very limited or no penetration of skatole through the skin (Bekaert et al., 2012; Wesoly, 2016), and therefore, the influence of environmental conditions remain unclear.

Enrichment: Providing an enriched environment, especially straw or forages has a great potential to reduce agonistic interactions (Holinger et al., 2015) and skin lesions in entire male pigs (Prunier et al., (2013). However, Prunier et al. (2013) found no effect of provision of straw on the development of boar taint.

6.2.3.3. Pre-slaughter conditions

Pre-slaughter conditions include the weight and age at slaughter and transport conditions.

The most effective method enabling to keep entire male pigs with absence, or limited, boar taint, is to slaughter them before reaching sexual maturity. However, commonly the weight, rather than the age, is the cut-off for slaughter (105–110 kg in Spain, 115 kg in Denmark, Belgium). Furthermore, for the heavy weight market, pigs are normally slaughtered at around 170 kg live weight (~ 9 months of age) (Vitali et al., 2021).

Transport and lairage conditions often result in mixing unfamiliar animals, which was shown to increase mounting behaviour and higher levels of aggression and skin lesions (Rydhmer et al., 2013; Van Staaveren et al., 2015). Longer duration of transport and pre-unloading times has been linked with increased androstenone and skatole levels (Wesoly et al., 2015), but increased time spent in lairage was not consistently associated with increased boar taint, despite increased skin lesions suggesting increased aggression and stress levels (Heyrman et al., 2018).

6.2.3.4. Genetics

Breed affects the levels of boar taint, with Duroc having the highest levels of androstenone (Oskam et al., 2010), followed by the maternal lines Landrace and Yorkshire and the least in the paternal line Pietrain, which is the most lean (Mathur et al., 2012). As the development of boar taint has a high heritability, developing breeding strategies within breeds is a promising option (Baes et al., 2013; Parois et al., 2015). To include such traits into breeding programmes, reliable detection methods at the slaughter line are required (for a review on this, please refer to the BoarCheck final report (Haugen et al., 2014). They include instruments (not commercially available so far) as well as sensory methods ('human nose') for an analytical determination of androstenone, skatole and indole. While breeding companies were initially reluctant to include boar taint as a selection criterion, due to some uncertainties regarding fertility traits and meat quality traits, there is increasing knowledge and willingness to implement this method (Fábrega, 2021).

6.2.4. Immunocastration

To benefit from the advantages regarding increased feed efficiency of entire male pigs, and to avoid the disadvantages of keeping entire males (mounting, development of boar taint), immunocastration can be performed. Immunocastration is an active immunisation (vaccination) against the Gonadotropin Releasing Hormone, which is a key hormone of the endocrine cascade regulating the reproductive function. This method postpones the onset of puberty for at least 10 weeks (Thompson,

2000) which resumes thereafter (Einarson et al., 2009). Two subcutaneous vaccinations at the base of the ear with 4 weeks interval are required using a special vaccinator designed to prevent accidental self-injection. A study reported that after the second vaccination, behaviour and growth performance of immunocastrated pigs became similar to that of surgically castrated animals (Pinna et al., 2015). A meta-analysis of 78 studies showed that, over the whole fattening period, immunocastrated animals have higher daily weight gains and leaner meat than boars and barrows (Nautrup et al., 2018). Immunocastration may also be considered a viable alternative to surgical castration in pigs that are raised for a longer period than usual (> 6 months) and reaching a heavy weight ('heavy pigs'). These pigs cannot be left entire because the boar taint will impact the quality of the meat and meat derived products (e.g. seasoned products such as Italian Protected Designation of Origin -PDO- ham). From a practical standpoint, heavy pigs raised for 9 months would require an additional dose of vaccine compared to lighter animals (3 vs. 2 doses, with the last administration at 36–37 weeks of age) (Pinna et al., 2015; Vitali et al., 2021a).

From a welfare point of view, immunocastration has advantages compared to keeping entire male pigs. Sexual behaviour including mounting is commonly only developing with a later age and is decreased with the second vaccination to the level of castrated pigs (Fabrega et al., 2010; Puls et al., 2017). This calmer behaviour leads to less mounting, reduced number of skin lesions, penile injuries, and less lameness and skeletal problems (e.g. Reiter et al., 2017; Kress et al, 2018). Disadvantages are related to the (at least) two injections required, and the associated handling stress and risk for incidences where the vaccine is incorrectly administered and causes abscessation (von Borell et al., 2020). However, there are studies reporting absence of tissue damage from injections (Dunshea et al., 2001).

6.2.5. Surgical castration

6.2.5.1. Tools for castration

Castration is frequently performed by cutting the spermatic cords (Fredriksen et al., 2009) which can be performed using either a scalpel, an emasculator or scissors (Schmid et al. 2022). While previous studies have observed no differences between tearing or cutting on the level of vocalisation (Tylor and Weary, 2000; Marchant-Forde et al., 2009), a recent study (Schmid et al., 2021) reported significant differences between cutting and tearing, indicating severe pain (measured in terms of vocalisation and body movement during the procedure) and increased tissue damage in piglets castrated with tearing. Tearing may also result in additional damage of intra-abdominal tissues and vessels (Schmid et al., 2021). The effects of emasculators compared to scalpels are so far not further investigated, however it can be assumed, that bleeding is decreased with additional squeezing, when an emasculator is used.

6.2.5.2. Effect of age

While castration is often carried out at a very early age, there is little new evidence on the relationship between age and pain experienced by the piglet. Most of the studies on this topic date from the 90s and early 2000s, with EFSA concluding in 2004 (EFSA, 2004) that castration is painful at all ages with no clear evidence existing of lower pain in piglets younger than 1 week of age. A later study found that piglets castrated at 3 days stood more in the first hours after castration than those who were castrated as older piglets, while no effects were observed regarding time spent nursing, lying, standing or sitting (Carroll et al., 2006). While previous studies noted increased vocalisations in older piglets compared to younger animals during castration (Geetha et al., 2008), a further review study hypothesised that the influence of age on calls at castration could be mainly attributable to an increase in vocal capacity in older piglets (Prunier et al., 2006). To conclude, no evidence exists that castration at a younger age is less painful than if implemented at a later stage. It has to be noted, that castrating at an older age leads to larger wounds and prolonged healing times.

6.2.5.3. Pain mitigation

When the adoption of alternatives to castration is not feasible, surgical castration may still need to be carried out. While it is known that the welfare consequences resulting from surgical castration can be mitigated by the use of analgesia and anaesthesia, a survey in Europe reported that only a small percentage of piglets was castrated under the effect of such drugs. It was estimated that only 5% of piglets received analgesia and anaesthesia and ~ 40% received analgesia (alone) in 18 countries during castration. Meloxicam, ketoprofen and flunixin were the most frequently reported drugs for analgesia, and procaine the most frequent local anaesthetic, and the sedative azaperone was also often mentioned despite not having analgesic properties (De Bryne et al., 2016). Data from countries consistently providing analgesia and or anaesthesia to piglets (such as Norway, Switzerland, The Netherlands or Sweden) indicated that, in contrast to countries where the use of such drugs is not mandatory, farmers tend to perceive the use of such pharmaceuticals as feasible and effective. The fact that a producer is allowed to administer anaesthesia and analgesia appears to facilitate the routine use of such products on a routine basis for piglet castration (DeBryne et al., 2016).

In this context, results of recent animal welfare research on the effectiveness of used analgesic and anaesthetic substances to alleviate pain in piglets were reviewed and are discussed below. For the definitions of anaesthesia and analgesia used, please refer to Section 3.1 of the CASTRUM report on pig castration (CASTRUM Consortium, 2016).

a) *Drugs for analgesia*

Analgesia is primarily used for post castration pain mitigation but has also been demonstrated to improve the effect of anaesthesia when given before the surgical procedure (CASTRUM Consortium, 2006). Most common analgesics in pig production are non-steroidal anti-inflammatory drugs (NSAIDs).

NSAIDS (e.g. meloxicam, ketoprofen)

NSAIDs, such as meloxicam and ketoprofen, are the most common analgesic drugs provided to farm animals and are often recommended to alleviate pain in piglets following surgical castration (Viscardi et al., 2019). A study from 2009 suggested an analgesic effect of these substances during castration, based on the absence of an increase in cortisol levels during the surgical procedure (von Borell et al., 2009). However, NSAIDs did not effectively alleviate pain (assessed via frequency of trembling, spasms, scratching, tail wagging, stiffness and via facial grimacing) in 120 surgically castrated piglets under either a standard dose (0.4 mg/kg) of **meloxicam**, a high dose (1.0 mg/kg) of meloxicam, or 6.0 mg/kg of **ketoprofen** in a more recent study (Viscardi et al., 2019). The authors hypothesised that the mechanism of NSAIDS to suppress pro-inflammatory prostaglandin, may be insufficient to suppress pain when tissue is damaged to a large degree.

In summary, while analgesic drugs have a positive effect on the relief of stress and post-operative pain associated with castration, the effect is temporary. Keita et al. (2010) suggested that a single preoperative intra-muscular injection of meloxicam (at a dose of 0.4 mg/kg) has worn off within 24 h. Therefore, to be effective, the administration will have to be repeated as post-operative pain continues for several days. This requires additional handling and treatment for which at present no validated protocols exist.

Drugs for local anaesthesia

Lidocaine and mepivacaine

Local anaesthetics can be more effective in suppressing pain compared to NSAIDs but only a few studies investigated their effect in surgically castrated pigs.

The efficacy of four local anaesthetics in piglets undergoing surgical castration was recently reported. Twelve piglets were allocated to each of six groups (procaine, lidocaine, bupivacaine, mepivacaine, or one of two control groups (saline, or 'handled' only) and defensive behaviour intensity and duration were scored during the three stages of the castration procedure (injection, skin incision and severing of the spermatic cord) to assess effectiveness of the drugs in mitigating pain. The authors concluded that the local anaesthetics **lidocaine** and **mepivacaine** achieved considerable pain relief during skin incision and during severing of the spermatic cord in conscious piglets (Abendschön et al., 2020) but procaine and bupivacaine were only effective during the severing of the spermatic cord. This study presents, however, limitations, such as a small sample size and the use of piglets of different weights and ages.

These findings are in line with a previous experimental study comparing the effect of five different treatments (castration without anaesthesia or analgesia; castration after local anaesthesia with lidocaine, castration after administration of meloxicam; castration after lidocaine and meloxicam and sham castration, with 32 piglets in each treatment) on plasma glucose, vocalisations, creatine kinase, mortality and piglet growth. It was concluded that lidocaine resulted in a significantly smaller increase in plasma cortisol and vocalisations compared to the other treatments (Kluivers-Poodt et al., 2012).

In summary, while local anaesthetics may be effective in reducing intra-operative pain, they provide minimal peri-operative analgesia (Viscardi et al., 2018) and may have to be combined with other analgesic drugs to achieve post-operative pain relief. In addition, the administration itself (often intra-testicular) is likely to cause pain (Viscardi et al., 2018).

b) *Drugs for general anaesthesia (injectable and inhalable)*

Injectable – Opioids (e.g. butorphanol and buprenorphine)

Opioids, such as butorphanol and buprenorphine, are more potent than NSAIDs and local anaesthetics. **Butorphanol** (0.2 mg/kg) use as single molecule to sedate piglets for castration was not considered safe in a small pilot study due to its very strong sedative and emetic effects, causing piglets to become 'groggy and unable to stand or walk' and hence being at heightened risk of being crushed by the sow (Viscardi et al., 2018). In contrast, **buprenorphine** (0.04 mg/kg) was considered safe; further tests involving 60 piglets showed that the drug significantly decreased pain behaviours and facial grimacing for up to 24 h post-procedure. However, buprenorphine did not reduce vocalisations at the time of castration (Viscardi et al., 2018).

While opioids offer more potent analgesic effects than NSAIDs and local anaesthetics, their use as single drug in piglets was either not considered safe or was not fully effective in preventing pain during castration. An additional drawback of opioids is that they present difficulties in terms of controlled on-farm distribution and use.

Injectable – Ketamine and azaperone

Lahrmann et al. (2006) concluded that the combination of ketamine (a general anaesthetic) and azaperone (a sedative with non-analgesic properties) was effective in anesthetising piglets for castration, but special measures had to be implemented to prevent piglets to become hypothermic and from being crushed by the sow (Lahrmann et al., 2005). The effectiveness of intra-muscular ketamine was confirmed in a later study (Becker et al., 2021).

Inhalable – Carbon dioxide (CO_2) and CO_2 mixtures

There are only a few studies investigating the use of carbon dioxide (CO_2) (as single substance) for piglet castration. The duration and depth of anaesthesia with a gas mixture of 70% CO_2/30% O_2 during surgical castration was tested in 25 piglets and evaluated through electroencephalogram (EEG) and electrocardiogram (ECG) measurements, blood gas values and behavioural responses (Gerritzen et al., 2008). Piglets showed heavy breathing during the induction phase and lost consciousness 30 s after exposure. Two out of five piglets died when exposed to the mixture for 3 min. It was concluded that it is possible to use CO_2 to anaesthetise piglets, but limitation of exposure duration is very important (Gerritzen et al., 2008).

The effectiveness of using CO_2 in combination with a NSAID to mitigate pain resulting from surgical castration was also evaluated in a study involving 70 3-day-old piglets through monitoring of behaviour and cortisol levels 30, 60, 120, 180 min, 24 h and 3 days after castration. Neither CO_2 anaesthesia nor a NSAID, administered in combination or separately, were effective in reducing castration pain-induced distress (Sutherland et al., 2012). While the recovery time from CO_2 administration was short compared to isoflurane, piglets' aversion to CO_2 and resulting distress was also seen as a disadvantage of using this substance (Sutherland et al., 2012).

In summary, CO_2 is not the best anaesthetic drug to castrate piglets, and in addition, its use seems to be associated with distress at the time of administration. The aversive effect on the animal and the limited safety margin eventually led the veterinary associations to oppose to the use of this substance for the purpose of general anaesthesia (CASTRUM Consortium, 2016).

Inhalable – Isoflurane

Walker et al. (2004) compared the efficacy of anaesthesia with isoflurane alone and isoflurane and NO_2 gas during skin incision and dissection of the spermatic cord. It was concluded that both options are a safe and effective method for anaesthesia of piglets. The palpebral reflex disappeared significantly faster in the isoflurane/N_2O group compared to isoflurane used alone, but recovery time was equally fast in both groups.

Isoflurane is often combined with analgesic drugs to ensure an appropriate pain relief during castration. Hug et al. (2018) compared the analgesic effect of butorphanol, meloxicam and intratesticular lidocaine for castration of piglets under isoflurane anaesthesia by evaluating heart rate, respiratory rate, mean arterial blood pressure and end-tidal carbon dioxide. Butorphanol showed strong side effects and was not further evaluated and meloxicam had a weaker analgetic power compared to lidocaine (Hug et al., 2018).

In Switzerland, the use of anaesthesia to castrate piglets is mandatory since 2010 and isoflurane is often used. However, a study looking at farmer experiences in this country concluded that there are still drawbacks in the practical implementation of inhalation anaesthesia with isoflurane: 14% of the piglets (from 100 farms visited) were not sufficiently anesthetised and 22% of the farmers reported dizziness or headache after the procedure (Enz et al., 2013).

In summary, none of the drug options used alone are fully effective, and to achieve adequate pain relief a combination of analgesia and anaesthesia is needed. These conclusions align with the outcomes of a systematic review looking at pain management studies and that reported that there is weak evidence in favour of the use of NSAIDS as analgesic drug, that there is weak evidence against the use of local anaesthetic, and strong evidence against the use of a CO_2/O_2 general anaesthesia mixture for neonatal piglets (O'Connor et al., 2014). Generally speaking, financial costs, higher workload, the lack of practical protocols are still barriers for a widespread use of drugs during piglet castration, although these considerations are not in the remit of EFSA.

6.2.6. Review of previous EFSA Conclusions and Recommendations on castration

Previous EFSA conclusions on castration from EFSA (2004) were reviewed (Table 51) and an indication on whether the EFSA experts re-endorse the conclusion (yes/no) was provided. When new scientific evidence was available to modify the conclusions, a note in the last column of the table was added.

Table 51: Assessment of conclusions and recommendations from a previous EFSA opinion on castration (EFSA, 2004)

Topic	Conclusions/recommendations from EFSA, 2004	Does EFSA AHAW Panel still agree with these conclusion/recommendations?	If EFSA AHAW Panel does not agree with the conclusion, what is the new evidence?
Welfare consequences from surgical castration	*'Castration is painful, regardless of the surgical procedure. Physiological and behavioural reactions indicative of pain are numerous during the process and in the first hours following surgery but decrease thereafter. Some behavioural alterations persist for several days, indicating that animals suffer from long-term pain'.*	Yes	
Anaesthesia	*'There are a limited number of anaesthetics specifically licensed in EU for pigs.'*	Yes	
	'The use of local anaesthesia offers the best practical prospects for pain alleviation in piglets.'	No	While local anaesthesia is more practical to be applied on farm, general anaesthesia offers better prospects for pain alleviation in piglets (CASTRUM Consortium, 2016).
	'Local injection of lidocaine into the testis and/or in the spermatic cord with or without subcutaneous injection is effective in reducing acute pain induced by castration.'	No	Studies indicate that local anaesthesia is not fully effective in reducing intra and peri-operative pain (CASTRUM Consortium, 2016) Additionally, there is evidence that intratesticular injection can cause pain (Viscardi et al., 2018).

Topic	Conclusions/recommendations from EFSA, 2004	Does EFSA AHAW Panel still agree with these conclusion/ recommendations?	If EFSA AHAW Panel does not agree with the conclusion, what is the new evidence?
	'General anaesthesia has numerous drawbacks: cost, time consuming, problems of safety for animals and people'	Yes	
	'There is no validated protocol for use of long-lasting analgesics which could be applied in commercial herds for reducing mid and long-term pain due to castration.'	Yes	There is no validated protocol for use of long-lasting analgesics. However, drugs are available for pain relief but there are still practical challenges such as the follow-up treatment post-operation (Keita et al, 2010) (see Section 6.2.5.3).
	'Surgical castration should be carried out using sufficiently long-acting analgesia provided that it is demonstrated that the benefits for welfare of using these are greater than any adverse effects on welfare.'	Yes	
	'The tearing of tissue when the testes are removed should be avoided unless prolonged analgesia is possible.'	No	The tearing of tissue when the testes are removed should be avoided even when prolonged analgesia is possible, because severe pain (vocalisation and body movement during the procedure) and increased tissue damage occur as compared to cutting (Schmid et al., 2021).
Husbandry practices – keeping entire male pigs	*'While slaughtering at lower live weights may reduce the chances of carcases having boar taint the practice cannot be one hundred per cent successful.'*	Yes	
Immunocastration	*'The advantages of the growth properties of entire males and the reduction in boar taint in carcases may be achieved by using immunocastration during the fattening period.'*	Yes	

6.2.7. Summary conclusions on castration

1) Surgical castration without anaesthesia is painful at any age and has short and medium-term negative welfare consequences including soft tissue lesions and integument damage, handling stress, fear, and pain.
2) The alternatives to traditional surgical castration fall into three main categories: avoiding castration by leaving the males entire with adequate implementation of management strategies, application of immunocastration, or surgical castration with anaesthetic and analgesic to mitigate pain resulting from the procedure.
3) Keeping entire male pigs is considered a valuable solution if the drawbacks in terms of aggressiveness and mounting behaviour, leading to welfare consequences for pen mates, are addressed.

4) Management practices are available to reduce the welfare consequences of surgical castration and at the same time to reduce boar taint when keeping entire male pigs (see Section 6.2.3). Slaughtering pigs before sexual maturity (5–7 months) is the most effective method to prevent those consequences; however, this is not possible for pigs slaughtered at a heavy end-weight (around 9 months of age).
5) From a welfare point of view, immunocastration has advantages compared to keeping entire male pigs due to less mounting behaviour, reduced number of skin lesions, penile injuries, and fewer locomotory disorders. In general, two doses of the vaccine are needed, but three doses may be needed in pigs reared for a longer period.
6) If the alternatives listed above are not feasible and surgical castration needs to be applied, it should always be carried out with administration of anaesthesia and analgesia. None of the molecules available are fully effective for pain relief when used alone, and to achieve adequate pain relief, a combination of analgesics and anaesthetics is needed.
7) Human and animal safety, the lack of validated protocols, the scarcity of drugs registered in the EU, financial costs and higher workload, are still barriers for a widespread use of drugs for anaesthesia and analgesia during piglet castration, thus preventing pain relief.

6.2.8. Recommendations on castration

1) Surgical castration without anaesthesia and analgesia should not be performed due to the severe consequences to the welfare of piglets.
2) In the case that surgical castration is performed, practical and effective methods and training of operators on the use of pain relief (anaesthesia and analgesia) during and after castration should be developed.
3) Under current commercial conditions, immunocastration should be adopted as the preferred alternative to surgical castration. Keeping animals entire should be considered as the next best alternative.
4) Further research should focus on the refinement of management practices, such as nutritional and breeding strategies, for decreasing the likelihood of boar taint in carcasses, reducing the welfare consequences and, by this, phasing out surgical castration.

6.3. Tail docking

6.3.1. Introduction

In this SO, 'tail docking' refers to 'amputating a portion of the tail' carried out by farm operators (Sutherland et al., 2011). In contrast, damage to the tail by 'tail biting' is provoked by other pigs. In both cases, shortening of the tail leads to damage of the skin, muscles, bones, cartilages, blood vessels and nervous tissues (Valros et al., 2020).

Tail docking is widely performed to reduce tail biting lesions in pigs raised under intensive conditions (De Briyne et al., 2018). However, while many evidence suggested that tail docking reduces the risk of tail biting lesions, other studies indicate this will not eliminate tail lesion totally (D'Eath et al., 2016; Lahrmann et al., 2017; Thodberg et al., 2018, reviewed by Prunier et al., 2020b). Tail docking causes acute and medium-term pain in the pigs (see Section 6.3.2). Routine tail docking is therefore a systematic source of pain that affects all the reared pigs (Valros and Heinonen, 2015). To reduce the need for tail docking, tail biting should be prevented through risk assessment and implementation of preventive and corrective measures (vom Brocke et al., 2019). Examples of risk assessment protocols are referred to in the review of Dippel et al. (in press). Risk factors for tail biting were reviewed by EFSA (2007c) and some are discussed in more detail in Section 7.7.

In the current document, an updated review of the scientific literature is presented, with a focus on welfare consequence for piglets when docked. This is followed by a description of tail docking procedures, providing details on the effect of different tail docking methods (instruments, tail length) age of piglets and tail length. Mitigation measures to reduce the welfare consequence are also considered. Finally, conclusions and recommendations are given.

6.3.2. Welfare consequences of tail docking

Welfare consequences due to tail docking occur during three stages: during the tail docking itself, directly afterwards and in the medium/long-term.

Welfare consequences of tail-docking in piglets will include soft tissue lesions and integument damage, bone lesion and handling stress, causing the overarching welfare consequences of pain and fear.

The cause of pain is the damage of the peripheral nerves of the tail tip as indicated by the presence of A-delta and C-fibre sensory neurons, already in 1- to 3-day-old piglets (Carr et al., 2015; Simonsen et al., 1991).

During tail docking, which lasts only a few seconds, welfare consequences of pain and fear were identified due to a combination of handling and interactions with humans, and the procedure of docking. ABMs such as the number and rate of high pitched vocalisations and defence movements during the procedures, were more intense in docked piglets compared to 'sham docked' ones (i.e. piglets handled as the actually docked group, but without cutting the tail) (Herskin et al., 2016). Also tail movement was higher in tail-docked pigs (De Giminiani et al., 2017a,b).

Straight after docking, more piglets were observed lying in the creep area (Tallet et al., 2019), and had their tail pressed against the body (Prunier et al., 2001).

Two weeks after being docked, fearfulness of humans was increased compared to sham docked pigs, and reaction to tail touching was still evident up to 4 weeks after the procedure (Tallet et al., 2019).

The effect of tail docking on long-term pain is still unclear. Long-term hypersensitivity was not found in Sandercock et al. (2011) at 4–5 weeks after the tail docking, and thus it was hypothesised that the effect lasts until wound healing is resolved. Conversely, De Giminiani et al. (2017b) observed hypersensitivity in tail-resected pigs at either 2 or 4 months following surgery. This study was conducted on pigs resected at 9–17 week of age, and therefore, the age of the pig can explain the results differing from neonatal tail docking. A transcriptomic study from Sanderkock et al. (2019) showed the differential expression of about 3,000 genes in piglets 16 weeks after tail docking. Those genes were related to inflammatory and neuropathic pain pathways, leading to the assumption of a hypersensitivity in the distal stump in the long-term after the procedure.

As another long-term consequence, spinal abscesses and arthritis due to unhygienic conditions during tail docking have been hypothesised (Valros and Heinonen, 2015).

6.3.3. Consideration before carrying out tail docking

The overall aim is to minimise pigs' pain and other welfare consequences, caused by tail biting and tail docking. Therefore, when critically questioning/examining the need for tail docking, the welfare consequences due to tail biting in some animals should be weighed against those caused by docking all animals, within a 'cost-benefit model' (Valros and Heinonen, 2015). For example, it was suggested by D'Eath et al. (2015) that the prevalence of tail biting is unacceptable when the sum of pain caused by tail biting in undocked pigs is larger than that of docked pigs.

However, the quantification of the pain between tail docking and tail biting is difficult to address scientifically but can only be estimated and ethically discussed (Valros and Heinonen, 2015).

Tail biting can occur in any husbandry system and the goal should be to rear all pigs with intact tails (normal length and without injuries). Therefore, risk assessment and the consequential implementation of improvement measures are key. However, if competent authorities make an exception and allow tail docking, the procedure to carry out it is described in the next sections.

6.3.4. Description of the procedure of tail docking

6.3.4.1. Age at which docking is performed

Tail docking is generally performed in the first 7 days of life, without the use of anaesthesia and analgesia. When docking in the first days of life, the growth of the tail (e.g. of the bone, cartilage, and soft tissues) is in a stage of early development (Ellenberger and Baum, 1943). It can be hypothesised that docking at this age leads to less damage of the tail tissues compared to docking at an older age. However, there is little scientific evidence that the age of the piglets influences pain perception. There was one study reporting that tail docking was less painful when performed in 2-day-old piglets compared 20-day-old, based on nociceptive indicators measured via electroencephalogram (EEG) (Kells et al., 2017). However, other indicators such as vocalisations did not support an effect of age (Courboulay et al., 2015).

6.3.4.2. Tools for tail docking

Tail docking is carried out traditionally either by manual clipping (performed using side-cutting pliers, called 'clippers', scalpels, scissors, or wire cutters), also called 'non-cautery methods' or 'cold methods', or by hot iron cauterisation ('cautery method' or 'hot methods'). Data on the prevalence of these practices are missing.

As discussed above, both methods cause significant pain to the pigs (De Giminiani et al., 2017b). There is evidence that cold methods (e.g. cold iron, scissors, scalpels) are associated with more acute pain compared to hot methods, based on indices of nociception such as changes in the EEG median frequency (F50) and 95% spectral edge frequency (F95) (Kells, 2017a). In support of this, De Giminiani et al. (2017a) reported an increased level of vocalisations in cold methods as compared to hot methods. Marchant-Forde et al. (2014) also concluded that cautery is better than clipping. The number of neuromas[29] as a long-term consequence of tail docking was also reduced in hot methods compared to scissors (Herskin, 2014), probably influencing the occurrence of long-term pain. However, both methods did not completely prevent the development of neuromas (Kells et al., 2017b).

6.3.4.3. Length of the tail

Independently from the method used, the length of the tail after tail docking can vary. Prunier et al. (2020a) reports a variation ranging from docking only the tip to ¾ of the tail, or even at level of the first coccygeal vertebras. There is some evidence that docking length affects the frequency of tail biting outbreaks with short tails reducing the risk compared to medium length and intact tails (Scollo et al., 2015; Thodberg et al., 2018). However, there is no consistency among studies on the correlation between tail length and pain. Nerves are present all the way in the tail tip, as documented by histological analysis from Simonsen et al. (1991), which suggests that pain is present when docking at any length. But Herskin et al. (2016) suggest the pain related to tail docking is higher in piglets when docked short as compared to long docked group. This was measured as the number of pigs screaming during docking and the number of pigs laying down 5 h after the procedure. Furthermore, as the tail gets thinner towards the tip, the more tail is removed, the more damage to soft tissue and bone is caused. This also has implications in terms of size of wound, wound healing, and risk of infections (Ellenberger and Baum, 1943).

Finally, no differences were observed regarding defence movements and attempts to escape, nor formation of neuromas depending on docking length (Herskin et al., 2015, 2016). From a hygiene perspective, keeping the tail sufficiently long to cover the anal–genital area is preferable as it prevents direct contact with the environment and other pigs and therefore reduced exposure of the anogenital tract to infectious agents and injuries (Sandercock et al., 2022 (in press)). However, only, an intact tail can fulfil its function as a response to skin irritation and flies (Kiley-Worthington, 1976) and for communication (Camerlink and Ursinus, 2020).

6.3.5. Mitigation of pain and prevention of infection during and after tail docking

To minimise welfare concerns, mitigation of pain and prevention of infections are important during and after tail-docking (Sutherland, 2015).

However, few studies have investigated the effectiveness of specific pain relief protocols. Among them, two studies showed no effect (Sutherland, 2011; Courboulay et al., 2015) and another reported the decrease of behavioural responses in piglets during docking, when treated with subcutaneous injection of lidocaine, but no reduction of post-procedural pain (Herskin, 2016). The use of meloxicam reduced standing with head lowered in the first hour after docking, independently of the method used, but did not mitigate the behavioural response during tail docking (Morrison and Hemsworth, 2020). An increase in handling time with the commercial application of meloxicam was also reported (Morrison and Hemsworth, 2020).

A recent study showed that an intramuscular injection of the opioid buprenorphine alone or in combination with meloxicam prior to the surgery, resulted in reduction of grimace score indicating reduced pain after docking (Viscardi and Turner, 2019, reviewed by Prunier et al., 2021). Another study using topical cream with lidocaine and prilocaine reported pain reduction (measured through EEG) following the procedure with cold docking compared to no cream (Kells et al., 2017). However, piglets tail docked with the cold method with topical cream reported similar results in EEG as piglets tail-docked using cauterisation (and no cream), but higher handling stress due to the time required for the application (Kells et al., 2017b).

[29] Neuromas have been linked with increased nociceptive sensitivity and abnormal spontaneous nervous activity in piglets and non-evoked pain (i.e., non-stimulus-dependent) in other species (Herskin et al., 2014).

General anaesthesia to reduce pain during tail docking is not feasible on a routine basis on farm. A combination of anaesthesia for castration and tail docking has been suggested, but would only cover 50% of the population (the males). Moreover, in some farms castration may be performed after tail docking, and thus require later tail docking with slightly older piglets.

Prevention of infection should be carried out by adequate hygiene and disinfection of the instrument and the tail, in order to avoid subsequent abscesses or arthritis (Valros and Heinonen, 2015). With this purpose, the use of a wound spray with povidone iodine and lidocaine has been shown to reduce behaviour associated with pain and bleeding, and to improve healing, while doing nothing at processing might increase the rate of infections and abscesses and slow the healing process (Strobel and Hawkins, 2012, reviewed by Nannoni et al., 2014).

6.3.6. Summary conclusions on tail docking

1) Whilst tail docking is effective in reducing the risk of tail lesions, it is not necessary if husbandry practices and management are appropriate.
2) Tail docking is painful, with short and medium-term negative welfare consequences including soft tissue lesions and integument damage, bone lesions (including fractures of the spinal vertebrae), handling stress, fear and pain.
3) In the cases where tail docking is allowed, the following aspects need to be considered:

   a) Although docking is painful for piglets of all ages, the amount of soft tissue, bone and nervous tissues damaged by tail docking increases with age.
   b) Cautery and non-cautery methods are both painful; however, the balance of evidence indicates less pain with cautery methods.
   c) Docking is painful regardless of the length of tail removed, however, (1) docking the tail close to the first coccygeal vertebras has larger impact on soft tissue, bone, and nervous tissues, and (2) cutting only the tip of the tail is less effective in preventing biting lesions.
   d) Since tail docking causes pain during and after the procedure, pain mitigation is necessary. However, there is currently no agreed protocol available and effective for this purpose.

6.3.7. Recommendations on tail docking

1) Tail docking should not be performed.
2) Tail biting should be prevented by applying preventive measures that are farm-specific after a risk assessment analysis for which tools currently exist (see Section 7.7).
3) In the cases where tail docking is allowed:

   a) The procedure should be done as early as possible.
   b) A cautery method should be used.
   c) Practical and effective methods of pain relief during and after tail docking is performed, should be developed.
   d) Adequate hygiene measures during the whole procedure should be carried out to prevent the risk of infection.

7. Assessment of the welfare of weaners and rearing pigs

The welfare of weaners and rearing pigs is further explored in this chapter.

The welfare consequences that were identified as highly relevant for weaners and the ones for rearing pigs are listed in Sections 7.1 and 7.4, respectively. In these sections, for each welfare consequence, the reasoning for its high relevance, the hazards that may lead to it and corresponding preventive, corrective and mitigation measures are described. General descriptions of these welfare consequences in pigs, with supporting references and the related ABMs are reported in Section 3.4. Other welfare consequences may negatively affect the welfare of weaners and the welfare of rearing pigs, but they were classified as of less or moderate relevance compared to the highly relevant ones. An overview of the expert judgement on the welfare consequences that may affect the welfare of the diverse pig categories is presented in Appendix B.

The husbandry **systems for weaners** that have been fully assessed in the General ToRs, are indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems. These systems are described in Section 3.3.5.

For weaners kept in indoor group housing and in indoor systems with access to an outdoor area, the same highly relevant welfare consequences were identified; however, the magnitude of the welfare consequences that the animals experience may be different in the two systems, as the access to an outdoor area gives the potential for greater space and environmental complexity. Section 7.2 presents the link between the highly relevant welfare consequences, ABMs, hazards, and preventive, corrective and mitigation measures in the three systems. A comparison among the husbandry systems in terms of welfare of weaners is provided in Section 7.3.

The husbandry **systems for rearing pigs** that have been fully assessed, are indoor group housing, indoor systems with access to an outdoor area and outdoor paddocks. These systems are described in Section 3.3.6.

Highly relevant welfare consequences were identified for rearing pigs kept in indoor group housing and indoor systems with access to an outdoor area; for these two systems, an outcome table linking the highly relevant welfare consequences, ABMs, hazards, and preventive, corrective and mitigation measures is provided in Section 7.5. In the case of outdoor paddock systems, no welfare consequences were identified as having high relevance, although other welfare consequences, classified as less or moderately relevant may negatively affect the welfare of rearing pigs, which are visualised in Table B.1 (Appendix B). A comparison among the husbandry systems in terms of welfare of rearing pigs is provided in Section 7.6.

In Section 7.7, the **welfare of weaners and rearing pigs** in particular on the risks associated with: (a) weaning, (b) space allowance, (c) types of flooring, (d) enrichment material, (e) air quality, (f) health status and (g) diet composition (Specific ToR 4) is assessed.

Finally, **summary conclusions** on the welfare of weaners and rearing pigs are listed in Sections 7.7 and 7.8; relevant **recommendations** are in Sections 7.7 and 7.9.

7.1. Highly relevant welfare consequences for weaners: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5)

7.1.1. Group stress

Group stress was classified as having high relevance for weaners in indoor group housing and indoor systems with access to an outdoor area. This welfare consequence can have a continuous effect (long duration) and affect many weaners (high prevalence) kept in current indoor housing conditions, although severity varies between individuals (medium severity).

There are three primary causes of group stress in weaners:

1) The need to establish and maintain a **social hierarchy**. Rank order fights are potentially severe, and can cause lesions, injuries and negative affective state in losers. Such fights are usually seen only during the first 2 days after mixing of unfamiliar animals. However, if space is subsequently inadequate for subordinate animals to show avoidance or submissive behaviours, aggression can persist.
2) **Competition for access to resources** (e.g. food, water, lying space) which may occur throughout the entire period that animals are in the group housing system.
3) **Disturbance resulting from the performance of pig-directed behaviours** such as belly nosing which can sometimes occur with high prevalence in the period following weaning.

Hazards, preventive, corrective and mitigating measures

The hazards that could lead to this welfare consequence are listed below, together with the measures that could help to prevent/correct each hazard or that can mitigate the welfare consequence:

1) **Mixing of unfamiliar animals** (relevant to both systems): It is common to regroup piglets at the time of weaning in order to maximise the use of the available pen space and to form groups of animals with similar bodyweight so that appropriate feeds can be given. Although less common, regrouping may occur again as piglets grow in order to maximise pen utilisation.
Preventive measures are to minimise mixing. This can be done by leaving litter groups intact, or by allowing co-mingling of litters during the lactation period when less aggression occurs. Corrective measures include removal of bullied individuals and treatment in the case of any injury.

