SCIENTIFIC OPINION

Scientific Opinion on the use of animal-based measures to assess welfare in pigs[1]

EFSA Panel on Animal Health and Welfare (AHAW)[2, 3]

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ABSTRACT

Animal-based measures, identified on the basis of scientific evidence, can be used effectively in the evaluation of the welfare of on-farm pigs in relation to laws, codes of practice, quality assurance schemes and management. Some of these measures are also appropriate for ante-mortem inspection and there are additional post-mortem animal-based measures which can be taken at the slaughterhouse. Non-animal-based measures can be used when the association between them and the welfare outcome is strong and when they are more efficient than animal-based measures as a means to safeguard welfare. Both animal-based and non-animal-based measures can be useful predictors of welfare in pigs. In order to assess welfare, a wide range of measures is needed. However, to assess aspects of welfare it is unnecessary to use all animal-based measures on every occasion. The choice of animal-based measures will depend upon the specific objectives of the assessment. The full list is comparable to a 'toolbox', from which the appropriate range of measures can be selected. The Welfare Quality® protocol provides information on the majority of the welfare outcomes of the main hazards identified in the EFSA Scientific Opinions but not those where time limitation prevents it. There are currently insufficient animal-based measures to use as welfare outcome indicators on-farm or in the slaughterhouse to assess the issues of pain, frustration and other positive and negative emotional states. The extent to which short-term management can prevent the negative effects of hazards arising from genetic selection, and of most housing-related problems, is extremely limited. Herd monitoring and surveillance programmes should be implemented within the pig industry using a range of appropriate animal-based measures to document welfare changes over time. There should be both initial and ongoing training of assessors to ensure valid and reliable welfare measurement.

KEY WORDS

Pig welfare, welfare measure, tail biting, sow, boar, piglet, castration.

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SUMMARY

Following a request from the European Commission, the Panel on Animal Health and Welfare was asked to deliver a Scientific Opinion on the use of animal-based measures to assess the welfare of pigs. This Scientific Opinion relates to two key areas in the Community Action Plan on the Welfare of Animals: the first concerns upgrading existing minimum standards for animal protection and welfare, and the second introducing standardised animal welfare indicators.

Animal-based measures have been used by scientists for many years to measure the responses of animals as indicators of their welfare. However, rules related to animal protection have usually focused on measures of the environment (resources) or management (practices), in other words, on risk factors rather than on their consequences for the animal. A European Union (EU) financed project called Welfare Quality® has been influential in developing a standardised system for the assessment of animal welfare on farms. In line with the European Commission's intention to adopt a more outcome-based approach to animal welfare, the Welfare Quality® project focused on animal-based measures and produced a welfare-outcome assessment protocol for several species, including pigs. The concepts of animal welfare used in the Welfare Quality® project and EFSA Scientific Opinions overlap considerably, confirming general agreement in the scientific community concerning the definition of animal welfare. The challenge in this Opinion has been to merge the risk assessment approach of the EFSA Scientific Opinions on the welfare of pigs with the welfare assessment approach of the Welfare Quality® project, as well as other related research projects on pig welfare. Animal-based measures can be effectively used to evaluate the welfare of on-farm pigs in relation to laws, codes of practice and management. Many of these are also appropriate for ante-mortem or post-mortem inspection of animals at the slaughterhouse.

Some of the responses of an animal to features of its environment have little impact on its welfare. However, sometimes the response is of such magnitude that it indicates that the animal has difficulty coping, or did not cope, and its welfare is poor as a consequence. Sometimes these responses are the outcome of minor responses during a period of many days, weeks or months, and hence the terms 'welfare outcome indicator', or simply 'outcomes', are used in animal welfare science. The scientific report and Opinions on pig welfare focussed on identifying the hazards that led to these negative welfare outcomes and then making recommendations to reduce or eliminate them. The Welfare Quality® project, on the other hand, focused on measuring the magnitude of the outcomes, facilitating an assessment of pig welfare irrespective of the housing system and management.