2) **Inability to show submission or otherwise avoid aggression:** This is most relevant to indoor group housing, where space is more limited compared to indoor systems with access to an outdoor area.
   Preventive measures are to increase space allowance and to use pens with different functional areas where visual barriers can provide avoidance and escape possibilities (e.g. straw bales, barriers, outdoor areas). Mitigation measures include removal of bullied individuals and treatment in the case of any injury.
3) **Insufficient access to resources** (relevant to both systems): Aggression over resources may result from the limited access to the resource, or from limited availability of the resource.
   Preventive measures aim at minimising competition for resources, and include increasing access e.g. feeding space or number of drinkers, increasing spatial separation of limited resources (e.g. better positioning of drinkers and feeding troughs), or increasing the amount of the resource which is offered (e.g. lying space or enrichment). Corrective measures include increasing limiting resources (e.g. if restricting feed or providing point-source enrichment) and/or access to resources, removal of individual animals which are unable to compete successfully and treatment in the case of any injury.
4) **Early weaning** (relevant to both systems): pigs which are weaned at a younger age show a higher prevalence of belly nosing and other pig-directed behaviours causing group stress.
   The preventive measure is to increase weaning age. Corrective measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.
5) **Lack of enrichment** (relevant to both systems): Pig-directed behaviours are more prevalent when the environment provides few other opportunities for expression of exploratory behaviour.
   Providing additional environmental enrichment is both a preventive and corrective measure. Further corrective measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.

7.1.2. Inability to perform exploratory or foraging behaviour

Inability to perform exploratory or foraging behaviour was classified as having high relevance for weaners kept in indoor group housing and indoor systems with access to an outdoor area. Pens for group housing of weaners commonly have slatted floors with no bedding which provide no opportunities for exploration or foraging (high severity). This welfare consequence has a continuous effect and affects virtually all weaners (high prevalence) throughout the time they are kept in these housing systems (long duration).

Hazard, preventive, corrective and mitigating measures

Absence or inadequate access to appropriate enrichment/foraging material (relevant to both systems): Exploratory behaviour is an intrinsic need of pigs.

Provision of an adequate amount of appropriate enrichment material is a preventive and corrective measure. In group housed pigs, this means that any individual should be able to access the material when motivated to do so (Commission Recommendation (EU) 2016/336). This material should be clean and regularly replaced/replenished, and should have one of more of the following characteristics – be edible or feed-like, chewable, investigable (e.g. rootable) and/or manipulable (e.g. the pig can change its location, appearance or structure) (Commission Recommendation (EU) 2016/336). This material can be provided as bedding or in a rack/dispenser (e.g. straw, hay), or suspended/attached to pen fixtures (e.g. wood, natural rope).

In pens with fully slatted floor, it is more difficult to provide appropriate enrichment materials as these easily fall through the slats, and therefore commonly only e.g. objects attached to pen features can be used. A preventive measure is to consider solid or partly slatted flooring when designing a pen. As a corrective measure a rubber mat can be provided in a specific area of the pen to allow provision of enrichment materials on the floor.

7.1.3. Cold stress

Cold stress was classified as having high relevance in the outdoor paddock systems. Weaned piglets are particularly susceptible to cold because of their small body size and reduced feed intake after weaning. Whilst indoor weaners are commonly provided with controlled thermal conditions, often with supplementary heat, weaners kept in outdoor systems can be exposed to low temperatures and have difficulties in keeping a comfortable body temperature (high severity). This welfare consequence has a continuous effect (long duration) and affects many weaners (high prevalence) kept in outdoor housing in winter conditions (except perhaps those kept at lower latitudes).

Hazards, preventive, corrective and mitigating measures

1) **Low ambient temperature:** At low ambient temperatures, it may be impossible to provide adequate outdoor housing conditions to prevent cold stress.
   The preventive measure is to only use indoor housing where heat can be provided in regions and seasons where very low temperatures regularly occur. The corrective measure would be to move pigs to indoor housing with heating possibility.
2) **Housing with poor insulating properties:** Pigs can better resist low temperatures if their housing aids conservation of body heat and allows a warmer microclimate to be established. This includes high insulation of walls and roof, prevention of draughts and deep bedding of dry straw.
   The preventive measure is to provide suitable insulated housing conditions. A corrective measure is to increase the depth of dry straw bedding.

7.1.4. Soft tissue lesions and integument damage

The welfare consequence 'Soft tissue lesions and integument damage' was classified as having high relevance in indoor group housing and indoor systems with access to an outdoor for weaners. Skin lesions are often observed in these systems, resultant from aggression from peers when establishing the social hierarchy after grouping. Tail and ear lesions from biting behaviour, as well as lesions on the flank and belly from massaging behaviour, can occur after the hierarchy has been determined (high severity). This welfare consequence has a continuous effect (long duration) and affects many weaners (high prevalence) throughout the time animals are kept in these housing systems.

Hazards, preventive, corrective and mitigating measures

1) **Mixing of unfamiliar animals** (relevant to both systems): Soft tissue lesions and integument damage result from fighting to establish the social hierarchy. It is common to regroup piglets at the time of weaning in order to maximise use of available pen space and to form groups of similar bodyweight animals so that appropriate feeds can be given. Although less common, regrouping may occur again as piglets grow to maximise pen utilisation.
   Preventive measures are to minimise mixing. This can be done by leaving litter groups intact, or by allowing co-mingling of litters during the lactation period when less aggression occurs. Corrective measures include removal of bullied individuals and treatment in the case of any injury.
2) **Inability to show submission or otherwise avoid aggression:** (more evident in indoor group housing). Soft tissue lesions and integument damage occur when subordinate animals cannot avoid aggressive interactions from dominant animals. This is most relevant to indoor group housing, since it occurs when space allowance is too low.
   Preventive measures are to increase space allowance and to use pens with different functional areas where visual barriers can provide avoidance and escape possibilities (e.g. straw bales, barriers, outdoor areas). Corrective measures include removal of bullied animals and treatment in the case of any injury.
3) **Insufficient access to resources** (relevant to both systems): Soft tissue lesions and integument damage, including bitten tails, occur when animals compete to attain or protect limited resources. Aggression over resources may result from the limited access to the resource, or from limited availability of the resource.
   Preventive measures aim at minimising competition for resources, and include increasing access e.g. feeding space or number of drinkers, increasing spatial separation of limited resources (e.g. better positioning of drinkers and feeding troughs), or increasing the amount of the resource which is offered (e.g. lying space or enrichment). Corrective measures include increasing limiting resources (e.g. if restricting feed or providing point-source enrichment) and/or access to resources, removal of individual animals which are unable to compete successfully and treatment in the case of any injury.

4) **Early weaning** (relevant to both systems): Pigs which are weaned at a younger age show a higher prevalence of belly nosing and other pig-directed behaviours which can result in lesions from biting and vigorous massaging behaviours.
   The preventive measure is to increase weaning age. Corrective measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.
5) **Lack of enrichment** (relevant to both systems): Tail, ear and flank lesions caused by pig-directed behaviours are more prevalent when the environment provides few other opportunities for expression of exploratory behaviour.
   Providing additional environmental enrichment is both a preventive and corrective measure. Further corrective measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.
6) **Poor flooring and pen maintenance:** Soft tissue lesions and integument damage can be caused by contact with sharp edges or abrasive surfaces in the living environment of the animals. These may result from damaged or corroded feeders, drinkers or pen divisions, or from inappropriate or worn flooring materials.
   Preventive measures include the selection and maintenance of appropriate flooring and pen fixtures. Corrective measures consist in remedying injurious pen components (e.g. sharp edges) and providing mats, straw or other substrate on damaging floor surfaces if possible.

For all hazards, the most important measure to alleviate the welfare consequence is to treat the affected animals. If the consequence is serious then the animals need to be isolated in hospital pens. In case of very serious situations, euthanasia might also be considered. Early detection of minor soft tissue lesions and integument damage is important, potentially acting as an early warning sign. Early detection allows corrective measures to be applied at a stage when this is likely to be more effective, consequently reducing the likelihood of chronic and serious problems.

7.1.5. Gastro-enteric disorders

Gastro-enteric disorders was classified as having high relevance in all three husbandry systems that were fully assessed for weaners (indoor group housing, indoor systems with access to an outdoor area, and outdoor paddock systems). Pigs that are weaned when they still have an immature digestive system are poorly adapted for consuming and digesting solid food. This makes them prone to digestive disorders just after weaning, particularly when inclusion of prophylactic antibiotic agents in the diet is not allowed, as is now the case in the EU. Gastro-enteric disorders frequently cause diarrhoea, dehydration and loss of body condition, and may be fatal in severe cases. This welfare consequence has a continuous effect (long duration) and affects many weaners (high prevalence) in the first weeks that they are kept in these housing systems. Gastric ulceration, can be common in weaned pigs because of their irregular feeding patterns and the use of finely ground ingredients in pelleted diets. Severe gastric ulceration is believed to be painful, causes loss in body condition and may be fatal if haemorrhagic.

Hazards, preventive, corrective and mitigating measures

1) **Early weaning:** The age of the piglet at the time of weaning affects the probability that it will have regularly consumed solid food prior to weaning, which confers lower risk of post-weaning hypophagia and a more mature digestive system as a result of substrate induction of appropriate enzymes (for further details see Section 7.7.1).
   Preventive measures are to wean at a later age and to encourage solid feed intake before weaning by provision of easily accessible and highly palatable creep feed. Corrective measures are the early identification and treatment of individuals affected by gastro-enteric disorder.
2) **Inappropriate weaner diets:** Many aspects of the diet for early weaned piglets will affect the risk of enteric disease. These include e.g. absence of milk products, use of low digestibility feed ingredients, excess of protein, high acid-binding capacity.
   Preventive measures are to provide diets appropriately formulated for the age of pig at weaning, utilising advice from a professional nutritionist. Mitigation measures are the early identification and treatment of individuals affected by gastro-enteric disorder.

3) **Poor hygiene:** Since the newly weaned piglet has an immature immune system and is highly susceptible to pathogen challenge, contact with infectious agents in the environment is a major risk for disease.

   Preventive measures are to use an all-in-all-out housing system to prevent transfer of infectious agents from older pigs, and to thoroughly clean and disinfect pens, feeding and watering systems before the pigs are introduced. Pens should provide a well-drained floor surface and minimise contact of pigs with excreta by provision of adequate space and bedding and/or correctly designed slatted flooring. Mitigation measures are regular cleaning of soiled pens and the early identification and treatment of individuals affected by gastro-enteric disorder.
4) **Post-weaning stress:** Stress from low or fluctuating temperatures, draught, irregular feeding, poor handling and frequent disturbance will all increase the risk of gastro-enteric disorders.

   Preventive measures are to minimise thermal and psychological stressors. Corrective measures are the early identification and treatment of individuals affected by gastro-enteric disorder.

7.2. Outcome table on the welfare of weaners

Table 52 presents an overall outcome on the elements requested by the General ToRs on the welfare of weaners: identification of the highly relevant welfare consequences, welfare hazards, preventive and corrective measures or mitigating measures and related ABMs. This relates to the three husbandry systems for weaners that were fully assessed (indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems).

Table 52: Welfare of weaners: outcome table linking the highly relevant welfare consequences, ABMs, hazards, and preventive, corrective and mitigation measures in the three husbandry systems that have been fully assessed in the General ToRs (indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems). Cross-reference to the sections describing the welfare consequences and related ABMs, and husbandry systems is provided.

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Group stress **(overall description: Section 3.4.3; details in Section 7.1.1)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Mixing of unfamiliar animals (both systems)	– Minimise mixing – House in litter groups – Co-mingle litters in lactation	– Remove bullied individuals – Treat any injury	**(Table 16 – Section 3.4.3)** – Agonistic behaviour – Belly nosing – Skin lesions – Body condition
		– Inability to show submission or otherwise avoid aggression (mainly indoor group housing)	– Increase space allowance and use pens with functional areas – Provide visual barriers	– Remove bullied individuals – Treat any injury	
		– Insufficient access to resources (both systems)	– Increase amount of limiting resources* – Increase access to limiting resources*	– Remove uncompetitive individuals – Treat any injury	
		– Early weaning (relevant to both systems)	– Increase weaning age	– Remove disruptive individuals – Treat any injury	
		– Lack of enrichment (relevant to both systems)	– Provide additional enrichment*	– Remove disruptive individuals – Treat any injury	
Inability to perform exploratory or foraging behaviour **(overall description: Section 3.4.6; details in Section 7.1.2)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Absence or inadequate access to appropriate enrichment/foraging material (relevant to both systems)	– Provide enrichment and foraging material* – Provide part solid floor when offering loose materials	– Provide a rubber mat to allow provision of enrichment materials on the floor	**(Table 20 – Section 3.4.6)** – Exploratory behaviours directed at enrichment material – Exploratory behaviour directed to pen-fittings – Re-directed exploratory behaviour, towards pen mates

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
					– *Tail lesions* – *Ear lesions* – *Skin lesions on other body parts*
Cold stress **(overall description: Section 3.4.12; details in Section 7.1.3)**	Outdoor paddock systems (Section 3.3.5.4)	– Low ambient temperature	– Use indoor housing in regions and seasons where very low temperatures regularly occur	– Move pigs to indoor housing with heating possibility	**(Table 28 – Section 3.4.12)** – Rectal temperature – Skin temperature – Shivering – Huddling behaviour – Ratio of Lying in sternal position/Lying laterally
		– Housing with poor insulating properties	– Provide housing with good insulation	– Increase the depth of dry straw bedding	
Soft tissue lesions and integument damage **(overall description: Section 3.4.14; details in Section 7.1.4)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Mixing of unfamiliar animals (relevant for both systems)	– Minimise mixing – House in litter groups – Co-mingle litters in lactation	– Remove bullied individuals – Treat any injury	**(Table 32 – Section 3.4.14)** – Tail lesions – Body lesions – Leg injuries – Ear lesions – Bursitis
		– Inability to show submission or otherwise avoid aggression (more evident in indoor group housing)	– Increase space allowance and use pens with functional areas – Provide visual barriers	– Remove bullied individuals – Treat any injury	
		– Insufficient access to resources (both systems)	– Increase amount and access of limiting resources*	– Remove uncompetitive individuals – Treat any injury	
		– Early weaning (both systems)	Increase weaning age	– Remove disruptive individuals – Treat any injury	
		– Lack of enrichment (both systems)	– Provide additional enrichment*	– Remove disruptive individuals – Treat any injury	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Poor flooring and pen maintenance (both systems)	– Selection of appropriate flooring – Maintenance of flooring and pen fixtures.	– Repair injurious pen components – Provide mats, straw or other substrate on damaging floor surfaces – Treat any injury	
Gastro-enteric disorders **(overall description: Section 3.4.14; details in Section 7.1.5)**	All three systems: – Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3) – Outdoor paddock systems (Section 3.3.5.4)	– Early weaning	– Increase weaning age – Encourage solid feed intake before weaning	– Early identification and treatment of affected pigs	**(Table 34 – Section 3.4.16)** – Abnormal faeces – Faecal egg count – Blood in faeces – *Faecal staining of the skin* – *Body condition* – *Soiling of floor*
		– Inappropriate weaner diets	– Provide diets appropriate for weaning age – Consult a professional nutritionist	– Early identification and treatment of affected pigs	
		– Poor hygiene	– Practice all-in-all-out housing – Clean and disinfect housing before pig entry – Maintain hygienic pen conditions minimising oro-faecal pathogen transfer	– Regular cleaning of soiled pens – Early identification and treatment of affected pigs	
		– Post-weaning stress	– Minimise thermal and psychological stress	– Early identification and treatment of affected pigs	

*: The preventive measures that may also be used to correct an ongoing problem have been marked with a star key (*).
**: The ABMs considered neither sensitive nor specific (see Section 3.4) are presented in 'Italics' but for information purposes only and are not recommended to be used in practice.

7.3. Comparison of the systems for weaners

The welfare aspects of the three housing systems for weaners (indoor group housing, indoor systems with access to an outdoor area, and outdoor paddock systems) can be compared based on the information in Section 7.1 and Table 52. Some of the highly relevant welfare consequences, such as gastro-enteric disorders, result primarily from the biology of the early weaned piglet and are therefore seen in all three housing systems. Other welfare consequences are more influenced by the housing conditions and were ranked as being of lower relevance in outdoor paddocks because of the greater space and environmental complexity in this system. This applied to the related welfare consequences of inability to perform exploratory or foraging behaviour, group stress and soft tissue lesions and integument damage. Conversely, cold stress was ranked as being of high relevance only in outdoor paddock systems because of the greater possibilities for sophisticated housing and supplementary heating in the two indoor systems. The full comparison between the systems can be found in Table B (Appendix B).

7.4. Highly relevant welfare consequences for rearing pigs: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5)

In the case of rearing pigs, the systems that have been assessed are indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems (see the beginning of Chapter 7).

7.4.1. Restriction of movement

Restriction of movement was classified as having high relevance in the indoor group housing for rearing pigs (see Table 53, Section 7.5). Indoor pens often have limited space causing movement constraints; this can be a problem especially towards the end of the fattening period due to the increased size of the animals (high severity, long duration). Feeding space and resting space also become restricted when pigs grow. This affects all rearing pigs kept in these systems (high prevalence). The ability of the pigs to move freely may also be impaired by flooring of poor quality which does not provide adequate foothold.

Hazard, preventive, corrective and mitigating measures

The hazards that could lead to this welfare consequence are listed below, together with the measures that could help to prevent/correct it or that can mitigate the welfare consequence:

1) **Insufficient space**: Inadequate floor space allowance is the main impediment to movement. This limits the ability of the pigs to avoid aggressive penmates, to access resources such as feeders and drinkers, to maintain separate lying and dunging areas and to adopt preferred lying postures.
   This hazard can be prevented by increasing pen size. The corrective measure consists in reducing the number of pigs placed in pens.
2) **Poor floor quality**: Restriction of movement can be caused by slippery flooring resulting from inappropriate or worn flooring material, or soiling with excreta.
   Preventive measures include the selection and maintenance of appropriate flooring. Corrective measures consist of cleaning soiled flooring and providing straw or other substrate on slippery floor surfaces if possible.

7.4.2. Resting problems

Resting problems was classified as having high relevance in indoor group housing. These problems are linked to the use of low space allowances and hard flooring, and may mean that pigs cannot lie in preferred locations or postures, and that rest is disrupted (high severity). A reduced ability to perform lateral lying may also limit the ability of pigs to thermoregulate. This welfare consequence has a continuous effect, although it is especially important towards the end of the fattening period (long duration) and affects virtually all rearing pigs (high prevalence) kept in this type of husbandry.

Hazards, preventive, corrective and mitigating measures

1) **Insufficient space**: Inadequate floor space allowance can limit the ability of rearing pigs to lie comfortably. This may be due to restrictions on adopting preferred lying postures (e.g. lateral lying), inability to lie in clean areas or separately from penmates, or increased disturbance by active pigs.
   This hazard is prevented by increasing pen size. The corrective measure consists in reducing the number of pigs placed in pens.
2) **Poor flooring design:** Lying on hard floors can decrease comfort and lead to resting problems.
   This hazard is prevented by housing animals in systems in which a sufficient quantity of appropriate bedding material can be offered. In systems that are not compatible with bedding, the effect on comfort may be mitigated by use of softer flooring materials (e.g. rubber) but further research is needed. Resting problems can also occur when flooring is in poor repair (e.g. damaged or worn slats), and these hazards are prevented by appropriate floor maintenance.
3) **Wet and dirty flooring**: Lying comfort is reduced if solid floors are soiled by excreta.
   Preventive measures include the selection and maintenance of appropriate floor drainage and maintenance of a correct thermal environment, e.g. well-functioning ventilation system. Corrective measures consist of cleaning soiled flooring and adjusting the ventilation system.

7.4.3. Group stress

Group stress was classified as having high relevance in indoor group housing and indoor systems with access to an outdoor area for rearing pigs. This welfare consequence can have a continuous effect (long duration) and affect many pigs (high prevalence) kept in current indoor housing conditions, although severity varies between individuals (medium severity). There are three primary causes of group stress during the rearing period:

1) The need to establish and maintain a **social hierarchy:** if group disruption occurs, rank order fights are potentially severe, and can cause lesions, injuries and negative affective state in losers. Such fights are usually seen only during the first 2 days after group disruption. However, if space is subsequently inadequate for subordinate animals to show avoidance or submissive behaviours, aggression can persist.
2) **Competition for access** to resources (e.g. food, water, lying space) which may occur throughout the entire period that animals are in the group housing system.
3) Disturbance resulting from the performance of **pig-directed behaviours** such as mounting by entire male pigs, or persistent nosing and chewing.

Hazards, preventive, corrective and mitigating measures

1) **Disruption to social group** (both systems): Pigs may be regrouped with unfamiliar animals during the rearing period, e.g. if moved to new accommodation. Removal of some pigs from the group (e.g. in split-marketing slaughter practices) may also affect social dynamics and lead to increased aggression.
   Preventive measures are to minimise group disruption. Corrective measures include removal of bullied individuals and treatment in the case of any injury.
2) **Inability to avoid aggressive or other penmate-directed behaviours:** This is most relevant to indoor group housing, since it occurs when space allowance is too low.
   Preventive measures are to increase space allowance and to use pens with different functional areas where visual barriers can provide avoidance and escape possibilities (e.g. straw bales, barriers, outdoor areas). Corrective measures include removal of bullied individuals and treatment in the case of any injury.
3) **Insufficient access to resources** (both systems): Aggression over resources may result from the limited access to the resource, or from limited availability of the resource.
   Preventive measures aim at minimising competition for resources, and include increasing access e.g. feeding space or number of drinkers, increasing spatial separation of limited resources (e.g. better positioning of drinkers and feeding troughs), or increasing the amount of the resource which is offered (e.g. lying space or enrichment). Corrective measures include increasing limiting resources (e.g. if restricting feed or providing point-source enrichment) and/or access to resources, removal of individual animals which are unable to compete successfully and treatment in the case of any injury.

4) **Lack of enrichment** (relevant to both systems): Pig-directed behaviours such as nosing and chewing of penmates are more prevalent when the environment provides few other opportunities for expression of exploratory behaviour.
Providing additional environmental enrichment is both a preventive and corrective measure. Further corrective measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.

7.4.4. Inability to perform exploratory or foraging behaviour

Inability to perform exploratory or foraging behaviour was classified as having high relevance in indoor group housing and indoor systems with access to an outdoor for rearing pigs.

In indoor group housing, this is due to the lack of opportunities for foraging provided by this type of housing. Pen floors are often slatted without bedding or other appropriate enrichment materials (high severity). Even in indoor systems with access to an outdoor area there tends to be limited opportunities for exploratory and foraging behaviour. This welfare consequence has a continuous effect (long duration) and affects virtually all rearing pigs kept in this type of husbandry (high prevalence).

Hazard preventive, corrective and mitigating measures

Absence or inadequate access to appropriate enrichment/foraging material (relevant to both systems): Exploratory behaviour is an intrinsic need of pigs, and provision of an adequate amount of appropriate enrichment material is a preventive and corrective measure.

In group housed pigs, this means that any individual should be able to access the material when motivated to do so. This material should be clean and regularly replaced/replenished, and should have one of more of the following characteristics – be edible or feed-like, chewable, investigable (e.g. rootable) and/or manipulable (e.g. the pig can change its location, appearance or structure).

This material can be provided as bedding or in a rack/dispenser (e.g. straw, hay), or suspended/attached to pen fixtures (e.g. wood, natural rope). In pens with fully slatted floor, it is more difficult to provide appropriate enrichment materials as these easily fall through the slats, and therefore commonly only e.g. objects attached to pen features can be used.

A preventive measure is to consider solid or partly slatted flooring when designing a pen. As a corrective measure a solid surface (e.g. a board or a rubber mat) can be provided in a specific area of the pen to allow provision of enrichment materials on the floor.

7.4.5. Locomotory disorders (including lameness)

Locomotory disorders was classified as having high relevance in indoor group housing and indoor systems with access to an outdoor area for rearing pigs. Locomotory disorders including lameness are common in rearing pigs, particularly as they approach slaughter age (high prevalence). Lameness is associated with pain and stress, and also impairs the ability of pigs to compete for resources. It can affect pigs for extended periods and lead to increased lying behaviour and subsequent pressure injuries (high severity and duration).

Hazards, preventive, corrective and mitigating measures

1) **Poor flooring design** (relevant to both systems): Slippery or abrasive flooring, poor slat design (e.g. inappropriate slat or slot width) or sharp slat edges contribute to claw and leg injuries in rearing pigs.
This hazard is prevented by selection and maintenance of appropriate flooring material. The effects of slippery or abrasive solid floors are mitigated by the provision of a sufficient amount of appropriate bedding. Use of concrete floors is also associated with increased limb and claw lesions in finishing pigs and effects are mitigated by use of rubber in lying areas (Falke et al., 2018).
2) **Genetic predisposition:** Genetic predisposition and increased growth rate are linked to the development of osteochondrosis, a degenerative joint disorder.
Preventive measures include the use genetic stock selected against such leg problems, the use of slower growing breeds, or an adaptation of nutritional regimes such that growth is restricted during the growing and rearing period.

3) **Lesions and infectious disease:** Lameness may be caused by infectious diseases such as erysipelas, by infectious arthritis or by localised infections via limb and claw lesions.
Preventive measures include an appropriate vaccination programme and good pen maintenance and hygiene. Corrective measures involve treatment of affected individuals and seeking veterinary advice regarding causal agents.
4) **Aggressive behaviour between pigs:** pigs engaging in or receiving aggression may slip, twist or fall during sudden or uncontrolled movements.

Preventive measures are to minimise the occurrence of situations leading to aggression, such as mixing of unfamiliar animals or competition for resources.

For all hazards, the most important measure to alleviate the welfare consequence is to treat the affected animals. If consequence is serious then the animals need to be isolated in hospital pens. In case of very serious situations, euthanasia might also be considered.

7.4.6. Soft tissue lesions and integument damage

Soft tissue lesions and integument damage was classified as having high relevance in indoor group housing and indoor systems with access to an outdoor for rearing pigs. Sustaining a lesion is painful for pigs, and the magnitude of pain will depend on the severity of injury (high severity). Sufficiently severe injuries may also lead to chronic pain, infection, debilitation and early culling. This welfare consequence has a continuous effect (long duration) and potentially affects many pigs (high prevalence) throughout the time animals are kept in these housing systems. Abattoir surveys show a high prevalence of skin lesions in rearing pigs. A particular issue in rearing pigs is the occurrence of tail, ear and flank biting. This is discussed in detail in Section 3.4.14.

Hazards, preventive, corrective and mitigating measures

1) **Disruption of social group** (relevant to both systems): Pigs may be regrouped with unfamiliar animals during the rearing period, e.g. if moved to new accommodation. Removal of some pigs from the group (e.g. in split-marketing slaughter practices) may also affect social dynamics and lead to increased aggression. Fighting between pigs leads to skin lesions.
Preventive measures are to minimise group disruption. Mitigation measures include removal of bullied individuals and treatment in the case of any injury.
2) **Inability to avoid aggressive or other penmate-directed behaviours:** This is most relevant to indoor group housing, since it occurs when space allowance is low.
Preventive measures are to increase space allowance and to use pens with different functional areas where visual barriers can provide avoidance and escape possibilities (e.g. straw bales, barriers, outdoor areas). Mitigation measures include removal of bullied individuals and treatment in the case of any injury.
3) **Insufficient access to resources** (relevant to both systems): Aggression over resources may result from the limited access to the resource, or from limited availability of the resource.
Preventive measures aim at minimising competition for resources, and include increasing access e.g. feeding space or number of drinkers, increasing spatial separation of limited resources (e.g. better positioning of drinkers and feeding troughs), or increasing the amount of the resource which is offered (e.g. lying space or enrichment). Corrective measures include increasing limiting resources (e.g. if restricting feed or providing point-source enrichment) and /or access to resources, removal of individual animals which are unable to compete successfully and treatment in the case of any injury.
4) **Lack of enrichment** (relevant to both systems): Tail, ear and other lesions caused by pig-directed behaviours are more prevalent when the environment provides few other opportunities for expression of exploratory behaviour.
Providing additional environmental enrichment is both a preventive and corrective measure. Further mitigation measures are to remove any persistently disruptive individual and to treat any lesions caused by such behaviours.
5) **Poor flooring and pen maintenance** (relevant to both systems): Soft tissue lesions and integument damage can be caused by contact with sharp edges or abrasive surfaces in the living environment of the animals. These may result from damaged or corroded feeders, drinkers or pen divisions, or from inappropriate or worn flooring materials.

Preventive measures include the selection and maintenance of appropriate flooring and pen fixtures. Corrective measures consist in remedying injurious pen components (e.g. sharp edges) and providing mats, straw or other substrate on damaging floor surfaces if possible.

7.4.7. Respiratory disorders

The welfare consequence 'Respiratory disorders' was classified as having high relevance in indoor group housing and indoor systems with access to an outdoor area. A high prevalence of lung lesions in finishing pigs from housed systems is commonly observed (high prevalence). Respiratory disorders are associated with increased mortality and morbidity and reduced growth (high severity). They result from the presence of respiratory disease pathogens within the herd, and are exacerbated by housing conditions. Where disease is endemic, it can only be eradicated by herd repopulation and stringent biosecurity, but can be prevented by an appropriate vaccination strategy.

Hazards, preventive, corrective and mitigating measures

1) **Mixing pigs of different origin** (relevant to both systems): Purchasing rearing pigs from a variety of sources (different farms) increases the risk of introducing respiratory disease pathogens to the farm.
   This hazard is prevented by the operation of a closed herd (Stärk, 2000) and by the use of an appropriate vaccination strategy (Opriessnig et al., 2011).
2) **Poor air quality:** This is most relevant to indoor group housing. Increased concentrations of airborne particulate matter are linked with reduced respiratory health in pigs (Michiels et al., 2015). This particulate matter has different sources, e.g. from feed or pigs.
   The hazard can be prevented by use of less dusty feeds if appropriate, and levels of respirable dust are reduced by increasing ventilation rates (mitigation measure) (Kim et al., 2007).
3) **Regrouping and moving pigs** (relevant to both systems): Regrouping and moving pigs is linked to increased respiratory disease (Jäger et al., 2012). This may be due to the fact that it facilitates greater spread of pathogens, and/or that it causes stress and subsequent immunosuppression.
   This can be prevented by enabling pigs to stay in the same group and pen across the rearing period.
4) **Climatic stress** (relevant to both systems): Significant diurnal temperature variations and air currents/draughts are associated with increased incidence of respiratory disease (Bochev, 2007).
   This hazard is prevented by ensuring that an appropriate ventilation system is in place and is operating effectively.
5) **Poor pen hygiene** (relevant to both systems): Lack of appropriate cleaning and disinfection of pens means that respiratory pathogens pose a risk to new pigs entering.
   This is prevented by ensuring that pens are in good repair and are appropriately cleaned and disinfected before pigs enter.
6) **Continuous flow systems** (relevant to both systems): Risk of respiratory infection is greater in systems where pigs of different ages (e.g. greater than 1 month age difference) are reared together in the same airspace (Jäger et al., 2012).
   The hazard is prevented by the use of all in/all out buildings where pigs of a similar age are reared together and where cleaning and disinfection between batches of pigs is facilitated.

For all hazards, the mitigation measure consists in treating the affected animals.

7.5. Outcome table on the welfare of rearing pigs

Table 53 presents an overall outcome on the elements requested by the General ToRs on the welfare of rearing pigs: identification of the relevant welfare consequences, welfare hazards, preventive and corrective measures or mitigating measures and related ABMs. This relates to indoor group housing and indoor systems with access to an outdoor area. Outdoor paddock systems were also fully assessed, but no welfare consequences were classified as having high relevance. Other welfare consequences may negatively affect the welfare of rearing pigs (in all the three systems fully assessed in the General ToRs, see Appendix B), but they were classified as less or moderately relevant.

Table 53: Welfare of rearing pigs: outcome table linking the highly relevant welfare consequences, ABMs, hazards, and preventive, corrective and mitigation measures in the three husbandry systems that have been fully assessed in the General ToRs (indoor group housing, indoor systems with access to an outdoor area and outdoor paddock systems). Cross-reference to the sections describing the welfare consequences and related ABMs, and husbandry systems is provided

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Restriction of movement **(overall description: Section 3.4.1; details in Section 7.4.1)**	– Indoor group housing (Section 3.3.6.2)	– Insufficient space	– Increase pen size	– Reduce the number of pigs in the pen	**(Table 12 – Section 3.4.1)** – Locomotory behaviour – Lying behaviour – *Posture changes* – *Pressure injuries: calluses and bursitis*
		– Poor floor quality	– Appropriate floor selection and maintenance	– Regular cleaning of floors – Provide straw or other substrate	
Resting problems **(overall description: Section 3.4.2; details in Section 7.4.2)**	– Indoor group housing (Section 3.3.6.2)	– Insufficient space	– Increase pen size	– Reduce the number of pigs in the pen	**(Table 14 – Section 3.4.2)** – Lying behaviour – Pressure injuries: calluses and bursitis – *Pig cleanliness*
		– Poor flooring design	– Use systems in which a sufficient quantity of bedding material can be offered – Appropriate floor selection and maintenance	– Softer flooring materials (e.g. rubber)	
		– Wet and dirty flooring	– Good floor drainage – Effective ventilation system	– Regular cleaning of floors – Adjust the ventilation system	
Group stress **(overall description: Section 3.4.3; details in Section 7.4.3)**	– Indoor group housing (Section 3.3.6.2) – Indoor systems with access to an outdoor area (Section 3.3.6.3)	– Disruption to social group (relevant to both systems)	– Minimise group disruption	– Removal of bullied individuals – Treatment in the case of any injury	**(Table 16 – Section 3.4.3)** – Agonistic behaviour – Skin lesions – Body condition – *Abnormal gait* – *Claw lesions*
		– Inability to avoid aggressive or other penmate-directed behaviours (relevant to indoor group housing)	– Increase space allowance – Use pens with different functional areas	– Removal of aggressive or bullied individuals – Treatment in the case of any injury	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Insufficient access to resources (both systems)	– Minimise competition for resources – Increase amount of limiting resources* – Improve access to resources*	– Removal of individuals unable to compete successfully – Treatment in the case of any injury	
		Lack of enrichment (relevant to both systems)	– Provide adequate amount of appropriate enrichment*	– Remove any persistently disruptive individual	
Inability to perform exploratory and foraging behaviour **(overall description: Section 3.4.6; details in Section 7.4.4)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Absence or inadequate access to appropriate enrichment/foraging material (relevant to both systems)	– Provide additional environmental enrichment* – Provide part solid floor when offering loose materials	– Provide a rubber mat to allow provision of enrichment materials on the floor	**(Table 20 – Section 3.4.6)** – Exploratory behaviours directed at enrichment material – Exploratory behaviour directed to pen-fittings – Re-directed exploratory behaviour, towards pen mates – Stereotypic behaviour – *Tail lesions* – *Ear lesions* – *Skin lesions on other body parts*
Locomotory disorders (including lameness) **(overall description: Section 3.4.13; details in Section 7.4.5)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Poor flooring design (relevant to both systems)	– Select and maintain appropriate flooring	– Use of rubber in lying areas – Sufficient amount of appropriate bedding – Treatment of affected animals	**(Table 30 – Section 3.4.13)** – Abnormal gait – *Claw lesions* – *Calluses and bursitis*
		– Genetic predisposition	– Use genetic stock selected against leg problems – Adaptation of nutritional regimes	– Isolate and treat the affected animals	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Lesions and infectious disease	– Appropriate vaccination program – Good pen maintenance and hygiene	– Isolate and treat the affected animals – Seeking veterinary advice regarding causal agents – Euthanasia in very serious situations	
		– Aggressive behaviour between pigs	– Minimise the occurrence of situations leading to aggression (e.g. mixing of unfamiliar animals or competition for resources)	– Isolate and treat the affected animals	
Soft tissue lesions and integument damage **(overall description: Section 3.4.14; details in Section 7.4.6)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Disruption to social group (both systems)	– Minimise group disruption	– Removal of bullied individuals – Treatment in the case of any injury	**(Table 32 – Section 3.4.14)** – Tail lesions – Body lesions – Leg injuries – Ear lesions – Bursitis
		– Inability to avoid aggressive or other penmate-directed behaviours (mostly indoor group housing)	– Increase pen size and use pens with functional areas	– Removal of bullied individuals – Treatment in the case of any injury	
		– Insufficient access to resources (relevant to both systems)	– Minimise competition for resources – Increase limiting resources* – Increase access to resources*	– Removal of individuals unable to compete successfully – Treatment in the case of any injury	
		– Lack of enrichment (relevant to both systems)	– Providing additional environmental enrichment*	– Remove any persistently disruptive individual	

Welfare consequence	Husbandry system(s) for which the welfare consequence is highly relevant	Hazard(s) with indication to which husbandry system(s) it applies to	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
		– Poor flooring and pen maintenance (relevant to both systems)	– Selection and maintenance of appropriate flooring and pen fixtures	– Remedying injurious pen components – Providing mats, straw or other substrate on damaging floor surfaces	
Respiratory disorders **(overall description: Section 3.4.15; details in Section 7.4.7)**	– Indoor group housing (Section 3.3.5.2) – Indoor systems with access to an outdoor area (Section 3.3.5.3)	– Mixing pigs of different origin (relevant to both systems)	– Operation of a closed herd – Use of an appropriate vaccination strategy	– Treatment of affected animals	**(Table 33 – Section 3.4.15)** – Coughing – Lung lesions – *Sneezing* – *Mortality*
		– Poor air quality (mainly indoor group housing)	– Use less dusty feeds	– Increase ventilation rates – Treatment of affected animals	
		– Regrouping and moving pigs (relevant to both systems)	– Enable pigs to stay in the same group and pen	– Treatment of affected animals	
		– Climatic stress (relevant to both systems)	– Ensuring an appropriate and operating ventilation system	– Treatment of affected animals	
		– Poor pen hygiene (relevant to both systems)	– Ensure that pens are in good repair and are appropriately cleaned and disinfected before pigs enter	– Treatment of affected animals	
		– Continuous flow systems (relevant to both systems)	– Use of all in/all out systems	– Treatment of affected animals	

*: The preventive measures that may also be used to correct an ongoing problem have been marked with a star key (*).
**: The ABMs considered neither sensitive nor specific (see Section 3.4) are presented in 'Italics' but for information purposes only and are not recommended to be used in practice.

7.6. Comparison of the systems for rearing pigs

The welfare aspects of the three housing systems for rearing pigs (indoor group housing, indoor systems with access to an outdoor area, and outdoor paddock systems) can be compared based on the information in Section 7.4 and Table 53. Most welfare consequences are influenced by the housing conditions and were ranked as being of lower relevance in outdoor paddocks because of the greater space and environmental complexity in this system. This applied to the related welfare consequences of inability to perform exploratory or foraging behaviour, group stress and soft tissue lesions and integument damage. The full comparison between the systems can be found in Table B.1 (Appendix B).

7.7. Assessment of the welfare of weaners and rearing pigs in particular with the risks associated with: (a) weaning, (b) space allowance, (c) types of flooring (d) enrichment material, (e) air quality, (f) health status, and (g) diet (Specific ToR 4)

In the following sections, the seven different exposure variables listed in the mandate will be discussed in relation to their implications for the welfare of weaners and rearing pigs. The importance of each of these exposure variables for the different welfare consequences is briefly reviewed. The main focus was on risks associated with tail biting. Tail biting is one of the damaging behaviours which are prevalent in pig production and reduce welfare and performance. This abnormal behaviour can result in severe injury to the individual pig and have significant economic consequences (Henry et al., 2021). It increases days to slaughter (van Staaveren et al., 2021) due to reduced growth rates (Wallgren and Lindahl, 1996; Sinisalo et al., 2012), and is related to poor carcass characteristics and an increased risk of carcass condemnation (Valros et al., 2004; Harley et al., 2012; Di Giminiani et al., 2017a,b). In all cases, tail biting is connected with poor welfare of pigs because of the pain and stress (Munsterhjelm et al., 2013). Tail biting is multifactorial (Taylor et al., 2010) and has been proven difficult to predict and control (Henry et al., 2021). The risk of tail biting is increased in the conditions of poor management and housing practices that do not meet the basic requirements of pigs, thereby causing stress. Currently, tail biting is mitigated by tail docking (see Section 6.3), but alternatives are now required. These include farm specific assessment of the diverse risk factors for the behaviour (Dippel, in press, in press) and careful monitoring of the early signs to allow rapid intervention strategies and its implementation. Automated tools for this purpose are currently under development (D'Eath et al., 2018; Larsen et al., 2020; Ocepek et al., 2021).

Each exposure variable is first discussed individually, and then the information on tail biting is brought together in the summary conclusions on Specific ToR 4 in relation to tail biting and recommendations, as presented in Sections 7.8 and 7.9.

7.7.1. Weaning age

7.7.1.1. Introduction

Under (semi-) natural conditions, weaning is a gradual process involving changes in the pattern of nursing which begin from the first week of life and are completed by 13–17 weeks of age (see Section 3.2.5.1). In current farm conditions, piglets are typically weaned abruptly by removal from the sow at a much younger age than 13–17 weeks. A number of different welfare consequences result from this weaning practice because of the psychological stressors involved and the immaturity of the behavioural, digestive and immune system of the piglet at this time (Edwards et al., 2020). Such challenges are particularly of importance when the piglet is removed from the sow very soon after birth, as is the case with artificial rearing systems (see Section 3.3.2.1).

7.7.1.2. Specific methodology

An extensive literature search (ELS; see Section 2.2.1.2) was carried out to identify scientific evidence reporting welfare implications of weaning age and associated ABM(s). Due to a lack of standardisation of the observed ABMs between the studies reported in different papers, the results were grouped according to similar ABMs: (1) vocalisation (acute stress), (2) enteric diseases, (3) mortality, and (4) belly nosing. To compare the dependencies on weaning age of the ABMs, the relative change of the ABM in relation to a reference weaning age was calculated. This allowed the description of the effect of different weaning ages by avoiding the conversion of different ABMs to a common one.

The reference weaning age was set to 28 days thus including all studies with observations of the weaning age from day 28 to day 31. To enable references with no observations at a weaning age of 28 days to be included, a further reference point was set to 21 days (observation from day 20 to day 21). An exponential model was fitted to the data and used to convert the results of the additional studies to the reference point at the weaning age of 28 days.

7.7.1.3. The acute stress of weaning

Abrupt removal from the sow and transfer to an unfamiliar environment represents an event which, in semi-natural conditions, has life-threatening consequences. This results in 'separation stress' for the piglet which is greater at a younger age, when loss of the dam has more extreme implications. ABMs which reflect this welfare consequence are the frequency and intensity of distress vocalisations, and the frequency and vigour of attempts to escape from the novel environment and return to the mother. Figure 18 summarises the published information on the effect of weaning age on frequency or intensity of distress vocalisation using a weaning age of 28 days as reference. Weaning at an earlier age (negative days on the x-axis) shows an increase of the ABM and thus a lower welfare for the piglets.

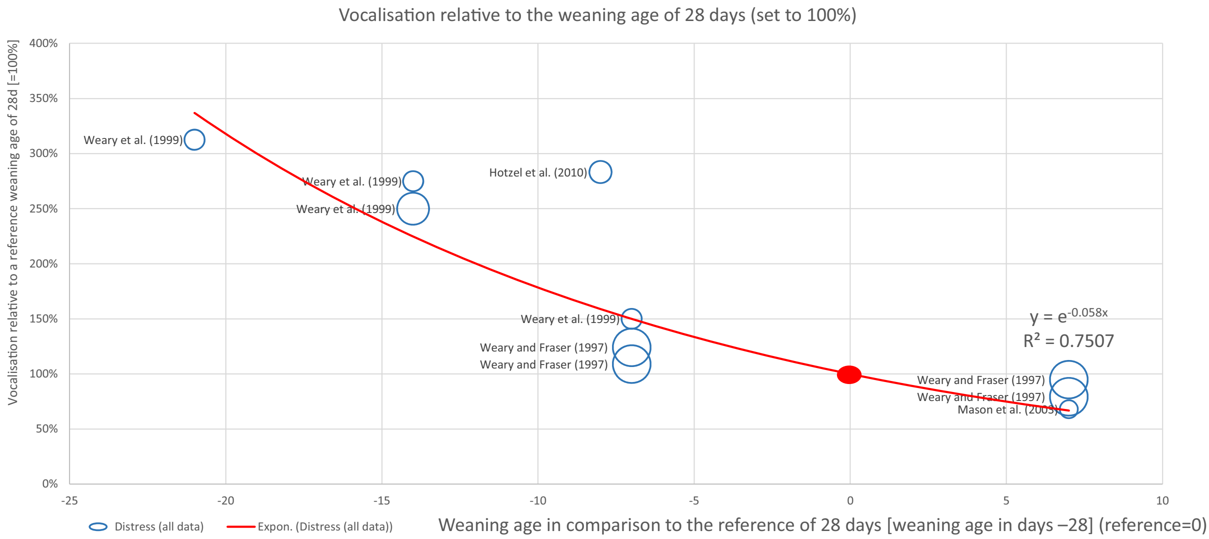


Figure 18: The relative frequency or intensity of distress vocalisations compared to a weaning age (WA) at 28 days (0 on the X-axis, set to a value of 100% on the Y-axis). Scientific studies with no observations at WA of 28 days were extrapolated from the analysis with reference of 20–21 days. The sizes of the circles indicate the sample size of the different studies. (Further information on the supporting literature is available upon request)

The data indicate an exponential relationship between separation stress and weaning age over the range from 7 to 35 days. The exponential model indicates that every 12 days of delayed weaning will halve the acute stress of the piglets (different ABMs are used by the references). There are no comparable data to indicate the extent of separation stress at weaning ages later than 35 days.

7.7.1.4. The health-related welfare consequences of weaning age

As described in detail and with supporting references in Section 3.2.5.1, piglets depend almost exclusively on the sow's milk for their nutrition in the first weeks of life, with the consumption of solid food only becoming significant from the fourth week onwards. As a result, both their behavioural and gastrointestinal system are not adapted to the ingestion and digestion of solid, plant-based feeds prior to this time. When abruptly removed from a supply of milk, there is a sharp decrease in nutrient intake while the piglet learns to eat solid food and its digestive enzymes adapt to the new substrate. This transient period of undernutrition may result in the welfare consequence of prolonged hunger for the piglet. Since milk also supplied much of the fluid intake prior to weaning, piglets may experience prolonged thirst especially if unfamiliar with a novel water delivery system provided after weaning. However, a more long-lasting consequence of the post-weaning period of undernutrition is a detrimental change in intestinal morphology and dysbiosis of the gut microflora, which impair nutrient absorption, compromise gut integrity, and allow proliferation of pathogenic organisms within the gut which can produce toxins migrating to the bloodstream and exerting systemic effects. This situation is exacerbated by the withdrawal of local protective effects within the gut of immune proteins present in maternal milk, and by the immaturity of the piglet's systemic immune system. Passive immunity obtained from ingestion of colostrum wanes progressively from the first to the sixth week of life, while the piglet's own ability to mount an active immune response develops only gradually during and after this time. Susceptibility to infection can also be increased by cold stress, to which piglets are predisposed as a result of their reduced energy intake over this period.

The combined effect of these challenges means that piglets weaned at a young age are highly susceptible to health disorders, and particularly gastro-enteric disorders, which can increase mortality and morbidity in the post-weaning phase. Historically this problem has been alleviated by the prophylactic dietary inclusion of antibiotics and antimicrobial agents such as zinc oxide, but new legislation within the EU will preclude this in the future. ABMs for gastro-enteric disorders include the prevalence of mortality, morbidity or veterinary treatments associated with the diagnosis of gastro-enteric disorders, or the abnormal consistency of the faeces. Figure 19 summarises the published information on the effect of weaning age on these ABMs indicative of gastro-enteric disorders, again compared to a reference weaning age at day 28.

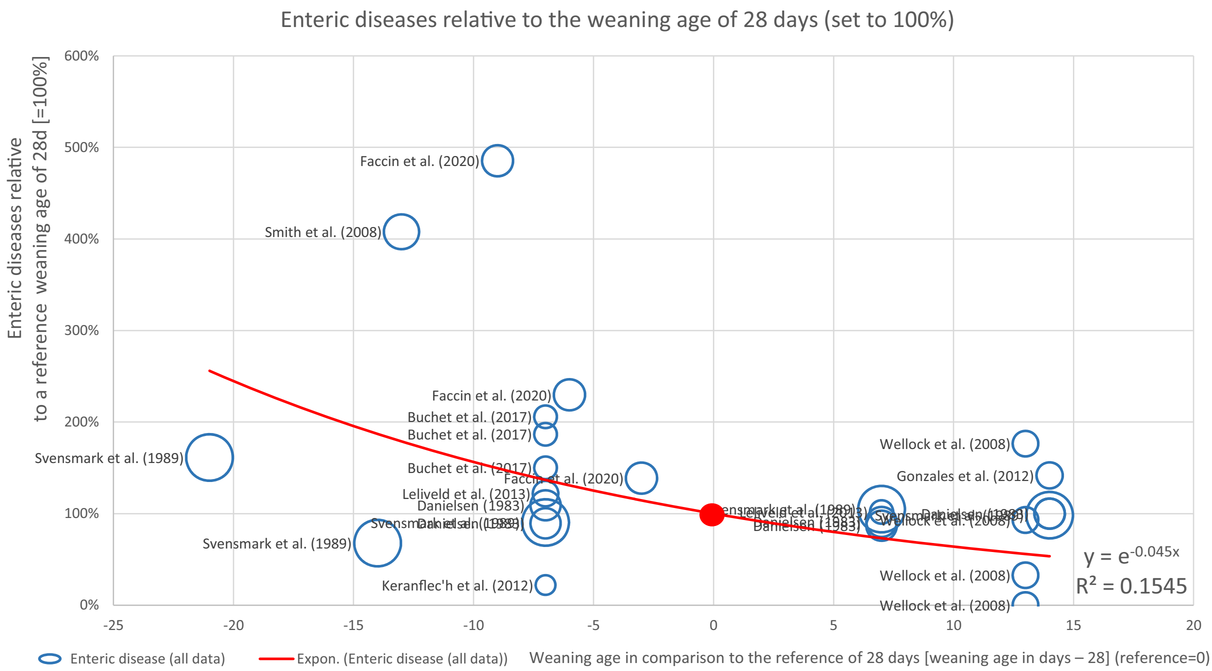


Figure 19: Studies showing the relative ABMs indicative of gastro-enteric disorders compared to a weaning age (WA) of 28 days (day 0 on the X-axis, set to a value of 100%). Scientific studies with no observations at WA of 28 days were extrapolated from the analysis with reference of 20–24 days. The sizes of the circles indicate the sample size of the different studies. (Further information on the supporting literature is available upon request)

The data are modelled with an exponential relationship between gastro-enteric disorders and weaning age over the range from 7 to 42 days in order to restrict the dependent variable to positive values. The exponential model suggests that every 15 days of later weaning will halve the prevalence or severity of the disorder (different ABMs are used by the references). However, the information is clustered around relatively few weaning ages and shows a high degree of variability within each weaning age, particularly at younger ages. This is expected, given the known important influences of farm health and hygiene status, diet quality and antimicrobial inclusion on the outcome.

Additional data sets are available to consider the effect of weaning age on post-weaning mortality, usually during the nursery phase, but sometimes in the subsequent period until slaughter. The cause of mortality is often unrecorded in large commercial studies, but gastro-enteric disease is the most prevalent reason during the post-weaning period when mortality is highest. These data are summarised in Figure 20.

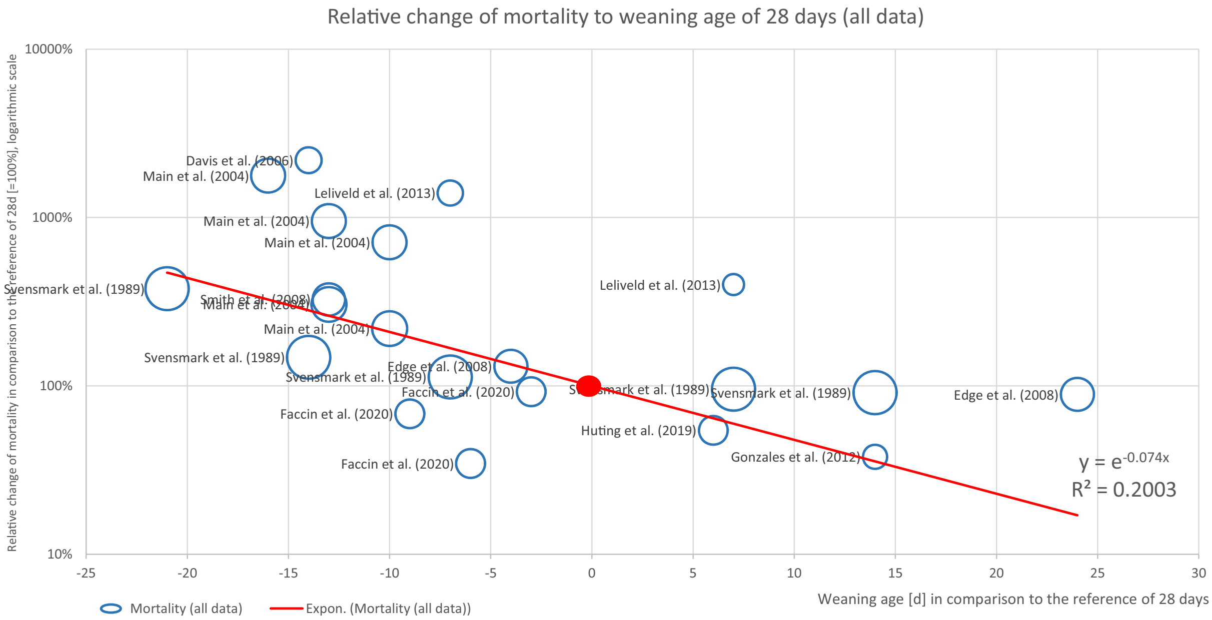


Figure 20: The change in post weaning mortality in relation to weaning age relative to the value at 28 days of age (day 0 on the x axis). (N.B., a logarithmic scale is used in the Y-axis). Scientific studies with no observations at weaning age (WA) of 28 days were extrapolated from the analysis with reference of 20–24 days. The sizes of the circles indicate the sample size of the different studies. (Further information on the supporting literature is available upon request)

The data indicate an exponential relationship between post-weaning mortality and weaning age over the range from 7 to 52 days. The exponential model indicates that every 9 days of delayed weaning will halve the mortality of piglets after weaning (different ABMs are used in the studies). However, most studies determining the model outcome are studies for which weaning age is 3 weeks or less, and these again show high variability in outcome. Two studies span a wide range in weaning age under European conditions. The first is an epidemiological study (Svensmark et al., 1989) based on 48,931 L in 89 Danish herds, which spanned a range of weaning ages from < 14 to > 50 days. The data are shown in Figure 21, and again indicate an exponential relationship with the benefits of increasing age above 28 days being rather small.

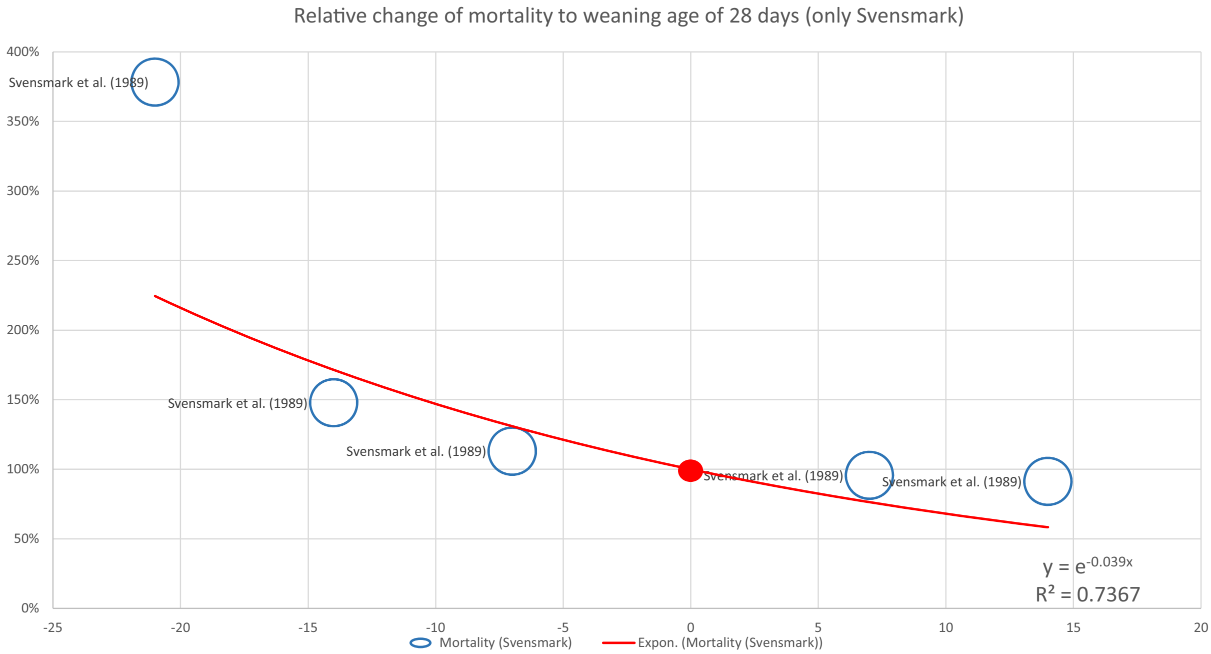


Figure 21: The change in post-weaning mortality in relation to weaning age (WA) relative to the value at 28 days of age (day 0 on the x axis, set to 100%) (data from Svensmark et al., 1989). Scientific studies with no observations at WA of 28 days were extrapolated from the analysis with reference of 20–24 days. The sizes of the circles indicate the sample size of the different studies

The second study from the UK describes an experiment comparing weaning ages of 4, 6 and 8 weeks involving ~ 380 L in a balanced design over 6 sites with different housing and management characteristics and no in-feed antibiotics (Edge et al., 2008). No effect of weaning age on the number of pigs requiring veterinary treatment from weaning to slaughter was reported, but there was a significant increase in the number of removed piglets weaned at 4-weeks of age (5.71, 4.36 and 3.88 removals and deaths per 100 pigs for 4-, 6- and 8-week weaning, respectively, $p = 0.05$).

However, it must be borne in mind that as weaning age is increased, there is a greater probability that a piglet might die before weaning and therefore some individuals which might have been more vulnerable will no longer be present in the post weaning population. Most preweaning mortality occurs in neonatal piglets, but North American studies with weaning ages ranging between 2 and 3 weeks suggested that mortality increases by 0.28% per extra day (King et al., 1998; Straw et al., 1998). The magnitude of this counter-effect on post weaning mortality is difficult to estimate for later weaning ages, as data on preweaning mortality over this range are lacking. Data from Slovenian farms spanning a range of weaning age up to 75 days indicated an increase of only 0.062% per day (Planinc et al., 2012). The data of Svensmark et al. (1989) (see Figure 19) show a 0.3% reduction in post-weaning mortality when weaning age increased from 4 weeks (22–28 days) to 5 weeks (29–35 days), and a further 0.1% reduction for an increase to 6 weeks (36–42 days). These are all less than the 0.4% increase in preweaning mortality estimated for each 1 week increase in weaning age by Planinc et al. (2012), suggesting little net benefit to increasing weaning age above 4 weeks.

7.7.1.5. The effect of weaning age on behaviour-related welfare consequences

The abrupt removal from the sow at an early age also has the welfare consequence of 'inability to perform sucking behaviour'. When deprived of the possibility for the normal appetitive and consummatory behaviours associated with suckling (massaging the udder of the mother and sucking from teats), early weaned piglets develop an abnormally high prevalence of behaviours directed to the bodies of their penmates and, in particular, a behaviour usually called 'belly nosing' which involves vigorous and prolonged massaging and sucking of the belly area. This disrupts the rest of other individuals (welfare consequence of resting problems and group stress) and may be extreme enough to result in skin lesions on the targeted body area (welfare consequence of soft tissue lesions and integument damage). The behaviour usually starts 3–5 days after weaning, peaks ~ 2 weeks later, and then gradually declines. It has therefore been suggested that it is a redirected foraging response to the reduced nutrient intake during the post-weaning period, but there is also evidence that the behaviour is closely linked to the frustration of sucking *per se*, since providing early weaned piglets with opportunities for either nutritive or non-nutritive sucking reduces its prevalence (Widowski et al., 2008).

Figure 22 summarises the published information on the effect of weaning age on the prevalence of belly nosing behaviour.

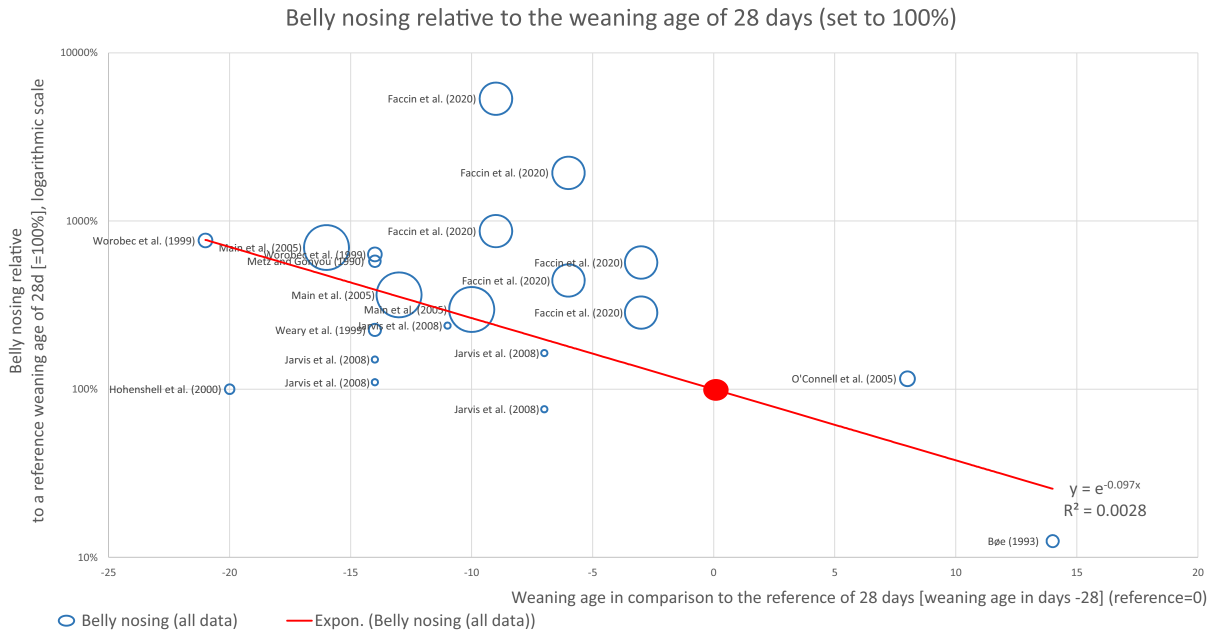


Figure 22: The relative prevalence of belly nosing behaviour (logarithmic scale) in comparison to a weaning age (WA) of 28 days (day 0 on the X- axis, set to 100%). Scientific studies with no observations at WA of 28 days were extrapolated from the analysis with reference of 20–24 days. The sizes of the circles indicate the sample size of the different studies. (Further information on the supporting literature is available upon request)

The data (all studies) were modelled with an exponential relationship between belly nosing behaviour and weaning age over the range from 7 to 42 days in order to restrict the prevalence of belly nosing to positive values. The prevalence halved for every 7 days increase in weaning age. However, the fit of the model is poor as a result of big differences between studies in both the absolute level of the ABM and its change in relation to weaning age.

To investigate this further, models were fitted to some of the divergent individual studies, as shown in Figure 23.

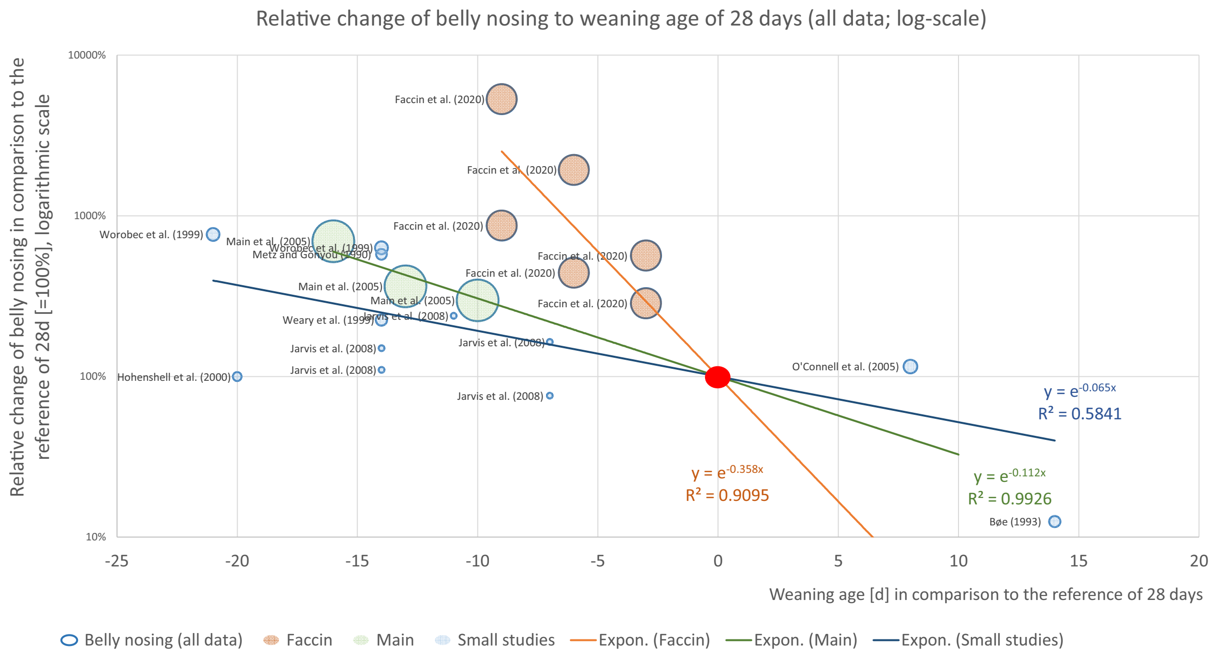


Figure 23: Behaviour in relation to weaning age (WA) relative to the value at 28 days of age (day 0 on the X-axis, set to 100%). (N.B., a logarithmic scale is used, and exponential relationships are fitted separately for some individual studies). Scientific studies with no observations at WA of 28 days were extrapolated from the analysis with reference of 20–24 days. The sizes of the circles indicate the sample size of the different studies. (Further information on the supporting literature is available upon request)

The results from Faccin et al. (2020) (orange) show a much higher exponent than derived from the study of Main et al. (2005) (green) or from the other studies with small sample size (blue). These studies only investigate weaning ages of < 28 days, and information relating to weaning ages greater than 28 days is very sparse.

The critical question would be at what age is belly nosing reduced to a prevalence which is no greater than that seen in pigs under conditions of natural weaning. Data to answer this question are currently lacking. The results of Jarvis et al. (2008) indicate that belly nosing increases with age when piglets remain with the sow (see Figure 24, white bars). However, up to a weaning age of 42 days (the highest investigated) the behaviour was always observed more frequently in weaned piglets.

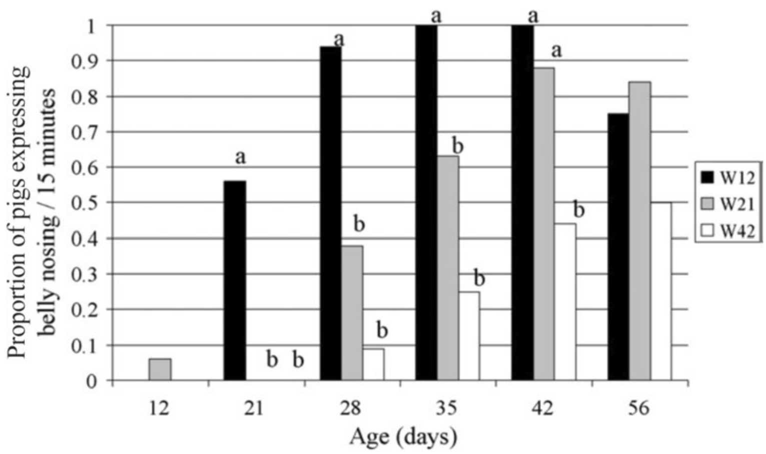


Figure 24: The proportion of pigs showing belly nosing at different ages in relation to whether they are suckling or weaned (from Jarvis et al., 2008). [N.B. data for the day on which weaning occurred (12, 21 or 42 days) were taken prior to weaning for that group on that particular weaning day]. Values with different superscript differ ($p < 0.05$) and represent results from post hoc test (Source: Jarvis et al., 2008)

Widowski et al. (2008) cite an unsupported observation that no belly nosing occurred in 8-week-old piglets in a semi-natural environment. However, the expression of this behaviour may depend on environmental conditions, since Hötzel et al. (2004) reported a mean prevalence of belly nosing in the first 3 weeks of lactation of 0.36% of time for litters in an unbedded indoor farrowing crate system and 0.02% for litters kept outdoors at pasture. A similar difference was reported in the post-weaning period after weaning at 21 days (0.84 vs. 0.05% for indoor and outdoor housing, respectively). It is therefore not possible to be certain at what weaning age belly nosing after weaning is not unnaturally elevated, and the available evidence on effects above 4 weeks of age in indoor housing are conflicting with regard to the interaction with environmental conditions (Bøe, 1993; O'Connell et al., 2005).

7.7.1.6. Artificial rearing

Artificial rearing is a special case of very early weaning, where piglets are removed from the sow within the first few days of life but continue to be fed liquid milk (see Section 3.3.4.1 for a detailed description). The welfare consequences identified for this system are discussed in detail in Section 3.4. and include all the behavioural consequences highlighted in the preceding sections for early weaning. In artificial piglet rearing systems, 'group stress' may arise from piglets that redirect massaging behaviour (belly nosing) to their pen mates as a result of 'inability to perform sucking behaviour'. This abnormal behaviour increases both in frequency and duration over the rearing period (Bench and Gonyou, 2009; Rzezniczek et al., 2015; Schmitt et al., 2019), and may disturb the lying behaviour of the piglets (Rzezniczek et al., 2015).

7.7.1.7. The effect of weaning age on tail biting risk

The increased level of penmate-directed behaviours seen in early weaned piglets can persist into the grower–finisher stage in some individuals (Gonyou et al., 1998; Worobec et al., 1999; Bench, 2005), and it has been suggested that this might result in an increased risk of tail biting. However, a recent review concluded that available data indicate that age at weaning has no clear influence on the subsequent risk of tail biting (Prunier et al., 2020b). An indirect effect of weaning age could be hypothesised as a result of the known factors which predispose pigs to tail bite. Both a check in growth rate and the presence of health disorders associated with inflammatory cytokine responses have been implicated in causation of tail biting (see Edwards and Valros, 2021, and Boyle et al., 2022, for a more detailed review) and these conditions are present in some individuals who fail to adapt adequately to the nutritional and environmental changes experienced at weaning. Such individual variation may be more influential for tail biting risk than an overall effect of weaning age, which would appear to be much less important than the prevailing post-weaning housing and management conditions.

7.7.1.8. Summary conclusions on Specific ToR 4: weaning

1) Abrupt weaning results in a range of welfare consequences including separation stress, prolonged hunger, prolonged thirst, gastro-intestinal disorders, and inability to perform sucking behaviour, which has further detrimental consequences for resting problems, group stress and soft tissue lesions and integument damage.
2) Weaning age has not been associated directly with tail biting, although there may be indirect effects via other welfare consequences (e.g. health-related) of a poor weaning transition.
3) These welfare consequences increase exponentially with reducing weaning age and are particularly pronounced at weaning ages of less than 21 days and with artificial rearing systems. However, there is great variability between different studies and housing systems.
4) The welfare benefits of increasing weaning age over the range between 21 and 28 days do appear to be meaningful as a result of the increasing maturity of behavioural, digestive and immunological systems over this period.
5) There are inadequate data to assess the welfare consequences of weaning ages greater than 28 days but indications from the ABMs that have been investigated are that, under good management, any welfare benefits are less pronounced.

7.7.1.9. Recommendations on Specific ToR 4: weaning

1) For animal welfare reasons, the current legal minimum weaning age of 28 days should remain and the exception allowing earlier weaning in specific circumstances should be reconsidered.

2) The welfare benefits of weaning age greater than 28 days should be further investigated.
3) Artificial rearing should only be used as a last resort and not as a routine management practice. Other measures should be prioritised, such as selection against extreme prolificacy to reduce the likelihood of birth of surplus piglets, or the use of a nurse sow.

7.7.2. Space allowance

7.7.2.1. Introduction

Space allowance refers to the amount of floor area provided per pig, and minimum unobstructed floor area allowances (m^2/pig) for pigs within particular weight bands are specified in legislation. Weaner and rearing pig systems are described in Sections 3.2.5 and 3.2.6. Weaners and rearing pigs are usually housed in pens of a fixed size for a period of time, meaning that free space available at the start of this period will be greater than at the end (when pigs are bigger). Most welfare concerns centre around the end of these periods, where available space is at a minimum. As the size of the animals increases over time, a stocking density (or the converse: space allowance) simply relating the number of animals to the available area is not meaningful. To allow for different bodyweights, an allometric approach is often used to calculate the amount -of floor space required:

A (space allowance in m^2) = k (constant) $\times$ body weight$^{2/3}$ (Petherick, 1983).

Appropriate k-values have been estimated for different postures and activities, and will form the basis of much of the discussion in this section.

Why is space important for pigs?

As reviewed by EFSA (2005), pigs need sufficient space to properly perform highly motivated behaviours, including exploratory, social and lying behaviours, play behaviour and to escape aggressors. Pigs also prefer to maintain separate functional areas in the pen, e.g. for lying and dunging, and require sufficient space to do this. They also need space to circumnavigate penmates in order to access resources such as feed, water and enrichment items. Pigs also rely on behavioural measures to regulate their temperature and need sufficient space to enable them to do this at high ambient temperatures. These measures include maintaining distance from penmates and adopting a lateral lying posture.

What happens when space is inadequate?

The effects of reduced floor space allowance on pig welfare are discussed in this SO in Section 3.4.1 (Restriction of movement and related ABMs for rearing pigs). In summary, there is evidence of reduced locomotion (Cornale et al., 2015), feed intake (Carpenter et al., 2018) and lying behaviour (Bulens et al., 2017) when space allowance is reduced. Pigs also show increased aggression and penmate manipulation (Bulens et al., 2017), and the ability of pigs to thermoregulate and to maintain separate functional areas is also adversely affected by insufficient space. This latter factor may, in turn, lead to increased fouling of lying areas (Larsen et al., 2017) and to associated health and welfare problems (Nannoni et al., 2020). There is also endocrinological evidence (increased faecal cortisol) of increased stress when space allowance is reduced (Cornale et al., 2015), perhaps due to a combination of factors.