Despite these different starting points, it is concluded that the Welfare Quality® Pig Protocol covers the majority of the main hazards identified in the EFSA Scientific Opinion and that animal-based measures are necessary to determine whether or not the improvements in welfare intended by the recommendations in the EFSA Opinion are achieved. However, it was noted that there is a lack of specificity in some of the hazards (e.g. floor type), which means that there are several outcomes that could be measured, and also sometimes there is a lack of specificity in an animal-based measure (e.g. injury score), which means a welfare outcome could have one or several causes. Thus, the links between hazards (resources and management) and their welfare consequences (using animal-based outcome measures as indicators) is far from simple. Nevertheless, a 'toolbox' of valid and reliable animal-based measures is described, from which the most appropriate 'tool' or combination of tools can be selected. The selection will depend on what welfare outcomes are to be assessed and the reason for wanting to assess them (e.g. whether part of a management/breeding strategy or to enforce legislation). Several animal-based measures listed in this Scientific Opinion are already fully developed, although they are not always widely used in commercial practice (e.g. sow stereotypies and injury scores). Other animal-based measures are in use (e.g. bitten tails or poor body condition in sows). Assuming that data from the standardised use of some of these measures, in a variety of real life situations, could be collected on a regular basis, the database could be analysed to describe these complex associations. This would continually improve the selection process of appropriate animal-based measures for different contexts. It would also pave the way for a move towards quantitative risk assessment of animal welfare.

There are several ways in which animal-based measures can and are being used to assess the welfare of pigs. Many of the animal-based measures that are referred to in this Opinion are related directly or indirectly to the health, production and behaviour of pigs. Although most often used to identify animals that already have poor welfare, some could also be used to identify animals whose welfare is becoming poor, so that changes can be made before the individual is adversely affected (e.g. early indicators of disease or signs of aggression prior to any injury). Thus, in monitoring and surveillance systems some animal-based measures may be useful, not only because they can indicate current welfare problems in the herd, but because they can also serve as a tool for early detection of findings that may indicate a potential, future, negative situation. Although animal welfare issues can be addressed using animal-based measures, several situations were identified where a non-animal-based measure is preferable in practice. The most common reason for this was that there was a resource-based measure that was easier to record and was more reliable. Another reason was that the animal-based measure was too time consuming to collect or required specific skills or analysis, although this situation is likely to change. In some cases, no measure is fully adequate. For instance, there are currently insufficient animal-based measures to use as welfare outcome indicators on-farm or in the slaughterhouse to assess the issues of pain, frustration and other positive and negative emotional states.

In some cases, such as with changes in breeding goals, it may take a long time for an improvement in animal-based measures to be noted at the farm level. A conclusion from this Opinion is that negative consequences of factors such as genetics and housing, often cannot be easily prevented through management. Nutritional and management related hazards, on the other hand, are easier to manage in the short-term, assuming that the person is willing and able to make the change. Nevertheless, reduction of some negative effects may require a long-term strategy.

Recommendations in the Scientific Veterinary Committee (SVC) Report and the EFSA Scientific Opinions on pig welfare were formulated around hazards and these, by definition, relate to the animal's environment and how it is managed. Controlling whether or not a recommendation is fulfilled is most logically carried out therefore by using the appropriate resource- or management-based measure. However, the likelihood of a feature in the environment becoming a hazard depends on the characteristics of the animal it is acting upon. Animals differ in aspects such as their genetics or age, and thus may experience and respond to hazards in different ways. Indeed, this is one reason why animal-based measures, describing the consequences of the animal's attempts to cope with its environment, are the preferred indicators of animal welfare. Future EFSA recommendations, although based on risk assessments, should whenever possible be formulated in such a way that it is clear which animal-based measure is to be used for control in order to ensure that the intention of the recommendation for improved animal welfare is achieved.