It is likely that pigs show different responses to space restriction depending on the level imposed. Averós et al. (2010) suggested that they initially make adjustments that are the least biologically demanding (i.e. adjusting lying behaviour). Responses such as reduced growth are then shown if the situation persists or intensifies. This suggestion is supported by broken line analyses that show that the threshold k-value below which further reductions in space allowance have an adverse effect is 0.039 for lying behaviour on slatted flooring (Averós et al., 2010). For growth rate, this value was estimated to be 0.032–0.035 for different data sets analysed by Gonyou et al. (2006). It is also important to note that the magnitude of effect of inadequate space on pig welfare differs depending on other environmental factors. Inability to perform thermoregulatory behaviour due to lack of space will obviously be more important when ambient temperatures are high. The space required to maintain separate lying and dunging areas is lower with fully slatted than other floor types and is higher at greater ambient temperatures. Averós et al. (2010) also found that the threshold k-value for observing effects of space allowance on lying behaviour was almost double in solid-floored pens (0.072) than in pens with slatted flooring. This suggests that growing-finishing pigs at a given body weight require more space for lying on a solid floor, compared to slats. The welfare implications of reduced space allowances may also be reduced in larger group sizes due to the additional 'free space' provided (McGlone and Newby, 1994).

7.7.2.2. Approach

To address the question of 'how much space do weaners and rearing pig need', two exercises were conducted.

Firstly, the scientific evidence mentioned above and that previously reported by EFSA (EFSA, 2005) were briefly reviewed (see Section 7.7.2.3)

Secondly, an extensive literature search (ELS; see Section 2.2.1.2) was carried out to identify scientific evidence reporting welfare implications of space allowance in weaners and rearing pigs and associated ABM(s). Details of the literature search strategy and results are reported in Appendix A. Relevant data on ABM(s) with a strong relationship to the exposure variable 'space allowance' were extracted and analysed, and growth rate and tail biting were chosen. Results of the ELS are reported in Sections 7.7.2.4 and 7.7.2.5.

7.7.2.3. Rearing pig behaviour in relation to k-values

Minimum permitted space allowances in the EU (Council Directive 2008/120/EC) roughly equate to an average k-value of 0.028. A 110-kg pig e.g. requires a minimum 0.65 m^2 according to the legislation. How different k-values relate to the behaviour of rearing pigs is presented in Table 54. This table summarises the evidence presented above and in EFSA (2005).

Table 54: Summary of key findings and recommendations presented in the literature on the relationship between the k-value (as a measure of space per individual pig) and the behaviour that is or can be expressed

k-value	Behaviour that can be expressed
0.019	Space required for **sternal lying** (Petherick and Baxter, 1981).
0.033	Space occupied when all pigs are **lying at thermoneutral conditions** (where 20–40% space sharing will occur) based on an estimated floor area for half recumbent pigs (Ekkel et al., 2003).
0.034	Space required for **lying and activity at thermoneutral conditions**. It is estimated that 80% of pigs are lying at a given time, and 20% are active. Active pigs are estimated to require a k value equivalent to 0.038 (2 × 0.019 (space of one pig standing). 80% × 0.033 and 20% × 0.038 = 0.034 EFSA (2005) also noted evidence of impaired physiological function, live weight gain and food intake of pigs on fully- or partially slatted floors at k-values of less than this.
0.036	To **maintain separate dunging and lying areas,** EFSA (2005) estimated that an additional space is needed for one animal to stand up and defecate (k-value 0.019). For a group of 10 pigs, this dunging space is shared, which means that each pig requires an extra k-value of 0.019/10 = 0.002, in addition to 0.034 under thermoneutral conditions. EFSA experts considered that this figure is increased for some designs of pens with part-slatted floors, because of possible solid floor soiling. EFSA (2005) recommended that this should be the minimum space allowance for pigs up to 110 kg where ambient temperature will not exceed 25°C.
0.039	Space below which growing-finishing pigs kept on a slatted floor will start **to reduce the % of lying behaviour** in response to the reduction in space (Averós et al., 2010).
0.047	Space required for pigs to **lie separated in a lateral position** (Petherick and Baxter, 1981). EFSA (2005) recommended that this should be the minimum space allowance for pigs up to 110 kg where ambient temperature is likely to exceed 25°C. EFSA (2005) also recommended that this is the minimum space allowance for pigs of more than 110 kg.
0.072	Space below which growing-finishing pigs kept on a solid floor will start **to reduce the %** of lying behaviour in response to the reduction in space (Averós et al., 2010).

Table 54 presents an overview of the relationship between a number of k-values, and behaviours that can be expressed. It can be read in reverse order to illustrate what happens if the k-value is reduced from a relatively large value of 0.072 (below which the animals will change their lying behaviour if kept on solid floors), to lower values. Initially they may not be able to lie separated from other pigs in a lateral position (below k = 0.047), which is particularly important for thermoregulation at higher ambient temperatures. As space allowance decreases further (below k = 0.039) pigs on slatted floors start to adapt their lying behaviour. Their ability to maintain separate lying and dunging areas is adversely affected below k = 0.036, although current EFSA experts consider this k-value to be an underestimate. Further reductions in space (below k = 0.34) appear to negatively impact biological functioning and may also compromise activity levels in pens, and a k = value below 0.33 will compromise the ability of pigs to lie in a half-recumbent position.

7.7.2.4. Analysis to explore the relationship between space allowance and growth rate

Reductions in growth rate can be caused by stress and represent a significant biological adjustment by pigs. This is linked to the high catabolic rate associated with stress hormones such as cortisol (Hyun et al., 2005), meaning that metabolic resources are mobilised to deal with stressors at the expense of functions such as growth. Animals that are stressed also show reduced feed intake levels (Martinez-Miro et al., 2016). Insufficient behavioural space in pens may also adversely affect the ability of pigs to access feeders (Cornale et al., 2015). An evaluation of more recent data investigating links between space allowance and growth (e.g. EFSA, 2005 and Gonyou et al., 2006) allows to account for developments in genetics and management.

Several recent scientific publications examine the relationship between space allowance and growth rate. An overview of these studies is presented in Table 55. For these studies, the weight or weight band investigated and whether or not there was a significant effect on growth rate is summarised. As it is agreed that the effect of space is highest at the end of the fattening period (due to the animals being the heaviest at that time), either the last reported evaluation period was used, or the total growth rate over the whole rearing period. Results for weaners (< 30 kg) were excluded.

Table 55: Overview of studies showing a positive effect of increased space allowance on growth rate (in relation to a specific weight range or end weight), and the degree of statistical significance of this effect

Reference (information added after a '/' helps to identify the study data in Figure 25 below)	Weight or weight range investigated or end weight	Significant effect of space allowance on growth rate ('yes' or 'no' at $p < 0.05$, or a value if $0.05 < p < 0.1$)
Anil et al., 2007	30.6–116 kg	Yes
Caldas et al., 2021/122 kg	137–154 days (av. end weight 119 kg/123 kg)	Yes
Caldas et al., 2021/total	68–172 days (av. end weight 137 kg/141 kg)	Yes
Camp Montoro et al., 2021/study 1	26.3–110 kg	No
Camp Montoro et al., 2021/study 2	26.3–110 kg	No
Jang et al., 2017/late	42–108 days (30–110 kg[(1)])	Yes
Jang et al., 2017/total	0–108 days (30–110 kg[(1)])	Yes
Jensen et al., 2012/A	91.25 kg	p = 0.07
Jensen et al., 2012/B	91.25 kg	p = 0.07
Li et al., 2021/toys	55.1 kg	Yes
Li et al., 2021/no toys	55.1 kg	Yes
Nannoni et al., 2019	23.9–160 kg	Yes
Vermeer et al., 2014	24–114 kg	Yes
Thomas et al., 2017	113.5–138 kg	Yes
Rossi et al., 2008/Phase 2	119.4–146.2 kg	p = 0.08
Carpenter et al., 2018/late	114–127/125/122 kg	Yes
Carpenter et al., 2018/total	End weight: 127/125/122 kg	Yes

(1): Estimated final weight.

All the studies in Table 55 used the average daily weight gain [in g/d] as measure of the growth rate and showed an increase in growth rate with increasing space. In many studies, the effect was statistically significant.

Examination of the data in these studies indicated that the beneficial effects of increasing space allowance on growth rate decreased with increasing space allowance. This suggested that beyond a certain space allowance, any additional growth rate gain may be negligible. The following analysis was performed to provide some evidence on this aspect.

Figure 25 shows the relation between the (average) space allowance of the study (horizontal axis) and the observed acceleration of growth in response to increased space in that study (vertical axis with a logarithmic scale).

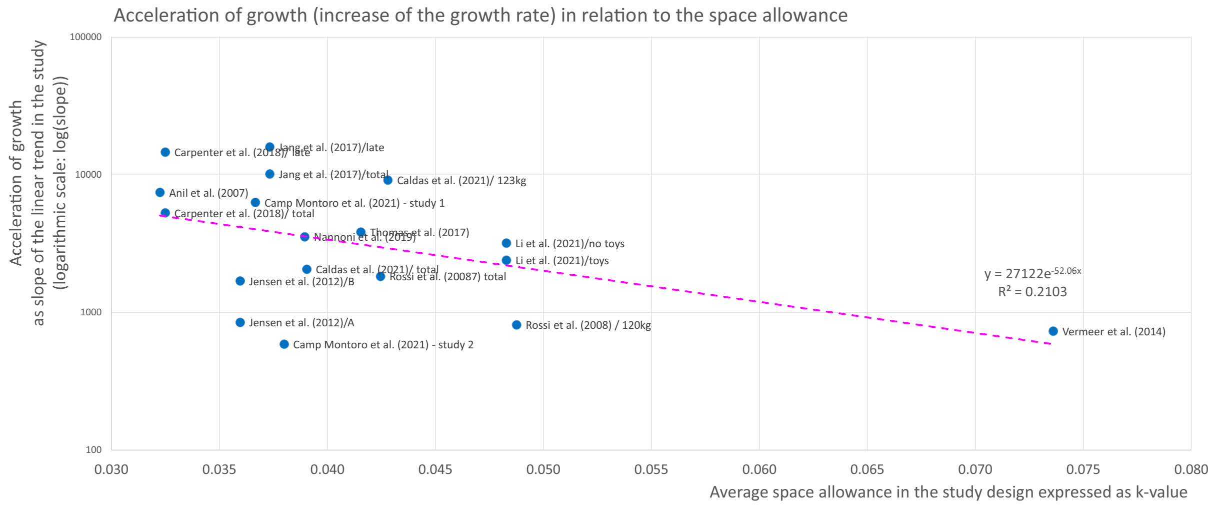


Figure 25: Acceleration of growth in relation to the space allowance. The studies are those presented in Table 55. Each study is represented by one point indicating the average k-value of the space allowance treatments (X-axis), and the increase of the growth rate as space was increased in that study (Y-axis). Please see text for further explanation

An exponential model was fitted to the data. This model summarises the effect of space allowance and can be transformed back to the relationship between space and growth rate by the integration of the exponential function. To be able to estimate the relative increase in growth rate, a reference point had to be chosen and it was decided to use k = 0.028 as this approximates the current legal minimum.

Growth rate (at k) = GrowthRate (at k = 0.028) + 109 – 775 × EXP(–70 × k)

The maximum possible increase of the growth rate for space allowances above k = 0.028 is given by the equation as 109 g/day. Therefore, the result is finally standardised to the proportion of the maximum possible increase, which could be reached by an enlarged space allowance. At a k-value of 0.028, the possible maximum increase is set to 100%, and at infinite space, the maximum increase is reached (0%).

Relative reduction of the maximum growth rate = 1 – [109 – 775 × EXP(–70 × k)]/109

To facilitate the interpretation of this model in relation to actual space allowances in m^2, Table 56 shows the relative reduction of the maximum achievable growth rate which is obtained for selected space allowances expressed as k-values, compared to the situation at the k-value of 0.028 (set at 100% reduction).

Table 56: Relative reduction of the maximum achievable growth rate (compared to the situation at the k-value of 0.028) for selected space allowances expressed as k-values (from the analysis of the data in the literature). To facilitate interpretation of the data, please see text below for an example

Space allowance as k-value	Relative reduction of the maximum achievable growth rate compared to the situation at the k-value of 0.028	m^2 for a 110-kg pig
0.028	100%	0.65
0.030	87%	0.70
0.036	57%	0.84
0.040	43%	0.93
0.045	30%	1.05
0.050	21%	1.17

Space allowance as k-value	Relative reduction of the maximum achievable growth rate compared to the situation at the k-value of 0.028	m^2 for a 110-kg pig
0.055	15%	1.28
0.060	11%	1.40
0.065	7%	1.52
0.070	5%	1.63
0.075	4%	1.75
0.080	3%	1.87
0.085	2%	1.98
0.090	1%	2.10

The quantification is given as relative reduction of the growth rate related to a specific space allowance and compared to the reduction of the growth rate at a k-value of 0.028 (approximately the current lower legally allowed space).

As an example, at a k-value of 0.040 (0.93 m^2 for a 110-kg pig) instead of 0.028 (0.65 m^2 for a 110-kg pig), the growth rate will be increased, but still below the predicted maximum achievable growth rate (at infinite space). In fact, 43% of the difference in growth rate between k = 0.028 and infinite space is not yet reached at k = 0.040. At a space allowance of k = 0.070, the growth rate is only 5% lower than the maximum, compared to the reduction at k = 0.028 (set as 100%).

It should be noted that the analysis above combines the effect of space allowance on the growth rate from a limited number of studies, studies with other limitations in their study designs and an exponential model to describe the relationship. This is subject to considerable uncertainties, which were not quantified. In particular, confounding in some study designs means that additional factors to space allowance may influence the growth rate. Especially the maximum achievable growth rate in the model is only covering the part influenced by space and assumes an average situation of all studies for the other factors. Therefore, the calculations cannot be used to predict the outcome of a specific experiment or observation. They are restricted to the particular effect of space expressed as a k-value.

7.7.2.5. Analysis to explore the relationship between space allowance and tail biting

The effect of space allowance on tail biting behaviour is an area of particular interest in this Specific ToR. As mentioned previously in this SO, there is evidence that reduced space allowance increases tail biting (Munsterhjelm et al., 2015), but this is not always the case (see D'Eath et al., 2014), and further clarity is needed.

Among the publications derived from the ELS, six references (Vermeer et al., 2014; Cornale et al., 2015; Larsen et al., 2018; Brandt et al., 2020; De Almeida et al., 2020; Lakowski et al., 2021) were identified as being particularly relevant for data analysis on the relationship between space allowance and tail biting. These publications reported different measures of tail biting in weaners and rearing pigs.

All of these studies estimated a positive effect of increased space, i.e. a reduction of tail biting prevalence or severity. In the studies of Brandt et al. (2020) and Vermeer et al. (2014), the effect was statistically significant (see Table 57).

Table 57: Results from an extended literature search on tail biting in relation to space allowance. The key word after the '/' in the Reference column relates to the same identified in Figure 26

Reference	Type of pigs	Weight at evaluation	ABM used to measure tail biting	Significant (yes/no: $p < 0.05$)
Brandt et al., 2020/pens	Weaners, rearing pigs	20–110 kg	% pens with tail lesions	Yes
Brandt et al., 2020/60 kg	Rearing pigs	30–60 kg	% pigs per pen with tail lesions	Yes
Brandt et al., 2020/90 kg	Rearing pigs	60–90 kg		
Brandt et al., 2020/110 kg	Weaners, rearing pigs	20–110 kg		
Cornale et al., 2015	Rearing pigs	110 kg[(1)] (31 wks)	% time pigs do tail biting	No

Reference	Type of pigs	Weight at evaluation	ABM used to measure tail biting	Significant (yes/no: $p < 0.05$)
De Almeida et al., 2020/ no	Weaners	21 kg	% pigs with tail injuries	Not presented
De Almeida et al., 2020/ injury	Weaners	21 kg	% pigs with moderate or serious injuries	Not presented
Vermeer et al., 2014/ blood	Rearing pigs	114 kg	% of max tail blood score	Yes
Vermeer et al., 2017/ lesion	Rearing pigs	116 kg	% of max tail lesion score	No
Lakowski et al., 2021/ave	Weaners	22 kg	% pigs with tail lesions	Yes (interaction)
Larsen et al., 2018/ undocked	Rearing pigs	(110 kg[(1)])	% pens with tail damage	Tendency: p = 0.064
Larsen et al., 2018/ docked	Rearing pigs	(110 kg[(1)])	% pens with tail damage	Tendency: p = 0.064

(1): estimated final weight.

Since the studies also showed that the beneficial effect on tail biting decreases with increasing space, it might become negligible at a certain space allowance. Therefore, the following analysis was performed to provide some evidence on this aspect.

In the studies used, the animal-based measurements were taken at either pen level (proportion and severity of tail lesions) or pig level (time of tail biting). These measurements were standardised from 0% (no tail biting) to 100% (maximal effect) to increase their comparability. Figure 26 shows the relation between the (average) space allowance of the study (horizontal axis) and the observed decrease in tail biting as space increased in that study (vertical axis with a logarithmic scale).

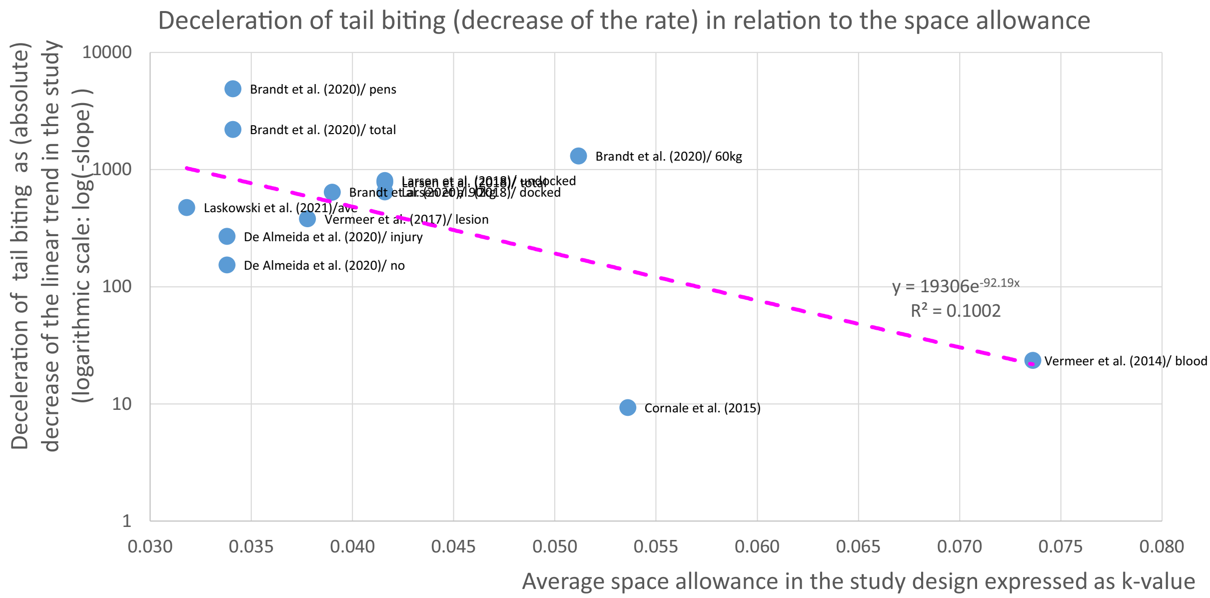


Figure 26: Deceleration of tail biting in relation to the space allowance. Each study is represented by one point, indicating the average k- value of the space allowance treatments and the decrease (the absolute value on a logarithmic scale: log[-slope]) in tail biting associated with increasing space in that study

An exponential model was fitted to the data. This model summarises the effect of space allowance and can be transformed back to the relationship between space and tail biting by the integration of the exponential function.

Nevertheless, the resulting ABM for tail biting is difficult to interpret, as it is a combination of the different ABMs used in the original studies. Therefore, the result is finally standardised between the effect on tail biting at a 'k-value of 0.028' (current legal situation) set as 100% and 'no tail biting' (0%) at infinite space:

$$\text{Relative tail biting} = 209.42 \times \text{EXP}(-92.19 \times k)/15.847$$

The information in Table 58 reflects relative tail biting compared to the current legal situation for selected space allowances expressed as k-values.

Table 58: Relative level of tail biting for selected space allowances expressed as k-values, compared to the current legal situation of k = 0.028 (from the analysis of the data in the literature)

Space allowance as k-value	Tail biting relative to the situation at k = 0.028	m^2 for a 110-kg pig
0.028	100%	0.65
0.030	83%	0.70
0.036	48%	0.84
0.040	33%	0.93
0.045	21%	1.05
0.050	13%	1.17
0.055	8%	1.28
0.060	5%	1.40
0.065	3%	1.52
0.070	2%	1.63

As an example, a k-value of 0.036 (representing 0.84 m^2 for a 110 kg pig) would be expected to almost halve the tail biting shown at a reference k-value of 0.028 (0.65 m^2 for a 110 kg pig), and only 33% of the reference tail biting is expected at a k-value of 0.040 (0.93 m^2 for a 110 kg pig). The model suggests tail biting to be reduced to 5% of the reference value at a space allowance of k = 0.060 (1.40 m^2 for a 110 kg pig).

It should be noted that the analysis above combines the effect of space allowance on tail biting from a limited number of studies, studies with different ABMs on tail biting, other limitations in their study designs, and an exponential model to describe the relationship. The quantification is given as relative space-related effect on a summary measure and is subject to considerable uncertainties. In particular, confounding in some study designs means that additional factors to space allowance may influence the proportion of tail biting. Therefore, the calculations cannot be used to predict the outcome of a specific experiment or observation. They are restricted to the particular effect of space expressed as k-value.

7.7.2.6. Summary of the effects of space allowance

An overview of the evidence presented above is visualised in a summary table (Table 59) with the effects of increasing k-values and its corresponding space (m^2 for a finisher pig of 110 kg) on different aspects of pig welfare. The table combines the effects on behaviours reported in Table 54, the relative reduction of the maximum achievable growth rate (Table 56) and the relative level of tail biting as presented in Table 58.

Table 59: Summary with the effects of different k-values on aspects of pig welfare: the space requirements for performance of certain behaviours or changes in behaviour (see Table 54), the relation to growth rate (based on Table 56) and the relative level of tail biting (see Table 58). The table also presents the calculated m^2 for a 110-kg pig for each of the k-values that are needed to express the behaviour([a]) or changes in behaviour([b]). The reference value (used to standardise within studies) has been highlighted in grey and approximates the current legal minimum. The assumption is that all the other influencing factors are at the level of good practice*

k-value	m^2 for each 110 kg pig (total available space)	Relevance to pig welfare: Effect on Behaviour	Relative effects on growth rate: Suppression relative to the reference value	Relative effects on growth rate: Increase relative to the reference value	Relative effects on tail biting
0.019	0.44	Space required for **sternal lying** (Petherick and Baxter, 1981)[(a)]	188%	–88%	229%
0.028	0.65	**Reference value:** Approximation of the minimum k-value in the current legislation (Council Directive 2008/120/EC)	100%	0%	100%
0.033	0.77	Space needed for all pigs to **lie at thermoneutral conditions** (where 20–40% space sharing will occur) based on an estimated floor area for half recumbent pigs (Ekkel et al., 2003)[(a)]	70%	30%	63%
0.034	0.79	EFSA (2005) reported the evidence of impaired physiological function, live weight gain and food intake of pigs on fully- or partially-slatted floors at k-values of less than this[(b)]	66%	34%	58%
0.039	0.91	Space below which growing-finishing pigs kept on a slatted floor will **start to reduce the % of lying behaviour** in response to the reduction in space (Averós et al., 2010)[(b)]	46%	54%	36%
0.047	1.10	Space required for pigs to **lie separated in a lateral position** (Petherick and Baxter, 1981)[(a)]**	26%	74%	17%
0.072	1.68	Space below which growing-finishing pigs kept on a solid floor will start **to reduce the %** of lying behaviour in respond to the reduction in space (Averós et al., 2010)[(b)]	5%	95%	2%

*: Please note that the calculations cannot be used to predict the outcome of a specific experiment or observation. They are restricted to the particular effect of space expressed as k-value (see text above).

**: Please note this is the space required for full lateral lying as estimated by drawing a rectangular box around the pig, and therefore does include some empty space.

To facilitate the interpretation of Table 59, the following two examples can be used:

A k-value associated with a particular behaviour([a]), is k = 0.047. At this space allowance, a pig can lie separately in a full lateral recumbency and the space required for this can be estimated by drawing a rectangular box around the pig. At this space allowance growth rate is less compromised (estimated as 26% of suppression or 74% of increaserelative to a k = 0.028) and tail biting is reduced (estimated as 17% relative to a k = 0.028). A k-value of 0.028 approximates the current legal minimum space allowance.

A k-value associated with a change of behaviour([b]), is k = 0.039. Below this space allowance, pigs in a fully slatted floor will start adjusting their lying behaviour relative to a higher space allowance. At this space allowance growth rate is less compromised (estimated as 46% of suppression or 54% of increase relative to a k = 0.028) and tail biting is reduced (estimated as 36% relative to a k = 0.028). A k-value of 0.028 approximates the current legal minimum space allowance.

7.7.2.7. Summary conclusions on Specific ToR 4: space allowance

1) If space is insufficient, it will prevent pigs from performing highly motivated behaviours, including exploratory/foraging, social, resting and thermoregulatory behaviours, and from maintaining separate dunging and lying areas. Reduced space allowance promotes damaging behaviours such as aggression and tail biting, and compromises growth (for an estimate quantification, see Table 59).
2) The impact on pig welfare of insufficient space to perform thermoregulatory behaviour is greater at high ambient temperatures where no other cooling mechanisms are in place. The space required to maintain hygiene is lower in fully slatted compared to other floor types and is greater at higher ambient temperatures.
3) A minimum space allowance equal to k = 0.036 (representing 0.84 m^2 for a 110 kg pig) was previously recommended by EFSA (2005) for thermoneutral conditions. At this space allowance, growth rate is less compromised (estimated as 57%) and tail biting is reduced (estimated as 48%) relative to a k = 0.028 (which approximates the current legal minimum space allowance). Please see Sections 7.7.2.2–7.7.2.6 for further explanation.
4) A minimum space allowance equivalent to a k-value of 0.047 (representing 1.10 m^2 for a 110 kg pig), was recommended by EFSA (2005) for temperatures above 25°C or for pigs above 110 kg. At this space allowance, growth rate is even less compromised (estimated as 26%) and tail biting is further reduced (estimated as 17%) relative to a k = 0.028 (which approximates the current legal minimum space allowance) (see Sections 7.7.2.2 and 7.7.2.6 for explanation).

7.7.2.8. Recommendation on Specific ToR 4: space allowance

The minimum space allowance should be increased relative to the current legal requirement to reduce many welfare consequences (e.g. restriction of movement, resting problems, inability to express comfort behaviour, inability to express exploratory/foraging behaviour, group stress, soft tissue lesions and integument damage), thus reducing tail biting behaviour and increasing growth rate.

7.7.3. Types of flooring

7.7.3.1. Introduction

The types of flooring typically used for weaners and rearing pigs are described in Sections 3.3.5.2 and 3.3.6.2 of this SO. Briefly, they consist of fully slatted, partly slatted or solid floored systems. Substrates (e.g. straw or sawdust) may be provided on the solid floor in part-slatted pens and in solid-floor systems. The amount of substrate provided differs between farms, and ranges from a light covering to deep litter (typically in solid-floored systems). Slatted flooring is usually constructed from concrete, metal or plastic, with concrete commonly used with older pigs, and appropriate slat and slot dimensions are stipulated in EU legislation. Solid floors are typically constructed from concrete. Relatively old European data (EFSA, 2005) indicate that 87% of weaner pigs and 91% of fattening pigs are housed in either partly or fully slatted systems.

The effect of floor type on the welfare of weaner and rearing pigs is discussed extensively in EFSA (2005). This indicates a range of welfare consequences potentially affected by floor type, including many that were also identified as highly relevant in Sections 7.1 and 7.4:

- Gastro-enteric disorders: these are reported to be more common on solid floors, particularly when faeces removal is infrequent or inefficient.
- Respiratory disorders: prevalence can be greater with slatted floors due to effects on air quality. This is especially the case if removal of slurry from the building is infrequent, or if air extraction between the surface of the slurry and floor is insufficient. Use of bedding may also contribute to increased airborne endotoxin concentrations due to bacterial and mycotoxin contamination.

- Locomotory disorders: claw and leg injuries may increase in slatted floors if slat and slot dimensions are inappropriate.
- Soft tissue lesions and integument damage: tail biting behaviour and pressure bursae on leg joints are reduced by provision of bedding.
- Heat stress: at high environmental temperatures (e.g. 20–25°C) pigs may prefer to lie on an area where cooling is most efficient, which may be a slatted rather than solid area. The heat production potential of deep bedding can result in heat stress and access to a different floor material is needed at high environmental temperatures.
- Cold stress: at lower temperatures presence of deep bedding provides thermal comfort.
- Inability to perform foraging or exploratory behaviour: a reduced ability to perform these behaviours may result from a lack of bedding material (which is discussed below).
- Resting problems: at temperatures below 18–20°C pigs show a preference to walk and lie on solid floors. When pigs are not heat stressed then lying behaviour is promoted by use of bedding.
- Inability to perform comfort behaviour: insufficient drainage/cleaning of solid floors can lead to a build-up of urine and faeces which reduces the ability of pigs to keep themselves clean.
- Restriction of movement: a build-up of urine and faeces due to insufficient drainage/cleaning of solid floors can lead to wet and slippery floors (and this may restrict movement).

It is clear that there are potential pig welfare advantages and disadvantages with each flooring system, and that the way in which they are managed is key to mitigating adverse effects. Given the extensive information that already exists on the broader effects of floor type on pig welfare, this section will focus on exploring links between floor type and tail biting behaviour in weaners and rearing pigs. Much of the information for this discussion is sourced from O'Driscoll et al. (in press). In addition, in light of moves by several European countries to either phase out or abolish fully slatted floors for pigs, current information on the appropriate level of solid flooring to provide in part-slatted systems will also be discussed.

7.7.3.2. Links between floor type and tail biting

There are a number of ways in which floor type can affect tail biting behaviour. Bedding substrates cannot generally be provided on fully slatted floors because they fall through slats and cause congestion in slurry tanks and pipelines, and also block slats causing hygiene problems. These problems may also limit the amount of bedding provided in part-slatted systems. A lack of bedding means that opportunities to perform exploratory behaviour by pigs are restricted, and Section 3.4.6 in this opinion indicates that redirection of this behaviour towards penmates contributes to tail biting in weaners and rearing pigs. A more detailed discussion on enrichment material and tail biting is presented in Section 7.7.4. Floor type may also affect ammonia levels and air quality, and links between air quality and tail biting are discussed in Section 7.7.5. Although there is little direct scientific evidence, other factors linked to floor type may also contribute to tail biting. For example, disease, poor pen hygiene and stress are risk factors for tail biting behaviour (Nordgreen et al., 2020) and are also recognised as welfare consequences linked to floor type (EFSA, 2005).

While floor type is considered a significant external risk factor for tail biting in pigs (Schrøder-Petersen and Simonsen, 2001; Valros, 2018; Henry et al., 2021), it is often confounded with provision of bedding in studies, making relative effects hard to disentangle. One controlled study without this confound showed greater massaging of pigs by penmates and greater chewing of pen fixtures in fully-slatted than in part-slatted pens, but no difference in tail, ear or feet biting (McKinnon et al., 1989). A number of on-farm epidemiological studies link tail biting to increased use of slatted floors. Moinard et al. (2003) found an increased risk of tail biting on English farms when partly or fully slatted floors were used rather than solid floors in weaning-finishing accommodation. There is also evidence from Belgian farms of increased tail and ear lesions with a greater proportion of slats in the farrowing unit (Smulders et al., 2008), and the risk of tail biting on Finnish farms also increased with an increasing percentage of slatted area in the piglet, weaner and finishing units (Kallio et al., 2018). Some of these studies (e.g. Moinard et al., 2003; Kallio et al., 2018) also indicate associations between floor type and other management factors such as provision of bedding, making it hard to disentangle relative importance.

7.7.3.3. Appropriate level of solid flooring in part-slatted systems

EU legislation states that flooring for pigs should be physically and thermally comfortable, and also clean. While slatted flooring can help to maintain pen hygiene, solid flooring is considered more comfortable for pigs (Larsen et al., 2019a). This is reflected in an increased preference of pigs to lie and stand on solid rather than on slatted flooring (EFSA, 2005; Börgermann et al., 2007). Use of solid flooring also enables the provision of bedding material, which facilitates exploratory and foraging behaviour and can further improve comfort. This suggests that some level of solid flooring should be provided to weaner and rearing pigs, and a number of European countries (Sweden, Germany, Denmark, the Netherlands, Finland and Switzerland) have either abolished or are phasing out the use of fully-slatted flooring (Mul et al., 2010; Commission Recommendation (EU) 2016/336).

Given the pig welfare benefits, it seems reasonable that the maximum solid floor area that does not compromise pen hygiene should be provided in part-slatted systems. Research findings on hygiene implications of different proportions of solid flooring are limited. Spoolder et al. (2002) found that keeping finishing pigs (housed at 1 m^2 per pig) on 60% solid flooring compromised pen hygiene relative to 40% solid flooring. For fattening pigs housed at 0.7 m^2 per pig, providing 0.3 m^2 of that space (43%) as solid convex flooring did not cause problems with pen hygiene, but the authors suggested increasing this to 0.4 m^2 (57%) would not be acceptable (den Brok and Voermans, 1995). There are a number of risk factors for pen fouling, including environmental temperature (Nannoni et al., 2020). Controlling these risks is likely to be key in maximising the proportion of solid flooring that can be provided while maximising hygiene in commercial systems.

While more controlled research on the pen hygiene implications of different proportions of solid: slatted flooring is required, industry guidelines/standards provide some insight into what is deemed commercially feasible. For example, industry guidelines in Finland recommend a minimum of 50% solid flooring in growing and finishing pens (O'Driscoll et al., in press). In Sweden, solid flooring is required in 62–75% of the total floor area depending on pig live weight (Wallgren et al., 2019). Although termed 'solid', in commercial practice, this type of flooring may also contain some slots for drainage. There is not a uniform definition of the degree of perforation which is acceptable in a floor deemed to be solid. Effects of different degrees of perforation of solid flooring on pig comfort and on the amount of 'traditional' slatted flooring required to maintain hygiene appear largely unknown.

An alternative approach to designing part-slatted pens would be to determine the minimum solid floor area required by pigs for lying as a starting point. The remaining slatted area for activity, feeding/drinking and elimination should then be determined by what is required to facilitate these behaviours and maintain pen hygiene. This approach may result in a greater overall space requirement than is currently in place. Section 7.7.2 indicated that a space allowance equivalent to a k-value of 0.033 was sufficient to accommodate lying under thermoneutral conditions.

7.7.3.4. Summary conclusions on Specific ToR 4: types of flooring

1) Provision of some solid flooring will increase comfort and facilitate provision of bedding substrates.
2) The minimum solid floor space allowance estimated to accommodate lying behaviour under thermoneutral conditions is equal to a k = 0.033 (equal to 0.77 m^2 for a 110-kg pig).
3) Tail biting risk is increased with increasing proportion of slatted flooring.
4) Maintenance of hygiene on the solid flooring is important and can be influenced by the proportion of solid to slatted flooring, but also by the pen layout, the nature of the airflow patterns and ambient temperature.
5) Because of these complications, it is currently not possible to define an area or percentage of solid floor in a partly slatted system, which reconciles the possibly conflicting requirements of pig behaviour and hygiene.

7.7.3.5. Recommendations on Specific ToR 4: types of flooring

1) Pigs should have a solid floor area equivalent to a k-value of 0.033 (equal to 0.77 m^2 for a 110-kg pig) to accommodate lying behaviour (under thermoneutral conditions), with additional space for activity, feeding/drinking and elimination.
2) Further research should be carried out to:
   a) Validate strategies for maintaining hygiene in partly slatted pens.
   b) Determine the effect of different degrees of perforation of the solid floor on pig comfort and pen hygiene.

7.7.4. Enrichment material

7.7.4.1. Introduction

Absence or inadequate access to appropriate enrichment/foraging material is a hazard for the welfare consequences 'Inability to perform exploratory or foraging behaviour', 'Soft tissue lesions and integument damage' and 'Group stress' in both weaners (see Sections 7.1.1, 7.1.2 and 7.1.4) and rearing pigs (see Sections 7.4.3, 7.4.4 and 7.4.6). EU legislation requires that pigs must have 'permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities, such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such' (Directive 2008/120/EC). De Briyne et al. (2018) carried out an online survey to investigate the situation regarding the practice of pig tail docking and the provision of enrichment material in Europe. They reported that only 67% of pigs across the 24 EU MS surveyed were said to be given suitable enrichment materials. Interestingly, this percentage was significantly higher in countries where no or few pigs (up to 5%) are tail-docked (mean 89%) compared to countries where most pigs (70% or more) are tail-docked (mean 63%).

In this section, the effect of enrichment material on the risk of tail biting in weaned and growing pigs is considered. The most common types of enrichment for pigs are organic substrates provided as bedding (e.g. straw or wood shavings), organic substrates provided in dispensers (e.g. long-cut straw in a rack or straw pressed into a block) and point-source enrichment-objects (e.g. hanging wooden blocks or chewable plastic toys). These stimulate investigative and manipulatory behaviour and give pigs some control over their environment. Moreover, such materials are used as corrective enrichment to overcome tail biting outbreaks. The effectiveness of different enrichment materials in reducing the risk of tail biting has been described in detailed reviews (EFSA, 2007; Van de Weerd and Day, 2009; D'Eath et al., 2014; Buijs and Muns, 2019; Buijs et al., in press) where the full list of scientific references which support the key points summarised below can be found.

In addition, EFSA experts discussed the ranking of different enrichment materials based on the evidence presented below and personal experience, considering the attractiveness of the materials to stimulate investigation and manipulation activities and, hence, their putative effectiveness in reducing the risk of a tail biting outbreak.

In housing conditions for weaners and growing pigs where there is inadequate enrichment material, appetitive foraging behaviour (nosing, rooting, chewing and biting) is directed to pen mates and especially to their tail. When tails are damaged and blood is present, they may become even more attractive for investigation, resulting in intense and focused biting behaviour. Consequently, tail biting can spread quickly within the group. In experimental studies, the incidence of tail damage, the frequency of tail-directed behaviours or, as a proxy, the time spent interacting with the enrichment is measured to assess the effectiveness of different enrichment materials for reducing tail biting.

In the case of a tail biting outbreak, enrichment is used as a remedial method on commercial farms. In an experimental study, provision of long straw on the solid floor (20 g/pig per day) lowered the percentage of pigs with fresh blood on the tails in the days following a tail biting outbreak, although tail biting still persisted. Also, adding hemp ropes was found to mitigate tail biting outbreaks. To be effective, the corrective enrichment used should be stimulating for the pigs. Therefore, chewable, destructible and ingestible enrichment material is recommended. Chopped straw (around 7 g/pig per day) provided on the floor was more effective than interventions with point-source enrichment-objects (hanging plastic toy, rope) in curbing an escalation of tail biting.

Enrichment materials that are attractive to pigs can also form a biosecurity risk. With point-source enrichment objects, safety concerns focus on the object itself being unsafe, for instance by causing injuries when swallowed (e.g. pieces of synthetic rope) or bitten (e.g. metal strips in tyres). For organic substrates, the main concerns are around contamination of the substrate with harmful pathogens (e.g. viruses, mycobacteria or other bacteria, high levels of mycotoxins). To avoid health problems in the pigs, the origin, hygiene and quality of organic substrates should be managed. At the present time there is particular concern on the role of bedding material in spreading ASF (EFSA, 2020).

7.7.4.2. Assessment of the types of material

Organic substrates provided loose

Compared to other organic substrates (e.g. hay, silage, grass, beets, peat and sawdust) straw provided as bedding has been studied the most. It is most effective in large quantities, although smaller quantities can still reduce tail biting. In studies comparing different amounts of straw, time spent exploring and manipulating straw rather than other pigs increased with straw quantity. However, tail biting occurred at very low levels in these studies, even in treatments with only 20 g/pig per day (undocked pigs) or 10 g/pig per day (docked pigs). Whilst an amount of 80 g/pig per day appears to be sufficient to ensure that some straw is left when the next day's ration is provided, the beneficial effects of straw continue to rise until ~ 400 g/pig per day. To reduce the risk of blocking the slats and slurry system in pens with fully or partly slatted flooring, straw is usually chopped into smaller pieces when provided as bedding. However, chopping straw affects the way the pigs can interact with it (e.g. shred the straw into small pieces), compared to long straw. This potentially explains why some studies found that chopped straw was less effective at reducing tail biting.

Several less-studied substrates seem at least as effective as straw, offering opportunities where straw is unavailable. Alfalfa hay, maize silage, mushroom compost and beets have been shown to reduce tail biting, and maize silage was shown to outperform chopped straw in its effectiveness. Moreover, a mixture of chopped straw and wood shavings was found to be effective at reducing tail damage. In a choice test, pigs preferred chopped straw mixed with maize silage over straw, possibly because it contained components with a higher nutritional value. Preference tests also suggested that pigs prefer peat, mushroom compost or sawdust as a medium to root in rather than straw.

Organic substrates provided in dispensers

To prevent straw from falling down the slats too quickly, it can be put into racks or offered in dispensers. In the latter case, the straw is usually chopped or pressed into compact straw blocks. This means that the pigs have to work to get the straw out before they can interact with it. Besides straw, other organic substrates can be offered in a dispenser. For example, pigs spent more time exploring a dispenser filled with chopped hay than when it was filled with chopped straw. However, providing minimal quantities of substrate as pressed blocks or in dispensers was only rarely found to reduce tail biting. In addition, offering straw in a dispenser or rack means that competition may occur as these are often not large enough for several animals to interact with simultaneously. In experimental studies, provision of straw in racks was found to reduce tail damage compared with a rubber hose, chain or hanging toy. Importantly, racks and dispensers provide only a limited supply of substrate if they are not topped up regularly.

Point-source enrichment-objects

Van de Weerd et al. (2006) first termed 'point-source' enrichment-objects, which are objects that are 'often restricted to a single location in a pen and they are limited in size, in that they generally do not allow all animals in a group simultaneous access.' Examples of point-source enrichment-objects are plastic balls, hessian sacks, wood posts provided in a vertical or horizontal position, car tyres, plastic biting toys, or metal chains. These items can be provided by hanging on the side/in the middle of the pen, loose/fixed on the floor of the pen or fixed on the pen walls. As they are limited in size, usually only a single pig can interact with the object at one time, which may increase competition. Consequently, interaction with point source enrichment has been reported to increase when more objects were provided. However, scientific information on how many point-source objects need to be provided to reduce tail biting is lacking. In addition, maintaining hygiene of the objects is also important as items covered in faeces may decrease pigs' interest quickly.

In a recent review (Buijs and Muns, 2019), no evidence was found that processed wooden, plastic or metal objects that are not exchanged regularly reduce tail biting. This is especially true when such objects are provided to undocked pigs. Novelty seems to be an important factor. In an experimental study (van de Perre et al., 2011), tail damage in docked pigs was reduced when they were offered a different hanging item every week (in total seven items tested) compared to pigs that only received a hanging metal chain. In line with this finding, Van de Weerd and Day (2009) recommended that objects such as chains are not to be recommended for long-term use, as they can quickly lose their novelty factor. Conversely, fresh wood and hessian sacks were found to reduce tail biting to some extent. Comparing different wood species and a floor toy made from natural rubber, Chou et al. (2020b) observed that time spent using enrichment was higher in pigs with spruce (Picea sitchensis) and rubber toy than with larch (Larix decidua), and beech (Fagus sylvatica), and that tail lesion scores were higher in pigs with spruce compared to the other materials.

7.7.4.3. Ranking of the enrichment materials that can be used to reduce tail biting

Taking into account both scientific evidence (Bracke et al., 2006; D'Eath et al., 2014; Buijs et al., in press) and expert opinion, EFSA experts suggested the following ranking of different enrichment materials in terms of attractiveness and likely efficacy in reducing tail damage:

1) organic materials (e.g. mushroom compost, peat, green forages and silages) or straw mixed with maize silage, stimulate more investigation and manipulation activities than,
2) long-cut straw offered as bedding,
3) chopped straw offered as bedding,
4) straw provided in a rack,
5) straw pressed into a block from a dispenser that requires extensive manipulation to obtain the substrate,
6) destructible point-source materials provided loose on the floor or fixed on the pen walls (e.g. fresh wood, hessian sacks, jute ropes, floor toys made from natural rubber) were considered to be less attractive, as these materials become soiled and thus less interesting over time if they are not renewed regularly, and
7) not edible point-source enrichment-objects made of plastic or metal (i.e. hanging toys, plastic hoses and chains).

7.7.4.4. Summary conclusions on Specific ToR 4: enrichment material

1) The AHAW Panel considers loose organic substrates, such as straw, hay and silage, more effective in reducing tail biting than (a) enrichment materials which are suspended from a ceiling or fixed to a wall, and (b) pressed straw blocks and dispensers that require prolonged manipulation to obtain the substrate.
2) Of all objects on the floor or fixed on the wall, jute bags and fresh wood can be effective in reducing tail biting whereas other objects (e.g. rubber toys) are not as effective, unless replaced regularly to maintain novelty.
3) The competition caused by limited amount and availability of enrichment materials reduces the effectiveness of the enrichment to reduce tail biting.
4) A reduction in tail biting can be achieved in undocked pigs if they are offered 20 g per day of loose organic substrates. However, quantities that are larger (e.g. up to 400 g/pig per day) are more effective.
5) A reduced interest of pigs in the enrichment due to soiling limits the effectiveness of the enrichment to reduce tail biting.
6) The effects of tail biting outbreaks can be mitigated by using attractive organic substrates.
7) Hygiene and quality criteria of organic enrichment are important to avoid biosecurity risks.

7.7.4.5. Recommendations on Specific ToR 4: enrichment material

1) All pigs should be provided with effective enrichment (as described in conclusions) to reduce the risk of tail biting.
2) In case of an outbreak of tail biting, novel attractive organic substrates should be immediately provided.
3) Enrichment choice should consider hygiene and quality criteria to avoid biosecurity risks.

7.7.5. Air quality

7.7.5.1. General introduction

Poor air quality has been identified as hazard for the welfare consequence 'respiratory disorders' (see Section 7.4.7), but in this section we particularly consider it in relation to the risk of tail biting.

Different elements of the housing environment are interlinked and can converge to increase the risk of tail biting (reviewed by O'Driscoll et al., in press). If the ventilation system is inadequate, air temperature may vary very unpredictably and levels of different gases in the environment of the pigs may increase. Therefore, several different environmental changes may be confounded. Both extremes and variability in temperature, although not strictly air quality parameters, are known risk factors for tail biting. This has been the subject of a recent detailed review (O'Driscoll et al., in press), where the full list of scientific references which support the key points summarised below can be found.

Poor air quality with high levels of dust and noxious gases, consequent on inadequate ventilation, is another risk factor category for tail biting (EFSA, 2014). Also, according to surveys on the opinions of pig farmers in various European countries, air flow and quality is almost always considered one of the top risk factors for tail biting (as reviewed by O'Driscoll et al., in press).

7.7.5.2. Ventilation and air flow patterns

The nature of the ventilation system may contribute to the appearance of tail biting. Draughts increase activity levels of pigs (Scheepens et al., 1991): they stimulate e.g. aggression and excessive rooting. They may also increase tail biting (Sallvik et al., 1984; Holling et al., 2017). Commonly used ventilation systems are natural ventilation, artificial controlled natural ventilation, and mechanical forced ventilation. Sometimes they are used in combination. Some epidemiological studies (Scollo et al., 2016; Pandolfi et al., 2017) suggest that the type of ventilation system does not have an effect on the risk of tail biting. Others disagree: Hunter et al. (2001) suggested that natural ventilation reduces the risk of tail biting compared with artificially controlled natural ventilation and combined systems. This effect was stronger in undocked pigs.

7.7.5.3. Composition of the atmosphere

Levels of many different noxious gases (e.g. ammonia, carbon dioxide, hydrogen sulfide) will increase if the ventilation rate is too low. In the case of ammonia, the rate of production can also be additionally affected by management and housing conditions. Ammonia (NH_3) is a gas with a very sharp odour. A major source of ammonia emission is the breakdown of urea, which is excreted via urine. Urea is converted into NH_3 and carbon dioxide by the enzyme urease, present in faeces. The most important factors affecting this process are the urinary urea concentration, pH, slurry temperature and the area polluted with urine and faeces in pig pens. Ammonia volatilisation is a process that depends on factors such as concentration of NH_3, air speed in the building and NH_3 and dry matter content in the manure.

In pig facilities, high concentrations of NH_3 result in respiratory problems like coughing and sneezing (Scott et al., 2007b), increased respiration rate, irritation of the mucosa lining the respiratory tract at concentrations exceeding 15 ppm (Banhazi et al., 2008). Ammonia levels of 50 ppm for three hours can produce coughing; eye, mouth and nose irritation; and poor weight gain and feed intake in pigs (Colina et al., 2000). At levels of 50 ppm and above, the clearance of bacteria from the lungs is also impaired and therefore the animal is more prone to respiratory disease (Colina et al., 2000) and an increased incidence of pneumonia has been observed (Stärk, 2000). Although the current standard for safe NH_3 levels is 25 ppm, recent research reports indicate that maintaining a level of no more than 10 ppm may help prevent health risk in both pigs and humans (Colina et al., 2000). Ammonia is also a risk factor for low body weight (Drummond et al., 1980) most likely due to reduced feeding behaviour (von Borell et al., 2007). Furthermore, air quality is also a risk factor for post-weaning digestive disorders (Madec et al., 1998).

A high carbon dioxide (CO_2) concentration may also have detrimental effects on respiratory tract health (see review of Boyle et al., 2022). Respiratory disorders are themselves considered risk factors associated with tail biting (Kritas and Morrison, 2007; van Staaveren et al., 2016).

Some experimental studies reported how pig react to different concentrations of harmful gases in the air in relation to tail biting. In experimental studies testing pigs' preferences, Smith et al. (1996) found that pigs avoid compartments with high levels of NH_3, and Raj and Gregory (1995) showed an aversion to CO_2. Already in 1969, Van Putten reported an outbreak of tail biting by reducing ventilation, resulting in 0.30% of CO_2 and NH_3 at 0.17%, in 16–17 week old rearing pigs (Van Putten, 1969). However, these studies are not easily reproducible, and may give inconsistent results: Ewbank (1973) did not find any tail biting in a two-day study with pigs kept in a room at 21°C, with 0.13% of CO2 and 80+ ppm of NH_3. In humans these concentrations provoke mild eye irritation.

In relation to tail biting, epidemiological studies demonstrated that a higher risk of tail biting was associated with poor perceived air quality and NH_3 higher than 10 ppm (Scollo et al., 2016). The concentration of $NH_3$was confirmed to be an important risk factor for tail biting when analysing the same data set with a regression tree model, which showed that $NH_3 > 28$ ppm (seen on only a single farm) increased the frequency of tail biting to 3.8% in comparison to 0.21% at lower levels (Scollo et al., 2017).

7.7.5.4. Summary conclusions on Specific ToR 4: air quality

1) Ventilation inadequacy may affect several different aspects of air quality including air speed, temperature and the concentration of gases (i.e. NH_3 and CO_2). All of these factors pose a risk to tail biting and other welfare issues (e.g. respiratory disorders, eye disorders and aversion).
2) Specific thresholds at which ammonia levels detrimentally affect respiratory health and the risk of tail biting are difficult to define because of many interacting factors. However, levels exceeding 10–15 ppm may be considered a risk factor for health-related disorders.

7.7.5.5. Recommendations on Specific ToR 4: air quality

1) To prevent health-related welfare consequences (respiratory disorders, eye disorders), and aversion, related to high temperatures and concentration of gases, buildings should be designed and equipped to guarantee correct ventilation. This would also contribute to prevention of tail biting.
2) The design and management of buildings should ensure regular manure removal and good hygiene in pens.
3) Buildings should be designed and managed to guarantee that the level of ammonia is kept below 10–15 ppm.

7.7.6. Health status

7.7.6.1. Introduction

There are many different health issues that may affect pigs.

The health-related welfare consequences that EFSA experts considered highly relevant for weaners and rearing pigs were assessed elsewhere in this opinion (see Sections 3.4, 7.1 and 7.4) and are listed in Table 60. In this SO, specific pathogens or diseases are not discussed, but rather general categories of health disorders.

Table 60: Health related welfare consequences considered highly relevant for weaners and/or for rearing pigs by expert opinion, and indication of the section of this opinion where more information is provided

Health related welfare consequence	Weaners	Rearing pigs
Locomotory disorders (including lameness)	–	Section 7.4.5
Soft tissue lesions and integument damage	Section 7.1.4	Section 7.4.6
Respiratory disorders	–	Section 7.4.7
Gastro-enteric disorders	Section 7.1.5	–

Relevant outcome tables linking these welfare consequences to the hazards of different husbandry systems are provided in Sections 7.2 for weaners, and 7.5 for rearing pigs.

Other health-related welfare consequences may negatively affect the welfare of weaners and rearing pigs, but they were considered of minor or moderate relevance compared to the highly relevant ones (see Section 2.2.2.1 and an overview of the expert judgement in Appendix B)

The European Commission mandate specifically asked for the relationship between health status and tail biting. This is addressed in the following sections.

7.7.6.2. Cause- effect relationship between health status and tail biting

The link between tail biting and decreased health condition/poor welfare is very complicated. It goes in both directions, i.e. health status causing tail biting /tail lesions and tail biting behaviour leading to poor health status. Considerations to answer three main questions are reported in detail in the review of Boyle et al. (2022), and summarised in the following sections:

1) Can we demonstrate that a poor health status may cause tail biting?
2) Do we have evidence that tail biting causes health problems?
3) Can we demonstrate that health status and tail biting are linked to the same risk factors?

7.7.6.3. Does poor health cause tail biting?

Findings of the review of Boyle et al. (2022) support a causal relationship that generalised poor health (e.g. enzootic pneumonia) on farms also poses an increased risk of pigs performing tail biting or other damaging behaviour. Numerous studies describe an association between tail lesions and different lesions of the respiratory tract; pleurisy (Elbers et al., 1992; Teixeira et al., 2016), pneumonia (Elbers et al., 1992; Teixeira et al., 2016; Pandolfi et al., 2018) and lung abscesses (Elbers et al., 1992; Sanchez-Vazquez et al., 2010; Pandolfi et al., 2018). It not possible to determine causality simply from association, but pigs with subclinical respiratory disease were more prone to bite the tails, which supports this (Munsterhjelm et al., 2017).

A poor health condition or suffering from chronic stress could also be reasons for sudden spreading of tail biting. Animals that feel unwell and/or stressed, experience an immune reaction and altered metabolic state (Nordgreen et al., 2018, 2020). This may lead them to increase manipulatory behaviour of their pen-mates (Fritschen and Hogg, 1975; Munsterhjelm et al., 2017, 2019) and also make them prone to be bitten. Sickness causes pigs to respond less to general manipulation by their pen mates, thereby placing them at higher risk of injury (Munsterhjelm et al., 2017, 2019).

There are also many anecdotal reports of increased tail biting following an outbreak of diarrhoea or enteric disease in weaners. In fact, on the role of poor health status in causing tail biting, Nordgreen et al. (2020) suggest that immune activation could be a major factor influencing social interactions in pigs, with outbreaks of damaging behaviour such as tail biting as a possible result. The hypothesis presented in the paper is that the effects of several known risk factors for tail biting are mediated by pro-inflammatory cytokines, proteins produced by the immune system and their effect on neurotransmitter systems. Increase of inflammation (measured by increase of cytokines expression in the brain) has been hypothesised to increase the risk for tail biting. These changes in the brain can persist also in time and influence tail biting at later stages. That could be the mechanism that links health status and presence of observed or subclinical disease with tail biting.

Additional evidence that poor health causes tail biting comes from intervention studies where vaccination was employed to reduce a herd health problem. Oral vaccination against Lawsonia intracellularis resulted in a reduction of problems associated with cannibalism compared to unvaccinated pigs (Almond and Bilkei, 2006). Similarly, a UK epidemiological study suggested that vaccination against PCV2 reduced tail biting risk (AHDB, website),[30] and this has also been reported as effective in the reduction of ear necrosis syndrome, although it is unknown if this was mediated by a reduction in injurious biting (Pejsak et al., 2011; Papatsiros, 2012).

Vom Brocke et al. (2019) found a correlation between tail lesions and bursitis. Niemi et al. (2011) observed that tail-bitten pigs were more often lame (20% of individuals were lame), compared to non-bitten pigs (9% lameness). In the same study, on average, lameness in pigs was diagnosed 3.7 days before a pig was diagnosed as having a bitten tail. This suggests a causal relationship.

7.7.6.4. Does Tail biting cause poor health?

It is argued that tail biting may cause or spread disease. This can either be done directly, when biters infect bitten pigs. It can also be done indirectly, when pathogens enter the body via the bitten tail.

Both Karlsson et al. (2013) and Clegg et al. (2015) found a spread of *Treponema* spp. through tail biting. *Treponema* spp. may be present in skin lesions and in gingiva. Once tail lesions are infected, systemic spread of the pathogen may occur via the blood to the lungs, and possibly via the lymphatic system (Sihvo et al., 2012).

The spread of pathogens from the bitten tails might also cause pyaemia (Sanchez-Vazquez et al., 2012) and abscesses especially in the spinal area (Valros et al., 2004). It may also cause embolic pneumonia (Kritas and Morisson, 2007; Marques et al., 2012).

Niemi et al. (2011) suggested that the risk of health problems is 1.8 times higher in tail-bitten pigs compared to non-bitten pigs.

7.7.6.5. Risk factors shared between tail biting and health problems

There are common risk factors for tail biting and several health problems. Risk factors for poor health can be subdivided into two main categories. The first category consist of non-infectious factors. These include animal characteristics and aspects of management such as climatic conditions, diet,

[30] https://webhat.ahdb.org.uk/browse-all-risks#wosubstrate

group composition, space allowance and the level and type of enrichment (Fablet et al., 2012a,b; Prunier et al., 2010, 2021). These factors may be involved when animals receive physical injury or are subjected to psychological stress. An example is keeping pigs on slatted floors without bedding. This is generally linked to an increased risk of tail biting as well as a higher incidence of lameness (Scott et al., 2006) (see Section 7.7.4).

The second category includes the infectious diseases, which involve exposure to pathogens related to respiratory and digestive disorders as well as a reduction of robustness of animals to deal with a disease challenge. Examples are insufficient space allowances that can affect both the health status of the animals and the behaviour of tail biting. Low space allowances may lead to pigs expressing exploratory behaviour towards penmates, as reported by several authors (e.g. Moinard et al., 2003; Bracke et al., 2004). Similarly, a low space allowance increases the risk of health problems, including respiratory disease (Stärk, 2000), clinical leg weakness and claw disorders (Jorgensen, 2003), swine dysentery (Burrough, 2017), and non-specific colitis (Kavanagh, 1992) (see Section 7.7.2).

Air quality is also known to be a risk for tail biting, whilst at the same time airborne pollutants (toxic gases, particulates, and airborne microorganisms) are associated with increased susceptibility to respiratory diseases, stress and decreased pig productivity (Cleveland-Nielsen et al., 2002; Michiels et al., 2015; Roque et al., 2018). As an example, NH_3 has been suggested to induce damaging behaviours including tail biting (Smith et al., 1996; Wathes, 2002) (see Section 7.7.5).

Finally, there is some (anecdotal) evidence that low feed quality and the presence of mycotoxins are risk factors for tail biting, because of their immunosuppressive effect (Pierron et al., 2016). Several authors have suggested that the intake of mycotoxin-contaminated feed increases the susceptibility to infectious diseases, whilst decreasing vaccine efficacy (e.g. Antonissen et al., 2014; Savard et al., 2015; Pierron et al., 2016). It is also implicated in reactivation of chronic infections.

7.7.6.6. Summary conclusions on Specific ToR 4: health status

1) Poor health status is a risk factor for tail biting.
2) Tail biting and health problems are often found jointly on a farm both because tail biting can cause health problems and because they share several common risk factors.
3) Preventive, corrective and mitigating measures on health disorders will also have a positive effect on tail biting and *vice versa*.

7.7.6.7. Recommendations on Specific ToR 4: health status

1) Farm health status should be maintained at high level to minimise tail biting risk and other welfare consequences.
2) In the case of tail biting outbreaks, checks for underlying health problems should be made.
3) Tail biting outbreaks should be rapidly addressed to prevent further health problems.

7.7.7. Diet composition

7.7.7.1. Introduction

A deficiency or imbalance in the supply of energy, macronutrients and micronutrients in the diet of pigs is a hazard for many different welfare consequences. This is because diet composition can influence the growth and integrity of all body tissues, the metabolic processes of the body, the function of the immune system in mitigating disease challenge and the processes in the brain which regulate cognition and mood.

In this section, the effects of diet composition on the risk of tail biting in weaned and growing pigs is considered. Surveys conducted in many countries have reported that farmers rank deficiencies in feed composition and method of provision as among the most important risk factors for outbreaks of tail biting. This has been the subject of a recent detailed review (Edwards, in press) where the full list of scientific references which support the key points summarised below can be found. Although this section is about diet composition, it should be noted that the amount of feeding space provided is also a very important risk factor for tail biting and further detailed information on this topic is also available in Edwards (in press).

One of the important causes of tail biting is the redirection of appetitive foraging behaviour (nosing, rooting, chewing and biting) to other pigs in the group. This occurs in an impoverished environment in which such behaviours have no other functional means for expression to reduce the feeding motivation which an animal is experiencing. The pig is an omnivore and has evolved sophisticated mechanisms to balance its dietary inputs in a way that matches nutrient intake to nutrient requirements for optimal growth and body function at any given phase of life. Experimental studies of voluntary feed intake and diet choice show that the pig can detect metabolic deficiencies in energy, protein, individual amino acids, minerals and micronutrients. This will give rise to a state of general hunger or specific hunger for a deficient dietary element, which will increase feeding motivation and initiate the appropriate behavioural response of appetitive foraging. Hungry pigs will thus show increased penmate-directed oral behaviours when housed in an environment offering limited foraging substrate, and such behaviours are frequently directed towards the tail as 'tail-in-mouth' behaviour. This can eventually lead to lesion and bleeding of the tail, which stimulates greater interest and chewing activity from both the initial perpetrator and from other animals in the group, and a rapidly escalating tail biting outbreak then results.

7.7.7.2. Dietary minerals

It has been suggested that pigs may develop a specific attraction to blood because of its content of minerals, particularly sodium. For this reason, a stress-induced increase in sodium excretion and dietary demand has been proposed as a unifying mechanism for the effect of many different environmental stressors on tail biting risk. This idea is supported by the frequently reported efficacy in reducing tail biting problems by increasing dietary salt inclusion or by providing additional salt as mineral blocks, by sprinkling on the floor or as an aqueous solution. However, it has not been possible to experimentally substantiate this mechanism and it cannot be the sole explanation for all dietary effects on tail biting.

7.7.7.3. Dietary protein

Another nutrient category which has been frequently associated anecdotally with tail biting and has been the focus of much research is dietary protein. Deficiencies or imbalances of some key amino acids (e.g. tryptophan, phenylalanine and tyrosine) can impair the synthesis of brain neurotransmitters involved in the regulation of feeding behaviour, exploration and mood. This can exacerbate conditions predisposing biting and has been suggested to contribute to the development of pathological obsessive tail biting which can be seen in individual pigs. Specific amino acid requirements are increased by fast growth or high genetic lean growth potential, which has been demonstrated to be a risk factor for tail biting. At the same time, pressures on farmers to decrease dietary protein content, in order to reduce environmental pollution arising from nitrogen excretion, make it more likely that deficiencies may occur in such animals. Amino acid imbalances may also be induced by health challenges and gut inflammatory conditions, because the profile of amino acids required to synthesise immune proteins differs from that for lean tissue growth which is the usual basis for diet formulation. Furthermore, immune activation and the production of pro-inflammatory cytokines can modify tryptophan metabolism and availability for neurotransmitter synthesis (Nordgreen et al., 2020). A change in health status of pigs can therefore modify metabolic requirements and induce deficiencies in specific amino acids, stimulating penmate-directed oral behaviours in pigs and leading to increased injurious biting.

7.7.7.4. Dietary energy

Irrespective of diet composition, an inadequate feed allowance will increase hunger and cause both increased foraging motivation and competition for any available feed. This can lead to frustration-induced tail biting if individuals are thwarted in feed access or fail to receive an anticipated feed delivery. A similar outcome can result from the delivery of daily feed in many small meals which fail to induce satiation. However, even when fed ad libitum, the composition of the diet may result in inadequate intake to satisfy metabolic needs if the nutrient density is too low and intake is limited by dietary bulk. This situation may arise in younger pigs or those selected for high feed conversion efficiency where gut capacity can be reduced. A low nutrient density diet will also increase the feeding time required by each individual to achieve satiation, which may result in inadequacy in the provision of feeding space and frustration-induced tail biting. Inadequate feeding space has been identified as one of the most important risk factors for tail biting. The amount of feeding space necessary to prevent competition depends on whether the diet is fed at restricted or ad libitum level. It also depends on the form of the diet which affects eating speed, with liquid diet eaten very quickly and meal diet eaten more slowly than pellets.

A low nutrient density diet is usually associated with inclusion of high levels of dietary fibre, which is relatively indigestible in the pig and must be broken down by the activity of gut bacteria, suggesting that extreme inclusion levels should be avoided in high-risk pig categories. However, dietary fibre can make a positive contribution to feeling of satiation, ulcer reduction, gut health, toxin binding and microbiome modification which may be beneficial for tail biting risk. At present, there is inadequate knowledge to quantify any recommendation on inclusion of the diverse fibre types and further research is required.

7.7.7.5. Other hazards relating to diet formulation and processing

Whilst there are many reports that various dietary raw materials constitute a risk for tail biting (see Edwards (in press) for a detailed discussion), these are generally from single epidemiological studies or anecdotal in nature. Thus, high inclusion of wheat, especially of varieties carrying the rye gene, will increase risk of gut inflammatory conditions. Cereals may also be contaminated with mycotoxins, which can have proinflammatory effects. Many vegetable proteins also contain antinutritive factors, such as tannins, metal chelators, protease inhibitors, indigestible oligosaccharides and antigenic proteins, which might adversely affect nutrient bioavailability or compromise gut health. Furthermore, whey and other by-products from human food processing have more variable nutrient composition which increases risk of formulation errors and dietary imbalances. It has also been anecdotally reported that tail biting outbreaks have been linked to abrupt changes in diet composition, possibly through effects on digestive upsets or disrupted feed intake. However, an association with diet change might also reflect the fact that diets will be least well matched to needs immediately after a transition between stages, especially when the diet for each stage is formulated on the basis of average nutrient requirement over a wide weight range. The risks arising from these reported effects of raw materials and diet changes can be mitigated by careful diet formulation using good databases of nutrient composition, supported by laboratory analyses.

The form in which the diet is fed, including the processing which it has undergone, is another frequently cited risk factor for tail biting and may interact with diet composition. Whilst the data are far from unanimous, and there is often confounding between diet form and method of feed delivery (between, e.g. liquid and dry feed), it seems consistent that feeding a pelleted diet increases tail biting risk. This may be associated with the fact that pelleting, particularly of diets with small particle size and high arabinoxylan content, is a known risk factor for gastric ulceration and colitis, which can give rise to gut inflammatory responses.

7.7.7.6. Summary conclusions on Specific ToR 4: diet composition

1) Deficiencies in feed composition and method of provision (such as feeding space) are major risk factors for tail biting.
2) Correct formulation of diets to minimise tail biting risk must take account of the growth stage, genetic potential and health status of the animals, with particular attention to amino acid and mineral composition.

7.7.7.7. Recommendations on Specific ToR 4: diet composition

1) Professional nutritional advice should be taken to correctly formulate diets.
2) Dietary raw materials should be analysed for nutrient composition, stored correctly and free from contamination.
3) Pigs should have adequate feeding space to avoid competition for access, taking account of feed form (as it affects eating speed), diet density and delivery system.

7.8. Summary conclusions on the welfare of weaners and rearing pigs

7.8.1. Summary conclusions from General ToRs

1) The highly relevant welfare consequences experienced by **weaners in indoor group housing** are group stress, inability to perform exploratory or foraging behaviour, soft tissue lesions and integument damage and gastro-enteric disorders. Other welfare consequences may negatively affect the welfare of weaners; however, were not classified as highly relevant (see Appendix B). Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 7.2.
2) The highly relevant welfare consequences identified for **weaners kept in indoor systems with access to an outdoor area** are the same identified in the case of weaners kept in indoor group housing; however, the magnitude of the welfare consequences that the animals in the two systems experience may be different as the access to an outdoor area gives the potential for greater space and environmental complexity.

3) The highly relevant welfare consequences identified in the case of **weaners housed in outdoor paddock systems** are cold stress and gastro-enteric disorders.
4) The highly relevant welfare consequences experienced by **rearing pigs in indoor group housing** are restriction of movements, resting problems, group stress, inability to perform exploratory or foraging behaviour, locomotory disorders (including lameness), soft tissue lesions and integument damage and respiratory disorders. Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 7.5.
5) The highly relevant welfare consequences identified in the case of **rearing pigs kept in indoor systems with access to an outdoor area** are group stress, inability to perform exploratory or foraging behaviour, locomotory disorders (including lameness), soft tissue lesions and integument damage and respiratory disorders.
6) In the case of rearing pigs kept in outdoor paddock systems, no highly relevant welfare consequences were identified by expert opinion. However, other welfare consequences may negatively affect the welfare of rearing pigs, but in the opinion of the panel, they were classified as of minor or moderate relevance (see Appendix B).

7.8.2. Summary conclusions on Specific ToR 4 in relation to tail biting

1) Weaning age has not been associated directly with tail biting, although there may be indirect effects via other welfare consequences of a poor weaning transition (further details are in Section 7.7.1).
2) Tail biting risk is increased with reduced space allowance (further details are in Section 7.7.2).
3) Tail biting risk is increased with increasing proportion of slatted flooring (further details are in Section 7.7.3).
4) Tail biting risk is increased by lack of enrichment (further details are in Section 7.7.4).
5) Tail biting risk is increased with high air speed and poor air quality, e.g. high level of ammonia (further details are in Section 7.7.5).
6) Tail biting risk is increased by poor health status (further details are in Section 7.7.6).
7) Tail biting risk is increased by deficiencies in feed composition (further details are in Section 7.7.7).

7.9. Recommendations on the welfare of weaners and rearing pigs

7.9.1. Recommendations from General ToRs

1) Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **weaners**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 7.2).
2) Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **rearing pigs**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 7.5).

7.9.2. Recommendations on Specific ToR 4 in relation to tail biting

1) Tail biting should be prevented by applying preventive measures that are farm-specific after a risk assessment analysis for which tools currently exist (see Section 6.3).
2) Pigs should be carefully inspected everyday for early signs of tail biting.
3) Automated tools for the early detection of tail biting should be further developed and widely applied.

8. Assessment of the welfare of boars

The welfare of boars kept for breeding is further explored in this chapter.

In Section 8.1, the welfare consequences that were classified as highly relevant for boars are listed; for each welfare consequence, the reasoning explaining its high relevance, the hazards that may lead to it and corresponding preventive, corrective and mitigation measures are described. General descriptions of these welfare consequences in pigs, with supporting references, and the related ABMs are reported in Section 3.4. Other welfare consequences may negatively affect the welfare of boars, but they were classified as less or moderately relevant compared to the highly relevant ones. An overview of the expert judgement on the welfare consequence that may affect the welfare of boars is presented in Table B.1 (Appendix B).

The boar husbandry systems are described in Section 3.3.7. The system that was fully assessed in the General ToRs is 'indoor individual pens' and, for this system, an outcome table linking the most relevant welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures was developed (Table 61, Section 8.2).

No further assessment under Specific ToRs for boars is requested in the European Commission mandate; therefore, **summary conclusions and recommendations** on the welfare of boars are performed on the assessment of the General ToRs only. These are listed in Sections 8.3 and 8.4.

8.1. Highly relevant welfare consequences for boars: hazards, preventive, corrective and mitigation measures (General ToRs 4 and 5)

8.1.1. Restriction of movement

Restriction of movement was classified as highly relevant in indoor individual pens. Despite their large size, boars are commonly housed in pens with a limited area (a minimum of 6 m^2 as specified in current legislation) resulting in severe movement restriction (high severity). All boars kept in this system suffer from limited freedom of movement (high prevalence). This welfare consequence tends to have a long duration because boars are often housed in this type of system during their whole life (from entering the breeding unit at ~ 6 months of age), with few opportunities to leave the pen, when they are moved to the service area or to the semen collection area.

Hazards, preventive, corrective and mitigating measures

The hazards that could lead to this welfare consequence are listed below, together with the measures that could help to prevent/correct each hazard or that can mitigate the welfare consequence:

1) **Insufficient space:** inadequate space is the main impediment of movement. Normal behaviour of pigs, including boars, is characterised by moving between different functional areas e.g. defaecation and urination away from the lying area. Movement is also important to fulfil exploratory needs.
   A preventive measure to reduce the impact of this hazard, is to match the pen size to boars' needs, including allowing access to an outdoor run. Another possibility for some farms, could be to consider grouping the boar with the sows during service and pregnancy. As a corrective measure temporary access to larger area (e.g. for a teaser boar in the service area) is possible.
2) **Poor floor quality:** flooring should ensure that boars move easily and rest comfortably without causing leg injuries. Floors can fail in this regard because of poor maintenance (worn surface or broken slats) and/or design flaws (e.g. sharp edges; abrasive or too slippery floors).
   To prevent this hazard, it is important to select and maintain appropriate flooring. This requires timely replacement of flooring when it became worn and/or broken. Also for boars, an appropriate amount of solid flooring is important for both moving and resting behaviour. This also allows corrective measures such as the addition of bedding (straw, sawdust) or the provision of rubber mats.
3) **Wet and dirty floor:** Poor floor hygiene may make floors more slippery and impair movement.
   Preventive measures are to provide adequate drainage, plan appropriate cleaning management and design the pen layout and room ventilation so that boars are encouraged to develop distinct functional areas, separating excretion from other activities. Corrective measures are to increase cleaning frequency, and on solid floors to provide fresh bedding more frequently or in greater quantity to soak up moisture.

8.1.2. Isolation stress

Isolation stress was classified as having high relevance for boars in indoor individual pens. Boars housed in this kind of system have limited opportunities for direct contact with other pigs (high severity). Even when visual, olfactory, tactile and auditory contact is ensured, physical contact is impossible in this system. Isolation stress can affect boars throughout the period animals are kept in individual pens which can be the whole production life (from 6 months of age) of the animal (long duration) and affects virtually all animals kept in this type of system (high prevalence).

Hazard, preventive, corrective and mitigating measures

Isolation from conspecifics: Boars are kept in individual pens without olfactorial, visual, acoustic and tactile contact to other pigs.