Data on animal-based welfare outcome indicators can be collected on-farm or at the slaughterhouse, provided that there is adequate traceability, either by observation or inspection of the animal, or from other sources, such as meat inspection, disease reporting systems and production records. Furthermore, although welfare is a characteristic of the individual animal, many of the animal-based measures are in fact reported at the herd level. A list of potential animal-based measures is provided in this Opinion. Benchmarking is increasingly used to track changes within the same farm over time or, more often, to compare farms. When the same animal-based measure is compared between farms with similar housing systems and management practices, it facilitates the identification of those farms that are outside the normal range of variation and this information is also relevant to the assessment of pig welfare.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Request for a Scientific Opinion concerning the use of animal-based measures to assess the welfare of pigs.

Council Directive 98/58/EC[4], concerning the protection of animals kept for farming purposes, lays down minimum standards for the protection of animals bred or kept for farming purposes, including pigs. Two main areas of action of the Community Action Plan on the Protection and Welfare of Animals 2006-2010 are "upgrading existing minimum standards for animal protection and welfare..." and "introducing standardised animal welfare indicators in order to class the hierarchy of welfare standards applied...".

One of the main outcomes of the EU-funded Welfare Quality® project is the science-based methodology for assessing animal welfare and a standardised way of integrating this information to assign farms to one of four animal welfare categories (from poor to excellent). Procedures and requirements for the assessment of welfare in cattle, pigs and poultry were presented in the assessment protocols. The use of animal-based measures to assess animal welfare is relatively new, although diverse research projects now focus on them, and such measures are also considered in various assessment schemes. Previous assessments relied mainly on resource-based parameters. Animal-based measures aim to measure the actual welfare status of the animal directly, and thus include the effect of resource- and management-based factors.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEN COMMISSION

The European Commission therefore considers it opportune to request EFSA, as a first step, to give an independent view on the animal-based welfare measures for pigs:

1. Identify how animal-based measures could be used to ensure the fulfilment of the recommendations of the EFSA Scientific Opinions on the welfare of pigs.

2. How the assessment protocols suggested by the Welfare Quality® project cover the main hazards identified in EFSA Scientific Opinions and *vice versa* for an overall classification of the welfare situation, and, where necessary, how other scientific information can be used to cover these hazards.

3. Identify which relevant animal welfare issues cannot be assessed using animal-based measures for pigs and what kind of alternative solutions are available to improve the situation.

4. List the main factors in the various husbandry systems which have been scientifically proven to have negative effects on the welfare of pigs and to what extent these negative effects can be or not prevented through management.

The assessment should be based on and linked to the risk assessment of the previous EFSA Scientific Opinions.

[4] Council Directive 98/58/EC, of 20 July 1998, concerning the protection of animals kept for farming purposes. OJ L 221, 8.8.1998, p. 23-27.

ASSESSMENT

1. Introduction

The current European Directives and Regulations relevant to the welfare of pigs are Council Directive 98/58/EC, concerning the protection of animals kept for farming purposes, and Council Directive 2008/120/EC[5] (amending Directive 91/630/EEC[6], Directive 2001/88/EC[7] and Directive 2001/93/EC[8]) laying down minimum standards for the protection of pigs.

The European Community Action Plan on the Protection and Welfare of Animals refers to the introduction of standardised animal welfare indicators. This Opinion presents an overview of the current and potential future use of animal-based measures, in addition to resource-based measures. It is intended for the assessment of pig welfare by farmers, veterinarians and other inspectors checking on compliance with laws or standards, and is divided into three main sections. The first section of this Opinion deals with concepts related to the assessment of welfare and is relevant to all farm animals, not only pigs. The second section (the main part of the Opinion) discusses the four terms of reference (ToRs) outlined in the mandate. A short, third section is a general discussion of issues related to the use of animal-based measures to assess animal welfare on-farm or at the slaughterhouse.