Preventive and corrective measures for isolation stress are to ensure that boars always have visual, olfactory, tactile and auditory contact with other pigs. The use of barred rather than solid pen partitions facilitates this. For boars used in on-farm breeding, contact with sows during oestrus detection procedures or temporary housing in large sow groups as a catch boar, can provide additional social contact.

8.1.3. Inability to perform exploratory or foraging behaviour

Inability to perform exploratory or foraging behaviour was considered highly relevant for boars kept in indoor individual pens. These pens may have (partly) slatted floors often with no or very little bedding, providing no opportunities for exploration or foraging (high severity). This welfare consequence has a continuous effect (long duration) and affects all boars kept in this type of husbandry (high prevalence).

Hazard, preventive, corrective and mitigating measures

Absence or inadequate access to appropriate enrichment/foraging material: Exploratory behaviour is an intrinsic need of pigs.

Provision of an adequate amount of appropriate enrichment material is a preventative and corrective measure. Council Directive 2008/120/EC states that pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities. In boars, any individual should be able to access the material when motivated to do so (Commission Recommendation (EU) 2016/336). Enrichment material should be clean and regularly replaced/replenished and should have one of more of the following characteristics – be edible or feed-like, chewable, investigable (e.g. rootable) and/or manipulable (e.g. the pig can change its location, appearance or structure) (Commission Recommendation (EU) 2016/336).

This material can be provided as bedding or in a rack/dispenser (e.g. straw, hay), or suspended/attached to pen fixtures (e.g. wood, natural rope). In pens with fully slatted floor, it is more difficult to provide appropriate enrichment materials as these easily fall through the slats, and therefore commonly only e.g. objects attached to pen features can be used.

A preventive measure is to consider solid or partly slatted flooring when designing a pen. As a corrective measure a rubber mat can be provided in a specific area of the pen to allow provision of enrichment materials on the floor.

8.1.4. Prolonged hunger

Prolonged hunger was classified as having high relevance for boars in indoor individual pens. Similar to pregnant sows, boars are fed concentrate diets, which fulfil nutritional requirements regarding health and reproductive performance, but fail to induce satiety. Together with insufficient feeding of roughage or other material for exploration, this causes an almost constant feeling of hunger (high severity) for most boars in this system (high prevalence) during their whole production life (long duration).

Hazards, preventive, corrective and mitigating measures

1) **Unsatisfying diet form and inability to functionally express foraging motivation**: Even when the diet provides adequate nutrients, if these are given in a concentrated form which is low in bulk and consumed in a short time, the animal will not feel satiated. In these circumstances, feeding motivation will remain high and, if this cannot be expressed in an appropriate form of appetitive behaviour (searching, rooting, chewing), then abnormal behaviours (stereotypies) may result.

Preventive as well as corrective measures are to increase dietary bulk and prolong feeding time by reducing nutrient density and increasing dietary fibre, which gives prolonged fermentation in the gut. This may be done by modifying the composition of the concentrate diet or by giving additional access to bulky feedstuffs such as straw/hay, silage or root vegetables. Providing substrate to allow appropriate expression of foraging behaviour will help to prevent redirection into undesirable abnormal behaviours. Outdoor boars can forage and root in soil (if not fitted with nose rings) but for indoor boars provision of straw or manipulable material is necessary.

2) **Insufficient water intake**: Insufficient water intake will not only give rise to the welfare consequence of prolonged thirst but will also cause reduced feed intake. Insufficient water intake can occur if drinkers are malfunctioning (blockage or low flow rate) or if not-potable water (high mineral content, contamination) is provided.
Preventive measures are to ensure the adequate and continuous access to water of appropriate quality, by ensuring that drinkers work properly, are clean and easily reachable. Corrective measures are the fixing of issues related to water supply and water distribution, and the provision of alternative drinking water if water quality is compromised.

8.1.5. Locomotory disorders (including lameness)

Locomotory disorders (including lameness) was classified as having high relevance in indoor individual pens. These types of pens often have slatted floor with no bedding which can lead to foot lesions and locomotory disorders (high severity). This welfare consequence has a continuous effect (long duration) and affects most boars kept in this type of husbandry (high prevalence).

Hazards, preventive, corrective and mitigating measures

1) **Poor flooring design**: Slippery or abrasive flooring, poor slat design (e.g. inappropriate slat or slot width) or sharp slat edges contribute to claw and leg injuries in boars.
This hazard is prevented by selection and maintenance of appropriate flooring material. The effects of slippery or abrasive solid floors are mitigated by the provision of a sufficient amount of appropriate bedding. Use of concrete floors is also associated with increased limb and claw lesions in boars and effects can be mitigated by use of rubber mats in lying areas (Falke et al., 2018).
2) **Floor hygiene:** Poor floor hygiene may make floors more slippery. Flooring permanently covered with excreta will also cause softening and weakening of the hoof and will act as a reservoir of pathogenic agents which enter through any cuts or abrasions and cause local or systemic infections.
Preventive measures are to provide adequate drainage, plan appropriate cleaning management and design the pen layout and room ventilation so that boars are encouraged to develop distinct functional areas, separating excretion from other activities. Corrective measures are to increase cleaning frequency and, on solid floors, to provide fresh bedding more frequently or in greater quantity to soak up moisture.
3) **Lesions and infectious disease:** lameness may be caused by infectious diseases such as erysipelas or by ingress of pathogenic agents through damaged tissue.
Preventive measures include internal biosecurity measures (e.g. frequent manure removal) and to ensure a non-injurious environment through optimal floor quality/integrity, regular claw trimming and an appropriate vaccination program. As corrective measures, more bedding can be provided. Affected animals need to be treated or euthanised if not responding to treatment.
4) **Genetic predisposition:** Genetic predisposition and increased growth rate are linked to the development of osteochondrosis, a degenerative joint disorder.
Preventive measures include the selection of boars with good leg conformation. To alleviate the welfare consequence affected animals need to be treated.
5) **Inappropriate nutrition:** A high plane of nutrition during boar rearing can predispose to leg problems during the breeding period. A diet for breeding animals which contains inadequate levels, or an imbalance, of calcium and phosphorus will result in weaker bone development, whilst deficiencies in micronutrients such as biotin can affect claw strength.
Preventive measures are to ensure an appropriate plane of nutrition and diet formulation for the genotype in use, consulting a specialist nutritional advisor. Corrective measures include the evaluation and change of the diet formulation.

8.2. Outcome table on the welfare of boars kept in individual pens

Table 61 presents an overall outcome on the elements requested by the General ToRs on the welfare of boars: identification of the relevant welfare consequences and related ABMs, hazards and relevant preventive, corrective or mitigating measures. This relates to the indoor individual pens as being the systems that were assessed and where highly relevant welfare consequences were identified. Other welfare consequences may negatively affect the welfare of boars, but they were classified as less or moderately relevant (see Appendix B).

Table 61: Welfare of boars kept indoor in individual pens: outcome table linking the highly relevant welfare consequences, ABMs, hazards and preventive, corrective and mitigation measures. Cross-reference to the sections describing the welfare consequences and related ABMs is provided

Welfare consequence	Hazard(s)	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Restriction of movement **(overall description: Section 3.4.1; details in Section 8.1.1)**	– Insufficient space	– Match the size of pen to boar's needs – Add access to outdoor run – Consider grouping the boar with sows (in service or pregnant sow pens)	– Allow temporary access to larger area (e.g. for teaser boar in service area)	**(Table 7 – Section 3.4.1)** – Locomotory behaviour – Lying behaviour – *Posture changes* – *Pressure injuries: calluses and bursitis*
	– Poor floor quality	– Select and maintain appropriate flooring – Increase percentage of solid flooring	– Provide adequate substrates on the floor	
	– Wet and dirty floor	– Provide adequate drainage – Plan appropriate cleaning management – Design the housing to encourage the use of functional areas	– Apply appropriate cleaning frequency – Provide bedding more frequently or in greater quantity	
Isolation stress **(overall description: Section 3.4.4; details in Section 8.1.2)**	– Isolation from conspecifics	– Ensure sufficient visual, olfactory, tactile and auditory contact to other pigs* – Consider (temporary) access of boars inside the dry sow group (when planning this system)		**(Table 12 – Section 3.4.4)** *Apathetic dog-sitting*
Inability to perform exploratory or foraging behaviour **(overall description: Section 3.4.6; details in Section 8.1.3)**	– Absence or inadequate access to appropriate enrichment/ foraging material	– Provide adequate amount of enrichment and foraging material* – Provide part solid floor when offering loose materials	– Provide a rubber mat to allow provision of enrichment materials on the floor	**(Table 15 – Section 3.4.6)** – Exploratory behaviours directed at enrichment material – Exploratory behaviour directed to pen-fittings – Stereotypic behaviours – *Skin lesions on body parts else than tail and ears*

Welfare consequence	Hazard(s)	Preventive measure(s) of the hazard*	Measure(s) correcting the hazard or mitigating the welfare consequence	ABM(s)**
Prolonged hunger **(overall description: Section 3.4.9; details in Section 8.1.4)**	– Unsatisfying diet form and inability to functionally express foraging motivation	– Increase dietary bulk and prolong feeding time* – Provide fibrous diet, *ad libitum* feeding of low-density diet* – Provide foraging material*		**(Table 19 – Section 3.4.9)** – Stereotypic behaviours – *Body Condition*
	– Insufficient water intake	– Ensure adequate access to appropriate quality water*	– Provision of alternative drinking water if water quality is compromised	
Locomotory disorders (including lameness) **(overall description: Section 3.4.13; details in Section 8.1.5)**	– Poor flooring design	– Select and maintain appropriate flooring	– Provide sufficient amount of adequate substrates – Use of rubber in lying areas – Treatment of affected animals	**(Table 25 – Section 3.4.13)** – Abnormal gait – *Claw lesions* – *Overgrown claws* – *Calluses and bursitis*
	– Floor hygiene	– Provide adequate drainage – Plan appropriate cleaning management – Design the housing to encourage the use of functional areas	– Provide appropriate cleaning frequency – Provide sufficient amount of appropriate bedding (on solid floors)	
	– Lesions and infectious diseases	– Ensure external and internal biosecurity – Ensure optimal floor quality/integrity – Claw trimming* – Appropriate vaccination program	– Treat affected animals – Add more bedding – Euthanise boars, if not responding to treatment	
	– Genetic predisposition	– Choose boars with good leg conformation and selected against osteochondrosis	– Treat affected animals	
	– Inappropriate nutrition	– Ensure appropriate diet formulation (especially for growing boars)	– Change the diet formulation	

*: The preventive measures that may also be used to correct an ongoing problem have been marked with a star key (*).
**: The ABMs considered neither sensitive nor specific (see Section 3.4) are presented in 'Italics' but for information purposes only and are not recommended to be used in practice.

8.3. Summary conclusions on the welfare of boars

1) The highly relevant welfare consequences identified for boars kept in indoor individual pens are restriction of movement, isolation stress, inability to perform exploratory or foraging behaviour, prolonged hunger and locomotory disorders (including lameness). Other welfare consequences may negatively affect the welfare of boars, but in the opinion of the panel, they were classified as of minor or moderate relevance (see Appendix B). Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 8.2.
2) The scientific information on the husbandry systems and the welfare consequences pertaining to boars is very limited.

8.4. Recommendations on the welfare of boars

1) Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for boars, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 5.2).
2) Further research is needed on the prevalence of welfare consequences, validation of ABMs specific to boars and related preventive and mitigating measures (e.g. regarding husbandry, enrichment materials, social environment).

9. Assessment of ABMs collected in slaughterhouses to monitor the level of welfare on pig farms (Specific ToR 5)

9.1. Introduction

This Specific ToR considers rearing pigs and sows at the end of the production cycle (from here on called 'cull sows'), that will be sent to the slaughterhouse. It aims at identifying for both pig categories, a list of ABMs that can be assessed and collected at slaughter and provide information on the overall welfare condition of a certain population in a herd, farm or region/country.

The ABMs that help to identify more than one welfare consequence are preferred. These indicators are commonly referred to as 'iceberg indicators'.

Recording ABMs at slaughter can provide information for assessment and benchmarking of pig welfare on farm and in the preslaughter stage (Stärk et al., 2014; Teixeira et al., 2016).

9.2. Methodology

The starting point was a list of 27 ABMs as potentially relevant ABMs for measurement at slaughter in rearing pigs and cull sows. These ABMs and their descriptions were identified by EFSA experts on the basis of existing literature (Welfare Quality®, 2009; EFSA AHAW Panel, 2012) and for each ABM the preferred time of assessment (i.e. *ante*- or *post-mortem*) was also proposed. To gather information on their use in practice, the 27 ABMs were discussed by the EFSA Animal Health and Animal Welfare (AHAW) Network[31] in the context of an exercise during the annual Network meeting (year 2021) (for the list of ABMs, their description, full details on methodology and results of this exercise, see EFSA, 2021).

In addition to the initial list of 27 ABMs, on the basis of EFSA expert opinion, 'vulva lesions' was added (*ante*- and *post- mortem*) and 'ear lesions' was changed in 'ear loss', to only refer to lesions derived from ear necrosis or biting. For the complete list of the 29 ABMs assessed under this Specific ToR, see Table 62.

[31] The EFSA AHAW Network includes nationally appointed EU Member State organisations representatives with expertise in the fields of animal health and animal welfare.

Table 62: List of ABMs potentially relevant to collect in slaughterhouses for monitoring the level of welfare on pig farms produced by the EFSA's experts, and indication of the preferred time of assessment (*ante-* or *post-mortem*). Descriptions of ABMs are available in Section 9.4 and EFSA (2021)

ABMs in Pigs			
Ante-mortem		**Post-mortem**	
1	Tail lesions	1	Tail lesions
2	Ear loss[(a)]	2	Stomach ulcers
3	Lameness	3	Lung lesions – pneumonia
4	Skin lesions – Shoulder ulcers (sows)	4	Lung lesions – pleurites
5	Skin lesions- Wounds/injuries	5	Pericarditis
6	Skin lesions – Lesions caused by on-farm fighting	6	Liver lesions
7	Skin lesions – abscesses	7	Skin lesions – bruises
8	Bursitis (swelling)	8	Skin lesions – lesions caused by on-farm fighting
9	Body condition	9	Bursitis (swelling)
10	Manure on the body	10	Abscesses
11	Coughing/ Sneezing	11	Carcass condemnations
12	Pumping/ Laboured breathing	12	Carcasses variability
13	Rectal prolapse and uterine prolapse (in sows)	13	Vulva lesions[(b)]
14	Hernia		
15	Diarrhoea		
16	Vulva lesions[(b)]		

(a): 'Ear lesions' in EFSA (2021).
(b): Added by EFSA experts.

From the ABMs listed in Table 62 a semiquantitative consensus exercise was carried out to identify those ABMs that could best represent the overall animal welfare conditions in the farm. The exercise consisted of two steps: (i) Screening; (ii) Selection (see Figure 27).

The Screening was carried through an Experts' opinion exercise on the initial list of ABMs, on the basis of four (screening) criteria (i.e. questions to answer with a Yes/No option):

1) Relevance to animal welfare: *Is the ABM relevant to the welfare consequences defined in this opinion, and not only to production and meat quality aspects?*
2) Relationship with the farm (and not transport or lairage): *Is the ABM indicative of a welfare consequence of the farm and not caused or masked by transport, lairage and slaughter?*
3) Existing data in literature: *Do scientific publications describe the ABM detailing methodologies, prevalence and the relation with on-farm welfare consequences?*
4) Feasibility for large scale collection: *Is the ABM already routinely collected or there is evidence that it could be collected in a national program?*

As precautionary principle, if consensus was not reached, the criterion was considered a 'Yes'. Only ABMs that received a 'Yes' for all criteria passed to the second step (Selection).

The Selection step consisted of a ranking of the ABMs based on four criteria presented below. This was followed by expert's selection of the most promising ones.

The four criteria were:

1) Welfare consequences (C1): The experts identified which welfare consequences on farm (from the list in Section 2.2.2.1) could be associated with the selected ABM. They scored the ABM according to the number of different welfare consequences selected.
2) Already used at slaughter (C2): The ABMs were scored according to the answers received from the exercises of the AHAW Network (EFSA, 2021).
3) Priority given by the Network (C3): The ABMs were scored according to the answer received from the AHAW network exercise (EFSA, 2021).

4) Technology readiness (C4): Each ABM was evaluated for the known level of readiness of an automated system to be adopted by the market, based on the technology readiness scale (Mankins, 1995).

For each of these criteria, the EFSA experts agreed on a score from 0 to 4, where '0' means absence and '4' the highest score.

Finally, a weight was attributed by expert consensus to each criterion according to its importance in answering the request of the mandate. The allocated weights were C1 = 6; C2 = 1; C3 = 1; C4 = 3.

A final score (weighted score) was calculated following the formula below:

$$\text{Weighted score} = \frac{(\text{score}_{C1} * \text{weight}_{C1}) + (\text{score}_{C2} * \text{weight}_{C2}) + (\text{score}_{C3} * \text{weight}_{C3}) + (\text{score}_{C4} * \text{weight}_{C4})}{\sum_{C4}^{C1} \text{weights}}$$

The full process leading to the final list of ABMs that were selected is summarised in Figure 27.

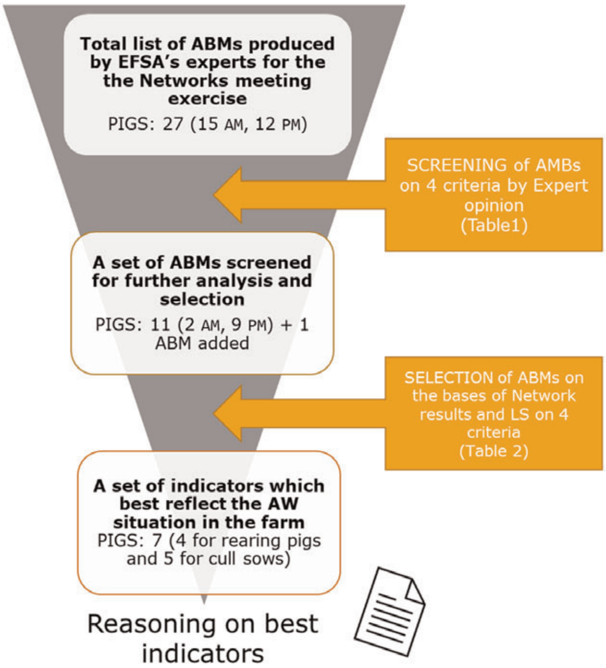


Figure 27: Flowchart of the process leading to the selection of the ABMs that were considered to best reflect the AW in the farmAM = ABMs measured *ante-mortem*; PM = ABMs measured *post-mortem*.

9.3. Results of the consensus exercise

Of the 29 identified ABMs, 11 passed a first screening procedure (see Table 62) and were submitted to the selection step. The screening procedure also identified where best to assess a certain ABM: *ante- or post- mortem*.

The outcome of the semiquantitative expert consensus exercise is presented in Tables 63 (for rearing pigs) and 64 (for cull sows), where the specific criteria to select the ABMs at slaughter are reported. As explained above, these criteria included the extent of their link to welfare consequences on farm (C1), and the possibility for automation (technology readiness) (C2), both were based on expert consensus. Scores on C3 (i.e. whether the ABMs are already measured at slaughter) and C4 (i.e. if the European countries consider it important to prioritise those ABMs) were based on the outcomes of the EFSA AHAW Network meeting (EFSA, 2021). The final score is based on expert opinion.

Table 63: Ranking of ABMs for rearing pigs on the basis of the four criteria. The score goes from 0 to 4, with 0 indicating an absence and 4 the highest value. The weight attributed by the experts to each criterion is in brackets. The ABMs that were selected are highlighted in grey

ABM	Assessment	Welfare consequence (weight = 6)	Technology readiness (weight = 1)	Already measured at slaughter (weight = 1)	Importance rated by the AHAW Network (weight = 3)	Weighted score
Tail lesions	*Post-mortem*	4	3	4	4	**3.91**
Lameness	*Ante-mortem*	3	1	4	4	**3.18**
Carcass condemnations*	*Post-mortem*	3	0	4	3	**2.82**
Lung lesions (pleuritis and pneumonia)	*Post-mortem*	2	2	4	4	**2.73**
Skin lesions – lesions caused by fighting	*Post-mortem*	3	2	2	2	2.55
Ear loss	*Post-mortem*	2	1	2	3	2.18
Abscesses	*Post-mortem*	2	0	4	2	2.00
Bursitis (swelling)	*Post-mortem*	2	0	3	1	1.64

*: Excluding abattoir contamination.

The experts agreed to select tail lesions, lameness, carcass condemnations and lung lesions as the most useful ABMs for rearing pigs (see Table 63).

Table 64: Ranking of ABMs for cull sows on the basis of the four criteria. Scores from 0 = absence to 4 = high. The weight of each criterion is in brackets. The ABMs that were selected are highlighted in grey

ABM	Assessment	Welfare consequence (weight = 6)	Technology readiness (weight = 1)	Already measured at slaughter (weight = 1)	Importance rated by the network (weight = 3)	Weighted score
Lameness	*Ante-mortem*	4	2	4	4	**3.82**
Body condition	*Ante-mortem*	4	1	3	4	**3.64**
Skin lesions-shoulder ulcers	*Post-mortem*	4	2	3	3	**3.36**
Vulva lesions*	*Post-mortem*	4	1	0	3	**3.09**
Carcass condemnations**	*Post-mortem*	3	0	4	3	**2.82**
Lung lesions (pleuritis and pneumonia)	*Post-mortem*	2	2	4	4	2.73
Skin lesions – lesions caused by fighting	*Post-mortem*	3	2	2	2	2.55
Abscesses	*Post-mortem*	2	0	4	4	2.55
Bursitis (swelling)	*Post-mortem*	2	0	3	3	2.18
Ear loss	*Post-mortem*	2	1	1	2	1.82

*: Vulva lesions was not included in the preliminary list submitted to the EFSA AHAW Network. However, the EFSA experts considered this ABM relevant to animal welfare, related to the on-farm situation, feasible for large-scale assessment and sufficiently described in literature.
**: Excluding abattoir contamination.

The experts agreed to select lameness, body condition, skin lesions-shoulder ulcers, carcass condemnations and vulva lesions as the most useful ABMs for cull sows (see Table 64).

In the following sections each ABM is described with its definition (as reported in EFSA, 2021), interpretation, means of assessment and arguments for the selection (linking the scores and the scientific evidence in the literature).

9.4. Animal-based measures

9.4.1. Tail lesions

9.4.1.1. Animal category

Rearing pigs.

9.4.1.2. Description of the ABM

Definition: *Lesions to the tail, ranging from bruises to mild bite marks, with or without puncture of the skin, up to a complete tail loss*.

The animal experiences negative affective states such as pain, discomfort and/or distress due to physical damage to the integument or underlying tissues of the tail (single or simultaneous occurrence of scratches, open or scabbed wounds, hematomas, swelling, scar, spinal rupture, muscle damage, tail infection or abscessation).

9.4.1.3. Interpretation

Tail lesions result from tail biting behaviour (e.g. Valros et al., 2020). Tail lesions occur during the suckling, weaner and grower phases on-farm and therefore reflect problems at farm-level. They rarely occur in the immediate preslaughter period (post farm-gate) (van Staaveren et al., 2017a,b).

Tail biting behaviour can spread rapidly in a pen or farm, resulting in many pigs showing tail lesions (including loss of tail) at slaughter. In conventional intensive farming, batches of pigs showing a higher prevalence of scars (healed lesions) on the tail were linked to a higher prevalence of carcass condemnations indicative of prior infection (Gomez et al., 2021).

Tail biting has multifactorial causations (see Section 7.7). The score received from the consensus exercise (score 4) in Table 63 reflects that this ABM is a good iceberg indicator because it is related to many welfare consequences on farm.

In conventional intensive farming, batches of pigs showing a higher prevalence of scars (healed lesions) on the tail were linked to a higher prevalence of carcass condemnations indicative of prior infection (Gomez et al., 2021).

Considerations for a risk assessment on tail lesions on farm are in Sections 6.3.3 and 7.7.

9.4.1.4. Assessment

Timing of assessment: *post-mortem*.

Assessment of tail lesions *post-mortem* is more reliable than *ante-mortem*, as there are important limitations associated with *ante-mortem* assessment. It can be difficult to inspect the tail of each animal, especially when pigs are in a group. Moreover, body position, tail position and cleanliness of the animals affects the visibility of tail lesions. Variable environmental conditions (e.g. poor lighting and dust) also limit the *ante-mortem* assessment. The visibility of the lesions is improved by cleaned carcasses being presented to the observer in a standardised way, allowing assessment of lesions in the entire batch.

In either case, the presence of artefacts (e.g. tail damage occurring during processing, i.e. *post-mortem*) and visual limitations shows that it is important to adjust any assessment protocols to the practical situation of a slaughterhouse (Valros et al., 2020).

Current use of this ABM

According to the AHAW Network delegates (EFSA, 2021), most of the EU countries record this ABM manually. Moreover, data on tail lesions are currently not often used for assessing animal welfare conditions on the farm, but mainly for food hygiene and meat inspection purposes or meat processing issues. Generally, only severe tail lesions are recorded. The AHAW Network considered this ABM as essential for assessing animal welfare on farm.

Considerations for use a standard method

Tail lesion assessment *post-mortem* can be carried out in several different ways, leading to different results in terms of reported prevalence and severity of this ABM (Honeck et al., 2019).

Artefacts, such as damage to the tail *post-mortem*, due to carcass procedures (e.g. intentional or unintentional cuts or burns after scalding) need to be recognised by the observer (Valros et al., 2020) in order to minimise any potential bias of the results.

For example, scabs covering the end of the tail can make it difficult to assess the size or severity of the underlying lesion. Scoring before scalding probably gives a better estimate of what the producer might see at the farm, while scoring after scalding is more accurate (Carroll et al., 2016, 2018a).

Scoring methods should allow docked and undocked tails to be assessed, however, there are different scoring methods for docked and undocked tails (Honeck et al., 2019). Scars on undocked pig tails are sometimes ignored, although they indicate healed tail lesions (Gomez et al., 2021). The identification of an intact tail is also challenging. By definition, an intact tail has all the vertebrae present. However, the length of the tail can, be on average, 31.6 cm according to Valros et al. (2020), making visual assessment challenging. An intact tail also has intact skin. However, according to Valros et al. (2020), even with intact tail length and unblemished skin, hematomas in the underlying tissue due to tail biting and chewing can involve muscular tissues, as well as vertebrae and their junctures. It is rare that hematomas in underlying tissue are considered in the scoring systems, even if this type of injury is likely to be a cause of acute and long-term pain in pigs.

In conclusion, there is a need for a harmonised scoring system to monitor tail lesions in the European population of pigs.

Possibilities for automation

The possibilities for automation of tail lesion assessment look promising. Several studies investigated the use of cameras and artificial intelligence, and tests in commercial slaughterhouse environments are far advanced (Bruenger et al., 2019; Larsen et al., 2019b; Blomke et al., 2020). Most methods involve taking pictures of tails on suspended carcasses moving down the slaughter line, usually after scalding and before splitting the carcass down the middle. Unpublished results suggest that the repeatability and reliability of the technology is sufficient for practical implementation (Hans Spoolder, Wageningen Livestock Research, personal communication, 2022). Although useful as a tool for continuous assessment and monitoring of slaughter pigs from herds delivered to the same slaughterhouse, for benchmarking purposes (across slaughterhouses or Member States) they are currently poorly standardised.

9.4.2. Lung lesions (pneumonia and pleuritis)

9.4.2.1. Animal category

Rearing pigs.

9.4.2.2. Description of the ABM

Definition: *Inflammation or consolidation of the lung tissue with or without an overlying pleurisy*.

Lung lesions include macroscopic lesions indicative of respiratory disease (Merialdi et al., 2012). They can manifest as pneumonia, pleurisy, pleuropneumonia or abscesses. Enzootic pneumonia-like lesions are described by (Eze et al., 2015) as 'red-tan-grey shades of discolouration and consolidation affecting cranioventral regions of the lungs in a lobular pattern'. The same authors described pleurisy as 'fibrous or fibrinous adhesions on the lung or between the lung and the chest wall', and pleuropneumonia lesions as 'focal areas of lung consolidation with overlying pleurisy usually affecting the middle or caudal lobes'.

9.4.2.3. Interpretation

A high incidence of lung lesions is associated with respiratory disease. Lung lesions are monitored in abattoir surveillance. They can be the result of the interplay of infectious agents, farm conditions and host physiology (Stärk, 2000).

Among the infectious agents, enzootic pneumonia is characterised by the development of ventrocranial bronchopulmonary lesions following *Mycoplasma hyopneumoniae* infection and other bacteria (Madec and Derrien, 1981; Mousing et al., 1990). Furthermore, chronic ventrocranial pleuritis is also considered a complication of enzootic pneumonia (Christensen and Eno, 1999). Differently, chronic dorso-caudal pleuritis suggest *Actinobacillus pleuropneumoniae* infections at farm level (Meyns et al., 2011; Merialdi et al., 2012).

During the consensus exercise (Table 63), lung lesions were scored 2 because they are mainly related to one welfare consequence, i.e. respiratory disease. However, this welfare consequence has a huge impact on the overall welfare of pigs, therefore the ABM was selected.

9.4.2.4. Assessment

Timing of assessment

The assessment can only be performed *post-mortem*.

Current use of this ABM

The AHAW Network (EFSA, 2021) reported that lung lesions are routinely assessed in EU countries and often registered for meat hygiene (Commission Implementing Regulation (EU) 2019/627[32]), and trimmed as part of a partial carcass condemnation (EFSA, 2021). The network considered this ABM essential when assessing animal welfare.

Considerations for use a standard method

Most of the slaughterhouses only assess severe cases of lung lesions (EFSA, 2021) that result in carcass trimming or condemnation (e.g. when pleuritic lungs are retained in the chest wall). Therefore, the reported lung lesions are an underestimation of the level of respiratory disease on farm (Pessoa et al., 2022), because it ignores mild and moderate damage and severe lung lesions that do not impact the carcass. All of these may also be associated with problems for pig health and welfare.

Other, more detailed, scoring systems are in place and are conducted sporadically for health surveillance monitoring of enzootic pneumonia and chronic pleurisy, or for research purposes. These can also be used for animal welfare assessment on farm (Scollo et al., 2017). Differences in the scoring systems means that prevalence and severity findings from different studies are difficult to compare, therefore limiting the usefulness of the information (Pallares et al., 2021; Vitali et al., 2021b).

The main challenges when developing protocols for lung lesions are the need to palpate, the speed of the slaughter line (Pallares et al., 2021), the space available for additional operators at the slaughterhouse and the training of the assessors (Alban et al., 2022).

The scoring method should determine the presence of lung lesions, pleuritis, abscessation and scars on the lung (Madec and Derrien, 1981). The use of palpation can be important to help with the score (Merialdi et al., 2012; Pallares et al., 2021).

The assessment should consider artefacts, such as modification in lung appearance due to the stunning and killing procedure. For example, differences in the appearance of the lung due to gas stunning (CO_2 or other gas or gas moisture) should be taken into account when developing the protocol (Sindhøj et al., 2021). There can be pulmonary congestion after CO_2 stunning and killing (Marcon et al., 2019) which can wrongly be interpreted as respiratory disease. Similarly, the presence of lather in the bronchus or on the lungs may be related to the killing procedure, and not to respiratory disease on the farm.

Possibility for automation

Systems are being developed that use automatic visual analysis to assess the presence and/or the severity of lung lesions. The methods mainly focus on the presence of lesions from enzootic pneumonia or rhinitis. Trachtman et al. (2020) looked at a convolutional neural network-based system to automatically score pleurisy in slaughtered pigs. Results showed that the proposed system is able to differentiate between carcasses affected with pleurisy and healthy ones and to recognise even better severely affected carcasses. Similarly, Bonicelli et al. (2021) developed an artificial intelligence- based method capable of recognising and quantifying enzootic pneumonia-like lesions on digital images captured from slaughtered pigs under routine abattoir conditions. Overall, the data indicate that the artificial intelligence-based method proposed could properly identify and score enzootic pneumonia-like lesions without interfering with the slaughter chain routine. It also avoids the handling of carcasses and organs, with a possible positive impact on food hygiene. Also, in the development of these promising systems, validation with a standardised manual method is desirable to allow collecting and comparing harmonised data.

[32] Commission Implementing Regulation (EU) 2019/627 of 15 March 2019 laying down uniform practical arrangements for the performance of official controls on products of animal origin intended for human consumption in accordance with Regulation (EU) 2017/625 of the European Parliament and of the Council and amending Commission Regulation (EC) No 2074/2005 as regards official controls OJ L 131, 17.5.2019, p. 51–100.

9.4.3. Skin lesions – shoulder ulcers

9.4.3.1. Animal category

Cull sows.

9.4.3.2. Description of the ABM

Definition: *Decubital shoulder ulcers are lesions in post-farrowing sows caused by pressure inflicted by the flooring, leading to oxygen deficiency in the skin and the underlying tissue. They are thought to be comparable with human pressure sores (Herskin et al., 2011).*

For a description of this ABM, see also Section 3.4.1 of this SO.

9.4.3.3. Interpretation

In sows, shoulder ulcers are caused by oxygen deficiency in the skin and the underlying tissue (Herskin et al., 2011) in the area of the shoulders surrounding the Spina scapula (Fogsgaard et al., 2018). An increased prevalence of shoulder ulcers measured at the slaughterhouse was associated with confinement (stalled or tethered sows) (Cleveland-Nielsen et al., 2004). The use of a hospital pen, the improvement in overall animal welfare conditions and the use of herd-own gilts for replacement were associated with a decreased prevalence of shoulder ulcers at slaughter. In line with this, Herskin et al. (2011) discussed that not only contact with the floor can cause shoulder ulcers, but that crated sows can interact quite forcefully with crate fixtures, e.g. when getting up, and sows in farrowing crates lean or rest their scapular spine against the horizontal bars.

From a gross examination, pathological characteristics can include skin ulceration (in the epidermis or in the underlying tissues), presence of scars and necrosis up to exposed bones in the ulcerated area (Jensen, 2009). Microscopic assessment of shoulder lesions may reveal one or more of the following characteristics: the presence of necrosis, heavy fibrosis, haemorrhages, colonisation of bacteria and abscessation, infiltration of neutrophils and macrophages, bone proliferation on the exposed bones, formation of neuromas (Dahl-Pedersen et al., 2013). The same authors found a high frequency of traumatic neuromas in both healed and unhealed lesions. The observation of viable nerve-ends in shoulder ulcerations suggest that ulcerations are associated with pain. These results suggest that shoulder ulcers may be associated with pain even after healing.

During the consensus exercise (Table 64), 'shoulder ulcers' was scored 4 because this lesion type is related to many welfare consequences in cull sows therefore it is a potentially good iceberg indicator of sow welfare.

Timing of assessment

Assessment of shoulder lesions is more reliable *post-mortem* than *ante-mortem* in terms of feasibility, allowing the assessment of lesions in the entire batch and improving visibility and grading of the lesions (Cleveland-Nielsen et al., 2004).

Current use of this ABM

Results of the AHAW Network consultation indicate that shoulder ulcers are assessed in eight of the Member States surveyed and in all cases by the Competent Authority (CA) rather than by the Food Business Operator (FBO) (EFSA, 2021). Although originally proposed for assessment *ante-mortem*, during the AHAW Network evaluation, it was later decided to change the proposal to a *post-mortem* assessment, because this was judged less time consuming and more feasible. However, according to Herskin et al. (2011), there are some limitations when developing the *post-mortem* assessment method. For example, undermined shoulder lesions (those that go under the skin) at farm level can deteriorate during transport and may rupture and look worse compared to the on farm situation (Herskin et al., 2011).

Considerations for use a standard method

At present, there is no international clinical scientific classification system for decubital shoulder ulcers in sows. In Denmark, studies by Jensen (2009) and Jensen et al. (2011) are used, which consider the severity of gross anatomopathological findings. In addition, there are reports of other scoring systems in research studies, mainly on-farm (Davies et al., 1996; Jensen, 2002; Thorup, 2006; Zurbrigg, 2006; Kaiser et al., 2007). These are characterised by a lack of consensus with regard to, e.g. the placing of certain criteria on the scoring system (e.g. existence of scar tissue) or the inclusion of measures of, e.g. depth or diameter of the lesion (Herskin et al., 2011).

Other systems that consider the diameter of the lesion and the presence or absence of scars, are used for farm inspection (Dahl-Pedersen et al., 2013). In some cases, redness and swelling (including categorisation as either soft or hard based on palpation) of the skin area surrounding a shoulder wound were also reported *ante-mortem* (Fogsgaard et al., 2018). These parameters can also be considered when developing a standardised scoring method *post-mortem*.

The development of a reliable classification system would make it possible to perform uniform recording of the extent of the ABM and could be the necessary basis to evaluate the welfare consequence in sows, as well as enabling comparison of different husbandry systems. The system would need to take transport-induced changes into account.

Possibility for automation

There was no evidence of an automated method of recording shoulder ulcers at the slaughterhouse. However, in the experts' opinion, the technologies developed for the assessment of skin lesions on the carcass could be easily adapted for use on shoulder ulcers. Some methods consider the use of a spectrophotometer (Vitali et al., 2017) or a camera-based system (Bloemke et al., 2020).

9.4.4. Body condition

9.4.4.1. Animal category

Cull sows.

9.4.4.2. Description of the ABM

Definition: *The body condition reflects body reserves or fat accumulation of an animal. Body condition scoring is used to critically examine the nutritional status of a pig*.

The body condition of an animal reflects its body reserves or subcutaneous fat accumulation.

Body condition scoring involves visual or tactile estimation of these subcutaneous fat reserves which relies on the animals' body shape or thickness of fat layers and muscles on key areas of the body.

9.4.4.3. Interpretation

Body condition is most often assessed to critically examine the nutritional status of pigs on-farm whereby variation in body condition between pen mates is higher if feed is not equally distributed (Welfare Quality®, 2009). The assessment of body condition indicates the degree to which an animal catabolised its fat reserves such that there is less subcutaneous fat. Hence, it also reflects higher energy expenditure due to under-feeding, poor thermal conditions, a debilitating process such as infection or injury and, in the case of breeding females, lactation (see Section 4.4).

In sows, competitive feeding systems can contribute to a variation in body condition (Spoolder et al., 2009). The prevalence of debilitating conditions such as lameness can be high in breeding sows (Gjein and Larssen, 1995b; Bonde et al., 2004; Heinonen et al., 2006; KilBride et al., 2009b; Pluym et al., 2011). Knauer et al. (2007) reported high levels of claw horn lesions in slaughtered cull sows, and indeed lameness is a major reason for culling sows (Anil et al., 2005). The association between lameness and poor body condition in sows is well established (Heinonen et al., 2013). Thin sows are more likely to be culled from the herd and sows culled for poor body condition and lameness had less back fat (Knauer et al., 2012).

Sows mobilise considerable body reserves during lactation such that they lose body weight and are at risk of being thin at weaning (see Section 4.4.5). For economic reasons, a high proportion of sows are culled while still lactating or recently weaned (40% – Fogsgaard et al., 2018; Herskin et al., 2020). Furthermore, old age is a major reason for culling (de Jong et al., 2014; Zhao et al., 2015) so a large proportion of 'old' sows are culled right after weaning their last litter (Engblom et al., 2007; de Hollander et al., 2015). The risk of large body weight losses in lactation declines with increasing parity (Esbenshade et al., 1986). However, the risk of body condition loss during lactation is higher in high producing herds (Esbenshade et al., 1986).

It is well established that sows in poor body condition are disadvantaged in a number of ways that relate to welfare, including failures in agonistic encounters for food (Norring et al., 2019). Also, there is a strong association between body condition score (BCS) and shoulder lesions in cull sows (Ritter et al., 1999). Stalder et al. (2004) indicated that poor sow BCS is a risk factor for poor longevity.

During the consensus exercise (Table 64), body condition was scored 4 because it is related to many welfare consequences in cull sows, and therefore is a good iceberg indicator of sow's welfare.

9.4.4.4. Assessment

Timing of assessment: *Ante-mortem*.

EFSA experts considered that assessment of body condition in cull sows is feasible, more easily achieved and more relevant to welfare if measured *ante-mortem* compared to *post mortem*.

Current use of this ABM

Results of the AHAW Network consultation (EFSA, 2021) indicate that body condition is routinely assessed in 8 of the Member States surveyed and in all cases by the CA rather than by the FBO (EFSA, 2021). Discussion revealed that only absence/presence is recorded, whereby identification, by exception, of a severely emaciated animal may trigger an animal welfare investigation.

Considerations for use as a standard method

In Denmark, Fogsgaard et al. (2018) found that almost 90% of cull sows fell within the commercial target for body condition and only 3.4% of sows scored as thinner than the commercial target. However, given their poor economic value, age and the stage in the production cycle at which they are sold, cull sows are more likely to be in poor body condition than sows still in production (McGee et al., 2016). Indeed, there is general acceptance amongst stakeholders that cull sows are thin (Grandin, 2016). This is an important issue to consider in the adoption of body condition as an ABM for cull sows at slaughter. Thin cull sows occur frequently and because of that are considered normal by stakeholders (Grandin, 2016). Establishing an agreed body condition scoring criterion may be required to de-normalise poor body condition (Mee, 2020) in cull sows in advance of employing body condition as an ABM for cull sows in routine ante-mortem assessments.

Routine and formal recording of body condition in cull sows *ante-mortem* may likely evidence welfare consequences for these animals at the farm (Fogsgaard et al., 2018).

Current body condition scoring methods for sows include, as for other species, palpation of sites such as over the ribs, lumbar spinal processes and tail head are carried out (Charrette et al., 1996; DEFRA website[33]). Body condition scoring systems can be only visual or including palpation, however palpation would not always be possible in a slaughterhouse setting.

Knudson et al. (1985) reported that the relationship between BCS and body composition in sows is not very reliable, but Charette et al. (1996) offered a combination of linear and semiquantitative scores, which demonstrated improved reliability of the evaluation process. Low values for body condition always reflect emaciation and high values equate to obesity (Roche et al., 2009). Different methods for assessing body condition are available for sows (Charrette et al., 1996; Welfare Quality®, 2009).

Possibility for automation

In the cattle industry, 2D and 3D based sensors are widely used to obtain body parameter information for BCS evaluation (Bercovich et al., 2013; Anglart, 2014). Vision as a non-intrusive approach is extensively used (Lynn et al., 2017), usually involving two steps. Visual feature extraction of relevant features such as curvature, distance or body contour and the estimation of model construction where collected features are used to construct a regression model either via manual construction or computer programming (reviewed by Qiao et al., 2021). Automatic BCS cameras are available commercially in the dairy industry. While the correlation with conventional manual scoring was high, agreement was poorer at the extreme scores (Mullins et al., 2019).

There are promising technologies, but most are developed for on-farm use and for use with rearing pigs (see reviews by Benjamin and Yik, 2019, Qiao et al., 2021 and Mahfuz et al., 2022). For example, there are methods to estimate the body size or body condition based on images analysed from a 2D camera (Chen et al., 2020). In addition, Kashiha et al. (2014) successfully estimated the individual pig weight by 2D image analysis. The result may vary due to the location of camera and the height of camera position from animals. Besides, animal density may affect monitoring, image analysis and weigh estimation (Matthews et al., 2016). Other studies showed a potential for commercialisation in the area of extracting the 3D shape of pigs for automatic mass and weight estimations (Condotta et al., 2018; Wang et al., 2019). There are no specific technologies for the measurement of BCS in slaughterhouses in cull sows or rearing pigs in the aforementioned reviews.

[33] http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000IL3890W.185EBLT3WHE457

9.4.5. Carcass condemnations

9.4.5.1. Animal category

Rearing pigs and cull sows

9.4.5.2. Description of the ABM

Definition: *Carcasses or parts of the carcass that are unfit for use as food, described as: no of pigs, weight of the carcass, waste per group*.

According to the Commission Implementing Regulation (EU) 2019/627, all slaughterhouses throughout the EU record carcass condemnations (including the part of the carcass condemned if only partially condemned). The reason for condemnation is recorded primarily for food hygiene and meat inspection purposes. Apart from carcass contamination (e.g. with stomach contents during evisceration) during the slaughter process, most of the reasons for trimming or condemning a carcass are linked to welfare relevant conditions. Carcass condemnation due to health and welfare issues is normally carried out at evisceration and can be differentiated from the condemnation due to other reasons (e.g. improper handling of the carcasses or other type of contaminations) or carried out at the end of the process.

9.4.5.3. Interpretation

During abattoir meat inspection, pig carcasses are trimmed or partially or fully condemned upon detection of disease or lesions that reflect animal welfare in any of the stages prior to slaughter (i.e. including on-farm and transport, lairage) (Harley et al., 2012).

Carcass condemnations was scored 3 in the consensus exercise (Tables 63 and 64) because it was considered related to many welfare consequences in cull sows and rearing pigs. However, the parts of a pig's carcass that are condemned are generally severely affected meaning that only the most severe cases are recorded. Clearly, other less severe conditions that do not require condemnation are not recorded. However, some of such conditions (e.g. external abscesses) might be trimmed; this could also be considered part of carcass condemnations. Hence it is a good indicator of the overall welfare of the animals.

9.4.5.4. Assessment

Timing of assessment: *post-mortem*.

Current use of this ABM

All FBOs must adhere to food safety legislation therefore all slaughterhouses already record this ABM for food hygiene purposes. There is little available information on the use of condemnation data for animal welfare purposes, though many projects are underway (EFSA, 2021).

Considerations for use a standard method

There is a large variation in the recording of carcass condemnations throughout the EU (Alban et al., 2022). Differences reported were due to the terminology used, the type, number and use of codes of classification and the use of electronic databases (Alban et al., 2022). Furthermore, some slaughterhouses do not weigh the condemned (or trimmed) parts of the carcass while entirely condemned carcasses are always weighed for economic purposes. Additionally, there is large variation between meat inspectors in the recording of the reasons for condemnation. Hence, it is difficult to compare data between different countries and/or slaughterhouses. Carcass condemnations due to other reasons than health and welfare (e.g. because of improper handling or of carcass contamination) must be excluded from the final score.

Carcass condemnations is expressed as the number of carcasses condemned (partially or fully) or trimmed, as the weight of the entirely condemned carcass or as the weight of the condemned/trimmed carcass parts (in the case of partial condemnation).

Possibility for automation

Recording carcass condemnation is performed by inspection from the Veterinary officers, and no large possibility for automation has been reported from the experts. However, developing automated and harmonised recording and electronic database can result in a valid tool to enhance the traceability of the pork chain and support animal welfare monitoring schemes.

9.4.6. Vulva lesions

9.4.6.1. Animal category

Cull sows.

9.4.6.2. Description of the ABM

Definition: *Lesions to the skin of the vulva which might be bleeding cuts, scabbed wounds or deformed vulval tissue after healing*.

Vulva lesions are caused by a sow biting the vulva of another sow. In a minority of the cases, it may be caused by piglets biting the vulva in the farrowing crate, by trampling or damage from the fixtures and fitting (e.g. in short gestation stalls or farrowing crates, Bracke, 2007). More information on the description of this ABM can be found at Section 3.4.14.

9.4.6.3. Interpretation

Vulva lesions usually result from biting injury in pregnant sows kept in group-housing systems. The prevalence tends to increase from farrowing to the end of the gestation (Gjein and Larssen, 1995a). Vulva lesions may deteriorate also in the preslaughter phases, but this occurrence is largely depending from cull sow management (Thodberg et al., 2019, Herskin et al., 2020).

'Vulva lesions' is a highly relevant ABM. It indicates pain in the bitten animal and often reflects competition for access to resources (Bracke, 2007). There are few data on the prevalence of vulva lesions at slaughter, however, one study reported a prevalence of 7% of sows with vulva lesions before transport (Fogsgaard et al., 2018).

There are several risk factors for vulva lesions: firstly, the type of feed (absence of roughage feeding) and type of feeder (Gjein and Larssen, 1995a) play an important role. In addition, a survey by Rizvi et al. (2000) reported that competition for feed, aggressiveness among sows, period around farrowing and mixing of sows were the most common reasons provided by farmers as causes of vulva lesions. The risk for vulva lesions showed no clear results in relation with the parity number. In Gjein and Larssen (1995a), gilts showed fewer vulva lesion as compared to sows, while according to Sørensen et al. (2016) higher parity sows had fewer vulva lesions.

During the consensus exercise (Table 64), vulva lesion was scored 4 because it is related to many welfare consequences in cull sows therefore it is a good iceberg indicator of sow welfare.

9.4.6.4. Assessment

Timing of assessment: *post-mortem*.

No protocols at abattoir are described in the literature on use of this ABM, but the EFSA experts considered it feasible to assess vulva lesions *post-mortem*. According to Bracke (2007), assessing vulva lesions *ante-mortem* is time-consuming.

Current use of this ABM

The present ABM was not included in the initial list of ABMs discussed in the EFSA report from the AHAW Network meeting (EFSA, 2021). It is likely that severe cases of vulva lesion are recorded as part of carcass condemnations, but that they are not identified separately.

Considerations for use a standard method

Clinical examination shows that vulva lesions are often inflamed, however, the inflammation is mainly superficial and local (Gjein and Larssen, 1995a).

The severity of the injuries was reported in a study by Rizvi et al. (2000) to range from bleeding to removal of the whole vulva.

Methods for assessing vulva lesions on farm are based on the absence/presence of lesions, including sometimes the severity of the lesions. Methods to assess severity are based on the dimension of the lesions (Sørensen et al., 2016) and the proportion of the vulva that is missing (Bracke, 2007; Welfare Quality®, 2009).

Wounds may also vary in the state of healing (e.g. fresh wounds vs. old scars) and in the occurrence of complications (e.g. secondary infections). A protocol should be developed to determine the severity of the wound and/or to explain which wounds are to be counted and which are not (Rizvi et al., 2000). As with tails, scars should be included to give a 'lifetime' picture.

Possibility for automation

There were no studies on the automatic assessment of lesions in the vulva. However, the experts considered that, in theory, it could be performed by visual image analysis using machine learning tools, similar to what is under development for skin lesions on the carcass and previously described for shoulder ulcers.

9.4.7. Lameness

9.4.7.1. Animal category

Rearing pigs and cull sows.

9.4.7.2. Description of the ABM

Definition: *Inability to use one or more limbs in a normal manner.*

Lameness can be caused by injury due to poor housing conditions, non-infectious and infectious conditions and degenerative diseases (Taylor, 1999).

9.4.7.3. Interpretation

Lameness is considered as a good iceberg indicator of pigs and sow's welfare (and was scored 3 in rearing pigs and score 4 in cull sows during the consensus exercise, Tables 63 and 64) because it is related to many welfare consequences (EFSA, 2021).

9.4.7.4. Assessment

Timing of assessment: *Ante-mortem* when the animals are unloaded and moved prior to stunning.

Current use of this ABM

This ABM is largely used for the assessment of lame animals after transport. However, some studies indicate that lameness relates to previous conditions on the farm. Indeed, anatomopathological examination correlated lameness to arthritis, severe bursitis and other chronic conditions on farm that may worsen after transport. Moreover, even if a lame animal cannot be considered fit for transport, a threshold does not exist and animals that externally appear fit for transport, can worsen their condition during transport (Thodberg et al., 2019; Grandin, 2016). This seems even more relevant in reproductive animals, such as sows, due to their longer production cycle and age (Thodberg et al., 2019). (For further details on pig fitness for transport, see EFSA AHAW Panel, in press). As a result, this ABM was prioritised by the AHAW Network (EFSA, 2021) and considered an iceberg indicator by the experts although it is difficult to relate the condition with certainty to on-farm conditions.

Considerations for use a standard method

Many methods exist to assess lameness in sows, and they change depending on the scale and score used. However, the major challenge is to differentiate lame animals that carried welfare consequence from the farm, from lame animals after transport and lairage.

During the discussion with the experts, it emerged that there may be other *post-mortem* indicators for this purpose. For example, the assessment *post-mortem* of osteochondrosis (De Koning et al., 2015), arthritis (Elina et al., 2019), bone and claw lesions, severe bursitis (Engblom et al., 2007, 2008; Ghidini et al., 2021). However, at the present time few studies exist and they were mainly experimental/anatomopathological, thus did not systematically record those ABMs under commercial conditions. However, due to the high number of welfare consequences related to sow lameness, there is potential to identify the proportion of lame animals at slaughter that had chronic physical issues.

Possibility for automation

Different systems exist for lameness detection, all developed for on-farm assessment. Image analysis technologies that detect locomotion and axial body-movement are promising tools for assessing lameness (Stavrakakis et al., 2015). The same authors tested the potential of depth-image analysis to evaluate axial body movements trajectory during walking, reporting the need for algorithms refinement to increase sensitivity and reliability, and the need to incorporate other elements.

Accelerometers were also applied for lameness detection based on sows' postures (Conte et al., 2014; Scheel et al., 2017). Even if this system can provide useful information, the application requires extra handling because the accelerometer needs to be attached to the animals' leg, or ear using an ear-tag.

Thermal imaging facilitates differentiation between lame and non-lame pregnant sows by distinguishing temperature differences in the affected leg (Amezcua et al., 2014).

However, there are no systems for the assessment of *post-mortem* ABMs potentially associated with lameness (e.g. arthritis, claw lesions, bone injuries).

9.5. Summary conclusions on Specific ToR 5

1) Tail lesions, carcass condemnations and lung lesions are the most useful and promising ABMs for collection at slaughterhouses to monitor the level of welfare on farm for rearing pigs.
2) Body condition, carcass condemnations, shoulder ulcers and vulva lesions are the most useful and promising ABMs for collection at slaughterhouses to monitor the level of welfare on farm for cull sows.
3) The prevalence of the welfare consequences on farm assessed through the ABMs collected at the slaughterhouse may be underestimated of welfare consequence on farms, as it does not include the animals that die on farm. This problem may be greater for cull sows because of the high rate of on-farm mortality.
4) There is a lot of variation in the assessment methodologies used for all the ABMs. which makes them difficult to standardise, harmonise and compare the current available data.
5) Lameness is an important ABM for rearing pigs and cull sows, but was not proposed as a promising ABM for further development because (i) it is difficult to distinguish if the welfare consequences occurred on farm or in the preslaughter phases; (ii) lame animals identified on farm should not be transported.
6) The TRL of automated monitoring of the ABMs at slaughterhouse is currently low. Methods for tail lesions and lung lesions are the most advanced.
7) Unified and standardised scoring systems and protocols across different regions/countries are necessary to monitor and benchmark the welfare of cull sows and rearing pigs transnationally.

9.6. Recommendations on Specific ToR 5

1) Monitoring tail lesions, carcass condemnation, lung lesions in rearing pigs at slaughter should be implemented to identify herds with diverse welfare consequences, thereby enabling guidance for the implementation of preventive and mitigation measures.
2) Body condition, carcass condemnation, shoulder ulcers and vulva lesions should be monitored in cull sows at slaughter.
3) To permit transnational benchmarking, traceability databases and risk assessment exercises, harmonised assessment methods and scoring systems should be developed for the identified ABMs.
4) Systems for automatic and continuous assessment of ABMs and data recording should be concordant with a standardised manual method. However, as the readiness for automation is different for the different ABMs, specific recommendations for the next steps are:

   a) For the assessment of **tail lesions,** existing tools in the slaughter line should be integrated with slaughterhouse infrastructure including IT systems;
   b) Further development of the currently available software for assessment of **lung lesions** should be carried out to be suitable for commercial slaughter operations;
   c) A standard slaughterhouse scoring system for **shoulder ulcers**, **vulva lesions** and **body condition** should be agreed, before further automation;
   d) It is not possible to automate measurement of **carcass condemnations,** but the use of automatic data recording and data management should be put in place to improve traceability thus implementing the use of carcass condemnations to assess animal welfare on farm.

10. Sources of uncertainty

The sources of uncertainty associated with the assessment methodology and inputs (see Section 2.2) for the identification and assessment of the welfare consequences, and related ABMs in pigs are listed in Table 65.

Table 65: Sources of uncertainty associated with the assessment methodology and inputs (broad literature search, ELS, expert opinions) for the identification and assessment of the welfare consequences, and related ABMs

Source of Uncertainty	Nature or cause of the uncertainty	Impact of the uncertainty on the assessment
Literature search – Language	The search was performed exclusively in English (at least the abstract for other languages). More studies could have been identified by including references with abstracts in languages other than English.	The number of relevant welfare consequences, ABMs and/or hazards may have been underestimated.
Literature search – Publication type	Studies considered included primary research studies identified through the extensive literature search and grey literature (factsheets, guidelines, conference papers, EU reports, book chapters, etc.) known to the EFSA experts, but an extensive search of the grey literature was not conducted. Therefore, there may be reports and other guidance documents on animal welfare of which the EFSA experts were not aware off.	Underestimation of the published relevant papers. The number of relevant welfare consequences, ABMs and/or hazards may have been underestimated.
Literature search – Search strings	Although the search criteria were thoroughly discussed, some synonyms may have not been used in the search strings, and thus less hits might have been retrieved	The number of highly relevant welfare consequences, ABMs and/or hazards may have been underestimated.
Literature search – Source of studies	The search was limited to Web of Science all databases. Although the search was complemented by internet searches and manual searches of the publicly available literature, no data were retrieved from other sources (e.g. industry data). More information could have been retrieved by applying different searches and/or methods (e.g. public call for data).	The number of highly relevant welfare consequences, ABMs and/or hazards may have been underestimated.
Literature search – inclusion and exclusion criteria	The screening phase might have led to the exclusion of certain studies that could have included relevant information.	Underestimation of the published relevant papers. The number of relevant welfare consequence, ABMs and/or hazards may have been underestimated.
Expert group – number and type of experts	A limited number (7–9) of experts were selected based on their knowledge on animal welfare in the different pig categories and related husbandry systems. They also had to show they have no conflict of interest. This may have resulted in reduced level of technical knowledge derived from the field practice.	The number and variety of highly relevant welfare consequence, ABMs and/or hazards may have been over or underestimated.
Pig categories considered in the studies retrieved in the extensive literature search	The animals used in the studies retrieved might not be the breeds/strains or categories currently used in the EU to study welfare consequences and ABMs, thus requiring an extrapolation exercise from the experts.	Under- or overestimation of the level of magnitude of the welfare consequences and related ABMs.
Farming conditions and practices in the studies retrieved in the extensive literature search	The studies retrieved through the ELS could have been performed anywhere in the world, and thus may consider pig farming conditions different from those currently allowed in the EU, also regarding animal welfare. Thus, experts had to extrapolate findings to the EU relevant conditions in some cases.	Under- or overestimation of the level of magnitude of the welfare consequences and related ABMs.
Time allocation	The time allocated to this opinion were limited and additional time for reflection would have facilitated a more in-depth discussion of some of the aspects.	Under- or overestimation of the level of magnitude of the WCs and related ABMs.

Source of Uncertainty	Nature or cause of the uncertainty	Impact of the uncertainty on the assessment
Lack of data on ABMs	Although many ABMs have been successfully developed and applied in the scientific literature, for many, the amount of data are still too limited to draw quantitative conclusions and conclusions relied largely on expert opinion.	Under or overestimation of the effect of exposure variables and husbandry circumstances on welfare consequences.
Approach/Type of assessment	The approach used to assess the exposure variables of Specific ToRs (EKE, semiquantitative, qualitative (y/n) or narrative) might have led to different representation of the results, enhancing or limiting the understanding of findings.	Under or overestimation of the effect of exposure variables and ABMs on welfare consequences.

11. Conclusions with results of the uncertainty analysis

The Conclusions in the following list (Tables 66 and 67) are derived from the summary conclusions in the different sections of the text (see Chapter 4–9). Summary conclusions which duplicate others have been omitted here. For some conclusions, rewording has been carried out to facilitate the expression of degree of certainty. No uncertainty statement is given for conclusions which are factual information. Summary conclusions derived from EKE exercises already had an certainty range estimated as part of the EKE process. They also can be found in Table 66.

Table 66: Conclusions with results of the uncertainty analysis (in brackets the section numbers where the associated summary conclusions are presented). Three ranges were used to express agreed (consensus) certainty around conclusions (see Table 8, Section 2.2.3, adapted from EFSA, 2019)

#	CONCLUSIONS
	Conclusions on the welfare of gilts and dry sows from the General ToRs (Section 4.5.1)
1	It is 66–100% certain that the highly relevant welfare consequences experienced by **gilts and dry sows in stalls** are restriction of movements, resting problems, group stress, inability to perform exploratory or foraging behaviour and prolonged hunger. Other welfare consequences may negatively affect the welfare of gilts and dry sows, however, they were classified less or moderately relevant (see Appendix B). Hazards leading to the highly relevant welfare consequences and ABMs that can be used to assess them are presented in Section 4.2.
2	It is 66–100% certain that there are measures to mitigate some of the highly relevant welfare consequences experienced by **gilts and dry sows in stalls** (e.g. resting problems by cleaning the floor and/or providing bedding), whereas other welfare consequences (e.g. restriction of movement and inability to perform exploratory behaviour) cannot be mitigated except by removing the animals from the stalls.
3	It is 66–100% certain that the welfare consequences that are highly relevant for **gilts and dry sows in outdoor paddock systems** are group stress and prolonged hunger.
	Conclusions on the welfare of gilts and dry sows from Specific ToR 1 (Section 4.5.2)
4	It is 90–100% certain that the welfare consequences experienced by **gilts and dry sows in groups** are primarily associated with competitive behaviour in groups (i.e. group stress and prolonged hunger), risks from physical condition after lactation (i.e. locomotory disorders and, soft tissue lesions and integument damage) and detrimental consequences of oestrus behaviour (i.e. inability to avoid unwanted sexual behaviour, bone lesions and handling stress).
5	It is 66–100% certain that the welfare consequences associated with grouping gilts and sows can be mitigated at any stage by adhering to the principles of good mixing, including the use of mixing pens, good home pen design/layout and good feeding and general management (see Table 38).
6	It is > 50–100% certain that grouping gilts and dry sows in the period between 8 and 21 days post-service, will cause detrimental effects to farrowing rate indicative of stress, and that farrowing rate of sows grouped at weaning is comparable to that of sows housed in stalls for the duration of pregnancy.

#	CONCLUSIONS
	Conclusions on pre-farrowing crate closing time (Section 5.7.7.1)
7	It is > 50–100% certain that initial confinement in a farrowing crate is stressful, but less so if animals have prior experience of the farrowing accommodation or of close confinement (e.g. feeding stalls) and to human interaction.
8	It is 90–100% certain that confinement imposed prior to farrowing is detrimental to sow welfare because it restricts the sows' possibility to move around and prevents the functional performance of highly motivated nest-building behaviour.
9	It is 66–100% certain that delaying the crate closing time until farrowing is completed results in increased neonatal piglet mortality.
	Conclusions on post-farrowing crate opening time (sow perspective) (Section 5.7.7.2)
10	It is 66–100% certain that the highly relevant welfare consequences for the sow (restriction of movement, resting problems, group stress, inability to perform exploratory or foraging behaviour, inability to perform maternal behaviour, heat stress, soft tissue lesions and integument damage, see Sections 3.4 and 5.1) can be mitigated with early opening times after farrowing. Intuitively this benefits sow welfare although objective evidence from ABMs to confirm this is lacking.
11	The possibility of longer term benefits for the piglets from improved sow–piglet interaction following maternal release from confinement requires further investigation.
	Conclusions on post-farrowing crate opening time (piglets perspective) (Section 5.7.7.3)
12	It is 90–100% certain that any change in farrowing system will need a transition period for people and animals to adapt to the new situation before the results indicated in the following conclusions are achieved.
13	Temporary crating systems (which provide an average 4.3–6.3 m^2 of space for the sow) can achieve the same piglet survival as a permanent crating system. The minimum confinement time of a sow in a temporary crating system to achieve this is 7 days after farrowing (90% certainty range between 3.4 and 16 days).
14	A situation where the sow is never crated in a pen designed for temporary crating will increase piglet mortality relative to permanent crating by 24% (with 90% certainty range from 3% to 59%).
15	The estimated mortality in a permanent crating system or a temporary crating system with a minimum of 7 days of confinement is 14% (with 90% certainty range from 12% to 17%) and a temporary crating system where the crate is never closed is 18% (with 90% certainty range from 14% to 24%).
	Conclusions on the amount of space pre-farrowing (Section 5.7.12.1)
16	The farrowing duration per piglet expressed as inter-piglet birth interval (IBI) is lower in pens than in crates. The IBI in a pen was estimated as 82% of that in a crate, with a 90% certainty range from 64% to 97%.
17	The effect on the estimated IBI can be quantified as a reduction of 4 min per piglet when comparing the average sow in an individual crate (22 min/piglet, with 90% certainty range from 15 to 29 min/piglet) to a pen (18 min/piglet, with 90% certainty range from 11 to 25 min/piglet) in good commercial conditions.
18	It is > 50–100% certain that, in uncrated sows, there is no effect of the pen size on IBI.
	Conclusions on the amount of space post-farrowing (sow perspective) (Section 5.7.12.2)
19	The minimum space required to allow a sow to express the same time in locomotor behaviour as shown in an unrestricted environment is much higher than that currently offered in any indoor individual farrowing pen. A space allowance of at least 47 m^2 (with a 90% certainty range of 12.2–179 m^2) is needed for a sow to show the full extent of locomotory behaviour, which is estimated to be 13.4% of 24 h (193 min per 24 h) (with a 90% certainty range of 8.6–22%).
20	In a pen allowing 6.6 m^2 of space for the sow (as subsequently shown to optimise piglets survival, see Section 5.7.11.2), the time spent walking is estimated as 2.6% (with a 90% certainty range of 1.2–6.0%). This would roughly equate to 23% of the locomotory behaviour a sow would express when not space restricted (with a 90% certainty range of 11–53%).
21	Each additional square meter of available space is associated with a predicted increase in locomotory behaviour of 0.3% (= 4 min per 24 h).
	Conclusions on the amount of space post-farrowing (piglets perspective) (Section 5.7.12.3)
22	Farrowing pens that provide at least 6.6 m^2 available space to the sow (with a 90% certainty range from 4.5 m^2 to 9.8 m^2) can achieve the same mortality as in a permanent crate. This roughly equates to a total pen space of at least 7.8 m^2 (with a 90% certainty range from 5.7 m^2 to 11 m^2). Above 6.6 m^2, the behavioural freedom of sows and piglets increases, but piglet mortality does not further decrease.

#	CONCLUSIONS
23	Reducing the pen space from 6.6 m^2 available space to the sow, will lead to higher piglet mortality if the sow is not crated: e.g. a pen with 4 m^2 available for the sow (which roughly equates to 5.2 m^2 of total pen size) will lead to 1.42 times the mortality of that in a permanent farrowing crate (with a 90% certainty range from 1.03 times to 2.22 times)
24	The use of a temporary farrowing crate system cannot be advised as a step in a farm's transition from using farrowing crates to farrowing pens, unless the size of the temporary farrowing crate system is the same as that of the future free farrowing pen.
	Conclusions on pre-farrowing enrichment materials (Section 5.7.16.1)
25	It is 90–100% certain that sows and gilts are intrinsically motivated to perform nest-building behaviour on the day before farrowing.
26	It is 90–100% certain that sows kept in crates cannot perform functional nest-building behaviour, because they cannot turn around. Additionally, their manipulatory behaviour may move loose material out of reach
27	It is 66–100% certain that the suitability to enable specific nest-building behaviours varies between materials and also depends on the amount of the materials. However, there is little evidence to allow a complete pairwise comparison of the suitability of all nest-building materials used in practice.
28	It is 66–100% certain that materials such as long-stemmed or long-cut straw, hay, haylage are the most suitable for nest-building. These materials need to be provided in an amount which allows all behavioural elements of nest-building to be performed at a functional level.
	Conclusions on post-farrowing enrichment materials (Section 5.7.16.2)
29	It is 66–100% certain that both sows and piglets are motivated to explore enrichment material during the whole period from farrowing to weaning and, if this is not available, will redirect explorative behaviour to pen fixtures and pen mates.
30	It is 66–100% certain that sows kept in crates cannot perform a full pattern of exploratory behaviour because of restricted movement. Additionally, their manipulatory behaviour may move loose material out of reach.
31	It is > 50–100% certain that provision of enrichment material to piglets during the lactation period reduces the risk for tail biting in weaners and growing pigs.
32	It is > 50–100% certain that piglets with access to enrichment material in the farrowing pen are better able to adapt to the weaning transition.
33	The evidence found in literature does not allow a complete pairwise comparison of the suitability of all enrichment materials used in practice.
34	Given the limited amount of evidence measuring explorative behaviour in sows and piglets from farrowing to weaning, a preference for specific enrichment materials cannot be determined scientifically. However, it is 90–100% certain that lactating sows and piglets prefer the same material characteristics as other pig categories.
	Conclusions on the time needed for adaptation (Section 5.7.17.1)
35	When converting from a system with farrowing crates to a system with farrowing pens, an adaptation period for individual sows, the herd as a whole and the stockperson will be needed before piglet survival levels will be similar or better than before the conversion. It is > 50–100% certain that a minimum of period of 6 months is needed for this adaptation.
36	It is 66–100% certain that longer term optimisation of the system will occur with the incorporation in genetic selection of traits focused on free farrowing
	Conclusions on the effects of litter size on sow and piglet welfare (Section 5.7.18.6)
37	It is 90–100% certain that selection for increasing litter size, such that the number of piglets born alive typically outnumbers the number of functional teats, is associated with negative welfare consequences for both the piglets and the sows.
38	It is 66–100% certain that the use of artificial rearing systems as a structural consequence of large litters provides challenges to piglet welfare that can only be mitigated by adapting the herd's average litter size to the physical capabilities of the sow, by genetic selection.
39	It is 90–100% certain that selection for litter size does not concomitantly result in an increase in the number of functional teats.
40	It is 90–100% certain that increasing litter size is characterised by increased within-litter birth weight variation, increased perinatal mortality and longer term detrimental effects for low birthweight piglets.

#	CONCLUSIONS
41	It is 66–100% certain that piglet survival in all farrowing systems will be improved by genetic selection for appropriate traits, including optimal litter size, good piglet viability, low birth weight variability, good maternal behaviour, good leg conformation and good udder quality.
	Conclusions on the welfare of farrowing and lactating sows and piglets from the General ToRs (Section 5.8.1)
42	It is 66–100% certain that the highly relevant welfare consequences experienced by **farrowing and lactating sows housed in farrowing crates** are restriction of movements, resting problems, group stress, inability to perform exploratory or foraging behaviour, inability to express maternal behaviour, heat stress and soft tissue lesions and integument damage. Hazards leading to these highly relevant welfare consequences and ABMs that can be used to assess them are presented in Section 5.2.
43	It is 66–100% certain that there are no highly relevant welfare consequences for **farrowing and lactating sows housed in farrowing pens or outdoor farrowing paddocks**. Welfare consequences in these systems are less or moderately relevant (see Appendix B).
44	It is 66–100% certain that the highly relevant welfare consequences experienced by **piglets housed in farrowing crate** systems are group stress, inability to perform exploratory or foraging behaviour, prolonged hunger, prolonged thirst and soft tissue lesions and integument damage. Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 5.5.
45	It is 66–100% certain that the highly relevant welfare consequences experienced by **piglets housed in farrowing pen systems** are group stress, prolonged hunger, prolonged thirst and soft tissue lesions and integument damage.
46	It is 66–100% certain that the highly relevant welfare consequences experienced **by piglets housed in outdoor farrowing paddocks** are group stress, prolonged hunger, prolonged thirst, cold stress and soft tissue lesions and integument damage.
47	It is 66–100% certain that the highly relevant welfare consequences experienced by **piglets housed in artificial rearing systems** are restriction of movement, group stress, separation stress, inability to perform exploratory or foraging behaviour, inability to perform sucking behaviour and prolonged hunger.
	Conclusions on tooth reduction (Section 6.1.4)
48	It is 66–100% certain that tooth reduction is a stressful procedure that if performed incorrectly causes short- and long-term pain. In particular, clipping is inherently injurious.
49	It is 66–100% certain that grinding to only blunt the sharp tip of the tooth does not injure sensitive tissue when correctly performed.
50	It is 66–100% certain that the necessity for teeth reduction can be minimised by risk mitigation; this includes sow management to promote optimal milk supply, and balancing litter size with the number of teats.
51	It is 90–100% certain that training of staff in correct procedures is the most effective measure to prevent and mitigate welfare consequences in individual litter situations where tooth reduction can be justified.
52	It is 90–100% certain that, although current legislation highlights teat damage as evidence to justify tooth reduction, facial damage to litter mates is a more related animal-based measure.
	Conclusions on castration (Section 6.2.7)
53	It is 90–100% certain that surgical castration without anaesthesia is painful at any age and has short and medium-term negative welfare consequences including soft tissue lesions and integument damage, handling stress, fear and pain.
54	The alternatives to traditional surgical castration fall into three main categories: avoiding castration by leaving the males entire with adequate implementation of management strategies, application of immunocastration or surgical castration with anaesthetic and analgesic to mitigate pain resulting from the procedure.
55	It is 66–100% certain that keeping entire male pigs is a viable solution if the drawbacks in terms of aggressiveness and mounting behaviour, leading to welfare consequences for pen mates, are addressed.
56	It is 66–100% certain that management practices are available to reduce the welfare consequences of surgical castration and at the same time to reduce boar taint when keeping entire male pigs (see Section 6.2.3). Slaughtering pigs before sexual maturity (5–7 months) is the most effective method to prevent those consequences; however, this is not possible for pigs slaughtered at a heavy end-weight (around 9 months of age).
57	It is > 50–100% certain that, from a welfare point of view, immunocastration has advantages compared to keeping entire male pigs. This is due to less mounting behaviour, reduced number of skin lesions, penile injuries and fewer locomotory disorders. In general, two doses of the vaccine are needed, but three doses may be needed in pigs reared for a longer period, and this is associated with risk of handling stress and abscessation.

#	CONCLUSIONS
58	If the alternatives listed above are not feasible and surgical castration needs to be applied, it should always be carried out with administration of anaesthesia and analgesia. It is 66–100% certain that none of the molecules available are fully effective for pain relief when used alone, and that to achieve adequate pain relief, a combination of analgesics and anaesthetics is needed.
59	Human and animal safety, the lack of validated protocols, the scarcity of drugs registered in the EU, financial costs and higher workload, are still barriers for a widespread use of drugs for anaesthesia and analgesia during piglet castration, thus preventing pain relief.
	Conclusions on tail docking (Section 6.3.6)
60	It is 90–100% certain that tail docking is effective in reducing the risk of tail lesions, and that docking is not needed if good husbandry practices and management are in place.
61	It is 90–100% certain that tail docking is painful and has short and medium-term negative welfare consequences including soft tissue lesions and integument damage, bone lesions (including fractures of the spinal vertebrae), handling stress, fear and pain.
In the cases where tail docking is allowed, the following aspects need to be considered:	
62	It is 66–100% certain that the amount of soft tissue, bone and nervous tissues damaged by tail docking increases with age, although docking is painful for piglets of all ages.
63	It is 66–100% certain that cautery methods cause less pain than non-cautery methods.
64	It is 66–100% certain that docking the tail close to the first coccygeal vertebras has a larger impact on soft tissue, bone and nervous tissues than leaving a longer length of tail, but also 66–100% certain that cutting only the tip of the tail is less effective in preventing biting lesions
65	Since tail docking causes pain during and after the procedure, pain mitigation is necessary. However, there is currently no agreed protocol available and effective for this purpose.
	Conclusions on the welfare of weaners and rearing pigs from Specific ToR 4: weaning age (Section 7.7.1.8)
66	It is 90–100% certain that abrupt weaning results in a range of welfare consequences including separation stress, prolonged hunger, prolonged thirst, gastro-intestinal disorders and inability to perform sucking behaviour, which has further detrimental consequences for resting problems, group stress and soft tissue lesions and integument damage.
67	It is > 50–100% certain that tail biting risk is not directly affected by weaning age. However, there may be indirect effects via other welfare consequences (e.g. health-related) of a poor weaning transition.
68	It is 66–100% certain that these welfare consequences (referred to in conclusion 67) are particularly pronounced at weaning ages of less than 21 days and with artificial rearing systems. However, there is high variability between different studies and housing systems.
69	It is 66–100% certain that there are welfare benefits of increasing weaning age over the range between 21 and 28 days, because of the increasing maturity of behavioural, digestive and immunological systems over this period.
70	It is > 50–100% certain that there are few, if any, welfare benefits of increasing weaning age above 28 days. Data are very limited.
	Conclusions on the welfare of weaners and rearing pigs from Specific ToR 4: space allowance (Section 7.7.2.7)
71	It is 90–100% certain that if space is insufficient, it will prevent pigs from performing highly motivated behaviours, including exploratory/foraging, social, resting and thermoregulatory behaviours, and from maintaining separate dunging and lying areas. Reduced space allowance promotes damaging behaviours such as tail biting, and compromises growth (for an estimate quantification, see Table 59).
72	A minimum space allowance equal to k = 0.036 (representing 0.84 m^2 for a 110 kg pig) was previously recommended by EFSA (2005) for thermoneutral conditions. It is > 50–100% certain that, at this space allowance, welfare is improved relative to a k = 0.028 (which approximates the current legal minimum space allowance); growth rate is less compromised (estimated as 57%) and tail biting is reduced (estimated as 48%). Please see Sections 7.7.2.2–7.7.2.6 for further explanation of quantification.
73	A minimum space allowance equal to k = 0.047 (representing 1.10 m^2 for a 110 kg pig), was previously recommended by EFSA 2005 for temperatures above 25°C or for pigs above 110 kg. At this space allowance, it is > 50–100% certain that, pigs can lie in full lateral position; growth rate is less compromised (estimated as 26%), and tail biting is further reduced (estimated as 17%), relative to a space allowance equivalent to a k value of 0.028 (which approximates the current legal minimum space allowance) (See Sections 7.7.2.2 and 7.7.2.6 for explanation of quantification).

#	CONCLUSIONS
	Conclusions on the welfare of weaners and rearing pigs from Specific ToR 4: types of flooring (Section 7.7.3.4)
74	It is 66–100% certain that provision of some solid flooring will increase comfort and facilitate provision of bedding substrates
75	It is > 50–100% certain that the minimum solid floor space necessary to accommodate lying behaviour under thermoneutral conditions is defined by k = 0.033 (equal to 0.77 m^2 for a 110-kg pig).
76	It is 66–100% certain that tail biting risk is increased with increasing proportion of slatted flooring.
77	Maintenance of hygiene on the solid flooring is important and can be influenced by the proportion of solid to slatted flooring, but also by the pen layout, the nature of the airflow patterns and ambient temperature.
78	Because of the complications in 77, it is currently not possible to define an area or percentage of solid floor in a partly slatted system which reconciles the possibly conflicting requirements of pig behaviour and hygiene.
	Conclusions on the welfare of weaners and rearing pigs from Specific ToR 4: enrichment material (Section 7.7.4.4)
79	It is 90–100% certain that straw, hay, silage or other loose organic substrates are more effective in reducing tail biting than enrichment materials which are suspended from a ceiling or fixed to a wall.
80	It is 66–100% certain that loose organic substrates are more effective in reduce tail biting than pressed straw blocks and dispensers that require extensive manipulation to obtain the substrate.
81	It is > 50–100% certain that regarding objects on the floor or fixed on the wall, jute bags and fresh wood can be effective in reducing tail biting whereas other objects (e.g. rubber toys) are not as effective, unless replaced regularly to maintain novelty.
82	It is 66–100% certain that the competition caused by limited amount and availability of enrichment materials reduces the effectiveness of the enrichment to reduce tail biting.
83	It is 66–100% certain that a reduction in tail biting can be achieved in undocked pigs if they are offered 20 g per day of straw or similar substrate. However, quantities that are larger (e.g. up to 400 g/pig per day) are more effective.
84	It is 66–100% certain that a reduced interest of pigs in the enrichment due to soiling limits the effectiveness of the enrichment to reduce tail biting.
85	It is 66–100% certain that the effects of tail biting outbreaks can be mitigated by using attractive organic substrates.
86	It is 90–100% certain that hygiene and quality criteria of organic enrichment are important to avoid biosecurity risks.
	Conclusions on the welfare of weaners and rearing pigs from Specific ToR 4: air quality (Section 7.7.5.4)
87	Ventilation inadequacy may affect several different aspects of air quality including air speed, temperature and the concentration of gases (i.e. NH_3 and CO_2). It is 66–100% certain that all of these factors pose a risk to tail biting and other welfare issues (e.g. respiratory disorders, eye disorders and aversion).
88	Specific thresholds at which ammonia levels detrimentally affect respiratory health and the risk of tail biting are difficult to define because of many interacting factors. However, it is > 50–100% certain that levels exceeding 10–15 ppm are a risk factor for health-related disorders.
	Conclusion on the welfare of weaners and rearing pigs from Specific ToR 4: health status (Section 7.7.6.6)
89	It is 90–100% certain that poor health status is a risk factor for tail biting. Tail biting and health problems are often found jointly on a farm both because tail biting can cause health problems and because they share several common risk factors.
	Conclusion on the welfare of weaners and rearing pigs from Specific ToR 4: diet composition (Section 7.7.7.6)
90	It is 66–100% certain that deficiencies in feed composition and method of provision (such as feeding space) are major risk factors for tail biting. Correct formulation of diets to minimise tail biting risk needs to take account of the growth stage, genetic potential and health status of the animals, with particular attention to amino acid and mineral composition.

#	CONCLUSIONS
	Conclusions on the welfare of weaners and rearing pigs from the General ToRs (Section 7.8.1)
91	It is 66–100% certain that the highly relevant welfare consequences experienced by **weaners in indoor group housing** are group stress, inability to perform exploratory or foraging behaviour, soft tissue lesions and integument damage and gastro-enteric disorders. Other welfare consequences may negatively affect the welfare of weaners; however, they were not classified as highly relevant (see Appendix B). Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 7.2.
92	It is 66–100% certain that the highly relevant welfare consequences for **weaners kept in indoor systems with access to an outdoor area** are the same identified in the case of weaners kept in indoor group housing (conclusion 91). However, the magnitude of the welfare consequences that the animals in the two systems experience may be different as the access to an outdoor area gives the potential for greater space and environmental complexity.
93	It is 66–100% certain that the highly relevant welfare consequences for **weaners housed in outdoor paddock systems** are cold stress and gastro-enteric disorders.
94	It is 66–100% certain that the highly relevant welfare consequences experienced by **rearing pigs in indoor group housing** are restriction of movements, resting problems, group stress, inability to perform exploratory or foraging behaviour, locomotory disorders (including lameness), soft tissue lesions and integument damage and respiratory disorders. Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 7.5.
95	It is 66–100% certain that the highly relevant welfare consequences experienced by **rearing pigs kept in indoor systems with access to an outdoor area** are group stress, inability to perform exploratory or foraging behaviour, locomotory disorders (including lameness), soft tissue lesions and integument damage and respiratory disorders.
96	It is 66–100% certain that there are no highly relevant welfare consequences for **rearing pigs kept in outdoor paddock systems**. Welfare consequences in these systems are less or moderately relevant (see Appendix B).
	Conclusions on the welfare of boars (Section 8.3)
97	It is 66–100% certain that the highly relevant welfare consequences **for boars kept in indoor individual pens** are restriction of movement, isolation stress, inability to perform exploratory or foraging behaviour, prolonged hunger and locomotory disorders (including lameness). Hazards leading to these welfare consequences and ABMs that can be used to assess them are presented in Section 8.2.
98	The scientific information on the husbandry systems and the welfare consequences pertaining to boars is very limited.
	Conclusions on Specific ToR 5 (Section 9.5)
99	It is 66–100% certain that tail lesions, carcass condemnation and lung lesions are the most promising ABMs for collection at slaughterhouses to monitor the level of welfare on farm for rearing pigs.
100	It is 66–100% certain that body condition, carcass condemnation, shoulder ulcers and vulva lesions are the most promising ABMs for collection at slaughterhouses to monitor the level of welfare on farm for cull sows.
101	It is 66–100% certain that the prevalence of the welfare consequences assessed through the ABMs collected at the slaughterhouse may be underestimated of welfare consequence on farms, ait does not include the animals that die on farm. This problem may be greater for cull sows because of the high rate of on-farm mortality.
102	There is a lot of variation in the methods used to assess the various ABMs.
103	Lameness is an important ABM for rearing pigs and cull sows, but was not proposed as a promising ABM for further development because: i) It is difficult to distinguish if lameness measured at the slaughterhouse resulted from welfare consequences that the pigs were exposed to on-farm or during the preslaughter phases. ii) lame animals identified on farm should not be transported.
104	The TRL (Technology Readiness Level) of automated monitoring of the ABMs at slaughterhouse is currently low. Methods for tail lesions and lung lesions are the most advanced.
105	Unified and standardised scoring systems and protocols across different regions/countries are necessary to monitor and benchmark the welfare of cull sows and rearing pigs transnationally.

12. Recommendations

The Recommendations on the welfare of pigs listed in the different sections of this Scientific Opinion (see Chapters 4 to 9) are reported in Table 67.

Table 67: Recommendations on the welfare of pigs

#	RECOMMENDATIONS
	Recommendation on the welfare of gilts and dry sows from the General ToRs (Section 4.6.1)
1	Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for gilts and dry sows, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 4.2).
	Recommendations on the welfare of gilts and dry sows from Specific ToR 1 (Section 4.6.2)
2	To avoid the welfare consequences of stall housing and the possible consequences of stress during early pregnancy for reproductive performance, it is recommended to group sows at the time of weaning (see Figure 9).
3	The welfare consequences associated with grouping gilts and sows should be mitigated at any stage (including for cull sows) by good mixing practice, including the use of mixing pens, good home pen design/layout and good feeding and general management (see Table 38).
4	Staff should be trained to mitigate handling stress in sows, particularly in stage 1 (preservice), and in identifying and mitigating the other welfare consequences in all stages.
5	The management of sows in lactation should ensure that sows are weaned (including cull sows) in good physical condition for grouping.
	Recommendations on the welfare of farrowing and lactating sows and piglets from the General ToRs (Section 5.9.1)
6	Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **farrowing and lactating sows**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 5.2).
7	Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **piglets**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 5.5).
	Recommendations on Specific ToRs 2 and 3: space allowance on farrowing systems (Section 5.9.2)
8	For animal welfare reasons, periparturient and lactating sows should not be housed in farrowing crates but in farrowing pens.
9	When housing a lactating sow and her piglets in a farrowing pen, the minimum available space for the sow should be around 6.6 m^2 in order to achieve comparable piglet mortality to a farrowing crate system. This equates to ~ 7.8 m^2 total pen size.
10	A larger pen size than referred to in recommendation 9 is recommended to improve the locomotory possibilities for the sow.
11	Training to farm staff should be offered to minimise welfare compromises during the transition period away from farrowing crates.
	Recommendations on Specific ToRs 2 and 3: pre-farrowing enrichment material (Section 5.9.3)
12	To satisfy their intrinsic motivation to build a nest, sows and gilts should be provided with material enabling nest-building behaviour at least on the day before farrowing.
13	Materials such as long-stemmed or long-cut straw, hay and haylage should be offered to sows and gilts, as these are suitable to enable a variety of functional behavioural elements of the nest-building behaviour. These materials should be provided in an amount which will allow all behavioural elements of nest-building to be performed at a functional level.
14	Further studies are needed to identify what amount of such materials is deemed to be functional.
	Recommendations on Specific ToRs 2 and 3: post-farrowing enrichment material (Section 5.9.4)
15	Sows and piglets should be provided with enrichment material that allows them to perform exploratory behaviour in the period from farrowing to weaning.

#	RECOMMENDATIONS
16	Suitable enrichment material should be provided and replenished in an amount which will allow the sow and the piglets to perform explorative behaviour at all times in order to allow them to express the behaviour when they are motivated to.
17	Future research should investigate the kind and amount of enrichment materials which elicit explorative behaviour in lactating sows and piglets and reduce the incidence of behaviours that are detrimental to animal welfare (such as tail biting). This would enable the definition of characteristics required by enrichment materials offered specifically in this period to elicit frequent and diverse exploratory behaviours.
	Recommendations on the time needed for adaptation (Section 5.9.5)
18	Staff should receive training in appropriate management of free farrowing system to facilitate rapid adaptation.
19	Temporary crating systems should not be used as interim step for farms that want to convert from crates to complete free farrowing if the total floor surface area, they occupy is insufficient to allow for a well-functioning pen system.
20	Genetic selection to improve pig welfare in free farrowing systems should be addressed by breeding organisations. Such traits include good piglet viability, low birth weight variability, good maternal behaviour, good leg conformation, good udder quality.
	Recommendations on the effect of litter size to sow and piglet welfare (Section 5.9.6)
21	To avoid excessive competition for access to teats and significantly increased piglet mortality in large litters, the average number of piglets born alive in a given sow breed or line should not exceed, and preferably be lower than, the average number of functional teats in the population of this breed or line.
22	For breeding to be sustainable in terms of sow longevity, selection for litter size should be limited to an average number of 12–14 piglets born alive.
23	Selection for litter size should be supplemented to a larger extent with selection for low birth weight variation within litters and other traits resulting in low piglet mortality before weaning.
	Recommendations on tooth reduction (Section 6.1.5)
24	Measures to prevent the need for tooth reduction should be implemented (Table 50).
25	Tooth reduction should only be done after a litter level risk assessment (Table 50).
26	Only well-trained staff judged to be competent should perform tooth reduction by correct grinding procedure that does not injure sensitive tissue.
27	Tooth clipping should not be used.
	Recommendations on castration (Section 6.2.8)
28	Surgical castration without anaesthesia and analgesia should not be performed due to the severe consequences to the welfare of piglets.
29	In the case that surgical castration is performed, practical and effective methods and training of operators on the use of pain relief (anaesthesia and analgesia) during and after castration should be developed.
30	Under current commercial conditions, immunocastration should be adopted as the preferred alternative to surgical castration. Keeping animals entire should be considered as the next best alternative.
31	Further research should focus on the refinement of management practices, such as nutritional and breeding strategies, for decreasing the likelihood of boar taint in carcasses, reducing the welfare consequences and, by this, phasing out surgical castration.
	Recommendations on tail docking (Section 6.3.7)
32	Tail docking should not be performed.
33	Tail biting should be prevented by applying preventive measures that are farm-specific after a risk assessment analysis for which tools currently exist (see Section 7.7).
34	In the cases where tail docking is allowed, the procedure should be done as early as possible.
35	In the cases where tail docking is allowed, a cautery method should be used.
36	In the cases where tail docking is allowed, practical and effective methods of pain relief during and after tail docking is performed, should be developed.
37	In the cases where tail docking is allowed, adequate hygiene measures during the whole procedure should be carried out to prevent the risk of infection.

#	RECOMMENDATIONS
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4: weaning age (Section 7.7.1.9)
38	For animal welfare reasons the current legal minimum weaning age of 28 days should remain and the exception allowing earlier weaning in specific circumstances should be reconsidered.
39	The welfare benefits of weaning ages greater than 28 days should be further investigated.
40	Artificial rearing should only be used as a last resort and not as a routine management practice. Other measures should be prioritised, such as selection against extreme prolificacy to reduce the likelihood of birth of surplus piglets, or the use of a nurse sow.
	Recommendation on the welfare of weaners and rearing pigs from Specific ToR 4: space allowance (Section 7.7.2.8)
41	The minimum space allowance should be increased relative to the current legal requirement to reduce many welfare consequences (e.g. restriction of movement, resting problems, inability to express comfort behaviour, inability to express exploratory/foraging behaviour, group stress, soft tissue lesions and integument damage), thus reducing tail biting behaviour and increasing growth rate.
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4: types of flooring (Section 7.7.3.5)
42	Pigs should have a solid floor area equivalent to a k-value of 0.033 (equal to 0.77 m^2 for a 110-kg pig) to accommodate lying behaviour (under thermoneutral conditions), with additional space for activity, feeding/drinking and elimination.
43	Further research should be carried out to validate strategies for maintaining hygiene in partly slatted pens
44	Further research should be carried out to determine the effect of different degrees of perforation of the solid floor on pig comfort and pen hygiene
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4: enrichment material (Section 7.7.4.5)
45	All pigs should be provided with effective enrichment (as described in conclusions) to reduce the risk of tail biting.
46	In case of an outbreak of tail biting, novel attractive organic substrates should be immediately provided.
47	Enrichment choice should consider hygiene and quality criteria to avoid biosecurity risks.
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4: air quality (Section 7.7.5.5)
48	To prevent health-related welfare consequences (respiratory disorders, eye disorders), and aversion, related to high temperatures and concentration of gases, buildings should be designed and equipped to guarantee correct ventilation. This would also contribute to prevention of tail biting.
49	The design and management of buildings should ensure regular manure removal and good hygiene in pens.
50	Buildings should be designed and managed to guarantee that the level of ammonia is kept below 10–15 ppm.
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4: health status (Section 7.7.6.7)
51	Farm health status should be maintained at high level to minimise the risk of tail biting risk and other welfare consequences.
52	In the case of tail biting outbreaks, checks for underlying health problems should be made.
53	Tail biting outbreaks should be rapidly addressed to prevent further health problems.
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4: diet composition (Section 7.7.7.7)
54	Professional nutritional advice should be taken to correctly formulate diets.
55	Dietary raw materials should be analysed for nutrient composition, stored correctly and free from contamination.
56	Pigs should have adequate feeding space to avoid competition for access, taking account of feed form (as it affects eating speed), diet density and delivery system.

#	RECOMMENDATIONS
	Recommendations on the welfare of weaners and rearing pigs from the General ToRs (Section 7.9.1)
57	Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **weaners**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 7.2).
58	Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for **rearing pigs**, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 7.5).
	Recommendations on the welfare of weaners and rearing pigs from Specific ToR 4 in relation to tail biting (Section 7.9.2)
59	Tail biting should be prevented by applying preventive measures that are farm-specific after a risk assessment analysis for which tools currently exist (see Section 6.3).
60	Pigs should be carefully inspected everyday for early signs of tail biting.
61	Automated tools for the early detection of tail biting should be further developed and widely applied.
	Recommendations on the welfare of boars (Section 8.4)
62	Measures to prevent or correct the hazards leading to the highly relevant welfare consequences identified for boars, and measures to mitigate the highly relevant welfare consequences should be put in place (see Section 5.2).
63	Further research is needed on the prevalence of welfare consequences, validation of ABMs specific to boars and related preventive and mitigating measures (e.g. regarding husbandry, enrichment materials, social environment).
	Recommendations on Specific ToR 5 (Section 9.6)
64	Monitoring tail lesions, carcass condemnation, lung lesions in rearing pigs at slaughter should be implemented to identify herds with diverse welfare consequences, thereby enabling guidance for the implementation of preventive and mitigation measures.
65	Body condition, carcass condemnation, shoulder ulcers and vulva lesions should be monitored in cull sows at slaughter.
66	To permit transnational benchmarking, traceability databases and risk assessment exercises, harmonised assessment methods and scoring systems should be developed for the identified ABMs.
67	Systems for automatic and continuous assessment of ABMs and data recording should be concordant with a standardised manual method.
However, as the readiness for automation is different for the different ABMs, specific recommendations for the next steps are:	
68	For the assessment of **tail lesions,** existing tools in the slaughter line should be integrated with slaughterhouse infrastructure including IT systems.
69	Further development of the currently available software for assessment of **lung lesions** should be carried out to be suitable for commercial slaughter operations.
70	A standard slaughterhouse scoring system for **shoulder ulcers**, **vulva lesions** and **body condition** should be agreed, before further automation.
71	It is not possible to automate the measurement of **carcass condemnations,** but the use of automatic data recording and data management should be put in place to improve traceability thus implementing the use of carcass condemnations to assess animal welfare on farm.

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Abbreviations

ABM	Animal-based measure
AHAW	Animal Health and Animal Welfare
AI	Artificial Insemination
BFP	Birth of First Piglet
BCS	Body condition score
CA	Competent Authority
CXCL8	C-X-C Motif Chemokine Ligand 8 (interleukin 8)
ECG	Electrocardiogram
ECI	European Citizen Initiative
EEG	Electroencephalogram
EKE	Expert Knowledge Elicitation
ELS	Extensive Literature Search
ESF	Electronic sow feeding
FBE	Functional Behavioural Elements
FBO	Food business operator
F2F	Farm to Fork
IBI	Inter-piglet birth interval
IT	Information Technology
LCT	Lower Critical Temperature
NNN	Non-nutritive nursing
NSAID	Non-steroidal anti-inflammatory drug
QTL	Quantitative Trait Loci
SO	Scientific Opinion
SVC	Scientific Veterinary Committee
ToR	Term of Reference
TRL	Technology Readiness Level
WA	Weaning age

Appendix A – Literature Searches

As described in Section 2.2.1, literature searches were carried out in order to identify scientific evidence on the elements requested by the ToRs. In particular, the searches focused on pigs husbandry systems, welfare consequences, ABMs, hazards and preventive and corrective or mitigation measures. Extensive literature searches (ELSs) were carried out to identify peer-reviewed publications on welfare implications and associated ABM(s) in relation to the exposure variables identified in subquestion 11 (see also Table 3, Section 2.2). Details of the different ELSs are described below.

All relevant publications were included in an EndNote x7 Library.

Sources of information included in the search:

Bibliographic database: Web of Science – all databases.

Search strings used in the bibliographic database:

The search strings were designed to retrieve relevant publications and to the specific exposure variables (see details below in this Appendix). Restrictions on the different categories of pigs were applied by including synonyms that are commonly used both in scientific publications and grey literature. Restrictions applied in the search string were also related to: (i) the date of publication, considering only those results published after a previous EFSA Scientific output on the topic (i.e. depending on the exposure variable: SVC, 1997; EFSA, 2004, 2005, 2007a,b,c, 2014; EFSA AHAW Panel, 2012, 2014), (ii) the pig categories considering only those relevant or each exposure variables. Language restrictions aimed at identifying only publications with an English abstract and full texts of a language covered in the expertise of EFSA experts. No document type restrictions were applied in the search string.

The records retrieved from Web of Science were exported to EndNote libraries/Excel files together with the relevant metadata (e.g. title, authors, abstract). Titles and abstracts were screened for relevance. Duplicates were removed when two or more records were identical. Full text publications were screened if title and abstract did not allow assessing the relevance of a paper. The screening was performed by two reviewers. Publications on the welfare of pigs during transport were excluded. In the case of Specific TORs 1–4, publications on the welfare of pigs at slaughter were also excluded.

Specific ToR 1 – exposure variable 'grouping time'

Date: 23 March 2021. Web of Science. All Databases. Advanced search. Timespan: 1997–2020. Restriction to English.

Search string TS=((gilt OR gilts OR sow OR sows OR "sus scrof*") AND (pregnan* OR gestat* OR serv*) AND (group* OR mix*) AND (time OR timing OR week* OR day* OR stage) AND (welfare OR protection OR behav* OR wellbeing OR well-being) AND (*farm*))

Result = 263. Result after screening for relevance: 17.

Specific ToRs 2 and 3 – exposure variable 'space allowance'

Date: 15 December 2020. Web of Science. All Databases. Advanced search. Timespan: 1997–2020. Restriction to English.

Search string TS=((gilt OR gilts OR sow OR sows OR "sus scrof*") AND farrowing AND (space OR density OR stocking OR pen OR crate) AND (welf* OR protection) AND *farm*))

Result = 311. Result after screening for relevance: 53.

Specific ToRs 2 and 3 – exposure variable 'nesting/enrichment material'

Date: 29 March 2021. Web of Science. All Databases. Advanced search. Timespan: 1997–2020. Restriction to English.

Search string TS=((gilt OR gilts OR sow OR sows OR "sus scrof*" OR piglet*) AND (farrowing OR pregnan* OR *partum OR lactati* OR suckling) AND (explor* OR manipulat* OR root* OR carry* OR arrange* OR paw* OR nesting OR "nest-building" OR behaviour* OR "straw-directed") AND (straw OR "saw dust" OR "wood shavings" OR "wood-shavings" OR bedding OR peat OR shredded OR chopped OR hessian OR jute OR branch* OR stick OR rack OR dispenser OR newspaper OR rope OR sisal OR cotton OR "cloth tassel" OR "nesting material" OR "nest material" OR enrich* OR barren) AND *farm*))

Result = 187. Result after screening for relevance: 55.

Specific ToRs 2 and 3 – exposure variable 'crating time/time spent in the crate'

Date: 26 January 2021. Web of Science. All Databases. Advanced search. Timespan: 1997–2020. Restriction to English.

Search string TS=((gilt OR gilts OR sow OR sows OR piglet* OR "sus scrof*") AND (farrowing OR pregnan* OR *partum OR lactati* OR gestation) AND (crat* OR confin* OR pen OR restr*) AND (time* OR timing OR temporary OR duration OR period) AND (welf* OR protection))

Result = 252. Result after screening for relevance: 15.

Specific ToR 4 – exposure variable 'weaning age'

Date: 13 October 2021. Web of Science. All Databases. Advanced search. Timespan: All years. Restriction to English.

Search string TS = ("wean* pig$" OR "rearing pig$" OR "growing pig$" OR "swine" OR weaners OR "nursery pig$") AND TS = ("weaning age" OR "weaning time" OR "age at weaning" OR "time at weaning") AND TS = (welf* OR health)

Result = 175. Result after screening for relevance: 17.

Specific ToR 4 – exposure variable 'space allowance'

Date: 26 November 2021. Web of Science. All Databases. Advanced search. Timespan: 2005–2021. Restriction to English.

Search string AB = (swine OR pig$ OR "sus scrofa") AND AB= ("post-wean*" OR wean* OR "finish*" OR growing OR rearing OR grower$ OR fattening OR fattener$ OR rearer$) AND AB = ("space allowance" OR "stock* density" OR "density" OR "space" OR "floor* area") AND AB = (wel* OR protection OR health) NOT AB = (transport OR abattoir OR slaughterhouse)

Result = 303. Result after screening for relevance: 46.

Specific ToR 4 – exposure variable 'tooth clipping'

Date: 4 May 2021. Web of Science. All Databases. Advanced search. Timespan: 1997–2021. Restriction to English.

Search string TS = ((TS = (pig* OR "sus scrof*") AND TS = (clip* OR grind* OR resect* OR reduce OR reduction) AND TS = (welfare OR "animal-based measure*" OR "animal based measure*" OR indicator* OR clinical OR behav* OR wellbeing OR well-being OR pain OR infection* OR infected OR lesion* OR injur*) AND TS = ("teeth" OR "tooth") AND TS = (*farm*)) NOT (KP = (pig* OR "sus scrof*") AND KP = (welfare OR "animal-based measure*" OR "animal based measure*" OR indicator* OR clinical OR behav* OR wellbeing OR well-being OR pain OR pain OR infection* OR infected OR lesion* OR injur*) AND KP = (farm*)))

Result = 38. Result after screening for relevance: 27.

Specific ToR 4 – exposure variable 'castration'

Date: 22 April 2021. Web of Science. All Databases. Advanced search. Timespan: 1997–2021. Restriction to English.

Search string TS = ((pig*OR "sus scrof*" OR boars OR "entire male*") AND (*castrat*) AND (welfare OR "animal-based measure*" OR "animal based measure*" OR indicator* OR clinical OR behav* OR wellbeing OR well-being OR pain) AND (anaesthe* OR "pain killer" OR analgesi* OR medical OR surgical OR surgery OR "topical treatment"))

Result = 464. Result after screening for relevance: 85.

Specific ToR 4 – exposure variable 'tail docking'

Date: 27 April 2021. Web of Science. All Databases. Advanced search. Timespan: 1997–2021. Restriction to English.

Search string TS = ((TS = ("rear* pigs*" OR "fatten* pig*" OR "wean* pig*" OR "growing pig*") AND TS = ("tail*dock*" OR "dock* tail" OR "tail reduction" OR "tail amputation" OR "amputated tail" OR undock* OR "tail length" OR "tail elimination" OR "tail cut*") AND TS = (welfare OR "animal-based measure*" OR "animal based measure*" OR indicator* OR clinical OR behav* OR wellbeing OR well-being OR pain OR infection* OR lesion* OR injur*)) NOT (KP = ("rear* pigs*" OR "fatten* pig*" OR "wean* pig*" OR "growing pig*") AND KP= ("tail*dock*" OR "dock* tail" OR "tail reduction" OR "tail amputation" OR amputated tail" OR undock* OR "tail length" OR "tail elimination" OR "tail cut*") AND KP= (welfare OR "animal-based measure*" OR "animal based measure*" OR indicator* OR clinical OR behav* OR wellbeing OR well-being OR pain OR infection* OR lesion* OR injur*))) OR ((TS = ("rear* pigs*" OR "fatten* pig*" OR "wean* pig*" OR "growing pig*") AND TS = ("tail dock*" OR "tail") AND TS = (welfare OR "animal-based measure*" OR "animal based measure*" OR indicator* OR clinical OR behav* OR wellbeing OR well-being OR pain OR infection* OR lesion* OR injur*) AND TS = (surgery OR surgical OR guideline* OR medical OR protocol* OR alternative* OR "best practice" OR anaesthe* OR "pain killer" OR analgesi* OR "topical treatment" OR cauther* or clip* OR "reduc* pain" OR "pain management" OR "pain control" OR instrument)))

Result = 111. Result after screening for relevance: 56.

Specific ToRs 5 – use of the ABMs at slaughterhouses to assess the welfare of pig farms

Date: 23 January 2022. Web of Science. All Databases. Advanced search. Timespan: 2012–2022. Restriction to English.

Tail lesions

Search string TS = ("pig$" OR "sow$" OR "swine" OR "finishing pigs" OR "finishers") AND TS = ("tail*") AND TS = ("slaughter*" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS = ("welfare" OR "health" OR "protection" OR "inspection" OR "meat")

Result = 175. Result after screening for relevance: 29.

Pneumonia and pleuritis

Search string TS = ("pig$" OR "sow$" OR "swine" OR "finishing pigs" OR "finishers") AND TS = ("lung$") AND TS = ("lesion*" OR "respiratory" OR "wound*") AND TS = ("slaughter*" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS = ("welfare" OR "health" OR "protection" OR "inspection")

Result = 177. Result after screening for relevance: 19.

Body condition

Search string TS = ("sow$") AND TS = ("body") AND TS = ("condition$") AND TS = ("slaughter*" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS= ("welfare" OR "health" OR "protection" OR "inspection" OR "meat")

Result = 44. Result after screening for relevance: 14.

Carcass condemnation

Search string TS=("pig$" OR "sow$" OR "swine" OR "finishing pigs" OR "finishers") AND TS = ("carcass*" OR "carcase$" OR "viscera") AND TS = ("condemnation" OR "trimming" OR "trimmed" OR "condemned") AND TS = ("slaughter" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS = ("welf*" OR "health" OR "protection" OR "inspection" OR "meat") NOT TS = ("econom*"ic OR "value")

Result = 44. Result after screening for relevance: 5.

Shoulder ulcers

Search string TS = ("sow$") AND TS = ("shoulder" OR "decubital") AND TS = ("ulcer*" OR "lesion*" OR "wound" OR "injury") AND TS = ("slaughter*" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS = ("welfare" OR "health" OR "protection" OR "inspection" OR "meat")

Result = 4. Result after screening for relevance: 3.

Vulva lesion

Search string TS = ("sow$") AND TS = ("vulva" OR "decubital") AND TS = ("ulcer*" OR "lesion*" OR "wound" OR "injury") AND TS = ("slaughter*" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS = ("welfare" OR "health" OR "protection" OR "inspection" OR "meat")

Result = 4. Result after screening for relevance: 1.

Lameness

Search string TS = ("pig$" OR "sow$" OR "swine" OR "finishing pigs" OR "finishers") AND TS = ("lame" OR "lameness") AND TS = ("slaughter" OR "abattoir" OR "slaughter plant" OR "slaughter line" OR "slaughter factory") AND TS = ("welf*" OR "health" OR "protection" OR "inspection" OR "meat")

Result = 66. Result after screening for relevance: 14.

Appendix B – Experts' judgement on relevance of the welfare consequences

Table B.1 provides an overview of the expert judgement on the welfare consequences that may affect the welfare of pigs for each of the considered pig categories and husbandry systems: red cells with the symbol 'X' indicate the welfare consequences that were identified as highly relevant, the yellow cells ('O') indicate the welfare consequences scored as moderately relevant, the green cells (symbol 'V') indicate the welfare consequences considered less relevant and grey cells indicate the welfare consequences considered non-applicable (for details, see Section 2.2.2.1).

Table B.1: Pig categories and husbandry systems that have been fully assessed in the General ToRs and overview of the expert judgement on the welfare consequences that may affect the welfare of pigs

Welfare consequences	Pig husbandry systems																
	Gilts + dry sows			Farrowing and lactating sows			Piglets				Weaners			Rearing pigs			Boars
	Individual stalls	Indoor group	Outdoor paddock	Individual crates	Individual pens	Outdoor paddock	Individual crates	Individual pens	Artificial rearing systems	Outdoor paddock	Indoor group housing	Indoor with access to outdoor	Outdoor paddock	Indoor group	Indoor with access to outdoor	Outdoor paddock	Indoor individual pens
Restriction of movement	X	O		X	O	V	O	O	X		O	V		X	O	V	X
Resting problems	X	O	V	X	O	O	O	O	O	O	O	O	O	X	O	O	O
Group stress	X	X	X	X	O	O	X	X	X	X	X	X		X	X	O	
Sensorial under and/or overstimulation	O	V	V	V	V	V	O	O	O	V	O	V	V	O	O	V	V
Handling stress	O	O	O	O	O	O	O	O	O	O	O	O	O	V	V	V	O
Isolation stress	O			O	V	V											X
Separation stress	O	V	V	V	V	V	O	O	X	O	O	O	O				O
Inability to perform comfort behaviour	O	O	V	V	O	V	V	O	V	V	V	V	V	O	O	V	O
Inability to perform sexual behaviour	O	V	V			V								V	V	V	O
Inability to avoid unwanted sexual behaviour		O	O			V								O	O	O	
Inability to perform exploratory or foraging behaviour	X	X	V	X	O	V	X	O	X		X	X	V	X	X	V	X
Inability to express maternal behaviour				X	O	V											
Inability to perform sucking behaviour							O	O	X	O	O	O	O				
Inability to perform play behaviour	V	V	V	V	V	V	O	O	O	V	V	V	V	O	V	V	V
Predation stress						O			V	O			V				
Prolonged hunger	X	X	X	O	O	O	X	X	X	X	O	O	O	V	V	O	X

Welfare consequences	Pig husbandry systems																
	Gilts + dry sows			Farrowing and lactating sows			Piglets				Weaners			Rearing pigs			Boars
	Individual stalls	Indoor group	Outdoor paddock	Individual crates	Individual pens	Outdoor paddock	Individual crates	Individual pens	Artificial rearing systems	Outdoor paddock	Indoor group housing	Indoor with access to outdoor	Outdoor paddock	Indoor group	Indoor with access to outdoor	Outdoor paddock	Indoor individual pens
Prolonged thirst	O	O	O	O	O	O	X	X	O	X	O	O	O	O	O	O	V
Heat stress	O	O	O	X	O	O	V	V	V	O	O	V	O	O	O	O	O
Cold stress	O	V	O	V	V	O	O	O	V	X	O	O	X	V	V	O	O
Locomotory disorders (including lameness)	O	X	O	O	O	O	O	O	V	O	O	O	O	X	X	O	X
Soft tissue lesions and integument damage	O	X	O	X	O	O	X	X	O	X	X	X	O	X	X	O	O
Bone lesions (incl. fractures and dislocations)	V	O	V	V	V	V	O	O	V	O	V	V	V	V	V	V	V
Skin disorders (other than soft tissue lesions and wounds integument damages)	V	V	O	V	V	O	O	O	V		V	O	O	V	O	O	V
Respiratory disorders	V	V	V	V	V	V	O	O	O	V	O	O	O	X	X	O	O
Eye disorders	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Gastro-enteric disorders	V	V	V	V	V	O	O	O	O	O	X	X	X	O	O	O	V
Reproductive disorders	O	V	V	O	O	O											V
Mastitis				O	O	O											
Metabolic disorders	V	V	V			V	O	O	O	V	V	V	V	V	V	V	V
Umbilical disorders and hernias							O	O	V	O	V	V	V	O	O	O	