1.1. EU reports and opinions on the welfare of pigs and the Welfare Quality® research project

The EFSA Animal Health and Welfare (AHAW) Panel and its predecessors the Scientific Veterinary Committee (SVC) and the Scientific Committee on Animal Health and Animal Welfare have produced several reports and Opinions relevant to the welfare of pigs.

The first report, "The welfare of intensively kept pigs", was published in 1997 by the SVC (SVC, 1997). The report contains information on the biology and behaviour of pigs in natural and semi-natural conditions, an overview of production systems, a production systems comparison, specific husbandry factors and pig welfare.

In 2004, 2005 and 2007, EFSA, following formal requests from the European Commission, published Scientific Opinions on different aspects related to the welfare of pigs: (i) Welfare aspects of the castration of piglets (EFSA, 2004); (ii) The welfare of weaners and rearing pigs: effects of different space allowances and floor types (EFSA, 2005); (iii) Animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, pregnant, farrowing sows and unweaned piglets (EFSA, 2007a); (iv) Animal health and welfare in fattening pigs in relation to housing and husbandry (EFSA, 2007b); (v) The risks associated with tail biting in pigs and possible means to reduce the need for tail docking considering the different housing and husbandry systems (EFSA, 2007c).

All the Scientific Opinions contain conclusions and recommendations about how current farming and husbandry systems fulfil the needs, and lead to good welfare of pigs from pathological, technical, physiological, and behavioural points of view. In addition, in the Scientific Opinions of 2007 (EFSA, 2007a, b, c), a risk assessment was performed leading to the identification of all factors that are risks for poor pig welfare (hazards). In addition, two technical reports were produced, on request from

[5] 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.

[6] Council Directive 91/630/EEC, of 19 November 1991, laying down minimum standards fo the protection of pigs. OJ L 340, 11.12.1991, p. 33–38.

[7] Council Directive 2001/88/EC, of 23 October 2001, amending Directive 91/630/EEC laying down minimum standards for the protection of pigs. OJ L 316, 1.12.2001, p. 1–4.

[8] Commission Directive 2001/93/EC, of 9 November 2001, amending Directive 91/630/EEC laying down minimum standards for the protection of pigs. OJ L 316, 1.12.2001, p. 36–38.

EFSA in 2011, by Wageningen Livestock Research (Spoolder et al., 2011a, 2011b) to update the conclusions and recommendations of all above mentioned Opinions and for identifying hazards in light of new literature. As a consequence of these reports, all of the existing conclusions and recommendations remained but some additional recommendations were added and these are included in this Opinion.

The welfare of an individual is defined according to Broom (1986) as its state as regards its attempts to cope with its environment. This concept was followed by the World Organisation of Animal Health (OIE) that defines animal welfare as: (i) how well an animal is coping with the conditions in which it lives, (ii) an animal having good welfare if, as indicated by scientific evidence, it is healthy, comfortable, well nourished, safe, able to express key aspects of behaviour, and if it is not suffering from unpleasant states such as pain, fear and distress, and (iii) good animal welfare requiring disease prevention and veterinary treatment for illness and injuries, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing (OIE, 2011). While the term "animal welfare" refers to the state of an individual animal, in practical circumstances measurements are used to assess the mean welfare in a group or herd. The SVC and EFSA reports and Opinions were based on a multidimensional concept of welfare that included both the physical health and the emotional state of the animal.

Welfare Quality® (2009) is the acronym for an EU project with the full title "Integration of animal welfare in the food quality chain: from public concern to improved welfare and transparent quality". The overall aims of the project were to develop a standardised methodology for the assessment of animal welfare, practical strategies/measures to improve animal welfare, and a standardised methodology to translate animal welfare assessments into easily understandable product information (Blokhuis et al., 2003). The project differed from the EFSA Opinions in that it did not aim to identify risk factors that were associated with good or poor welfare. Rather, the project focused primarily on animal-based indicators that could be monitored and used during inspection in order to assess current levels of welfare (Keeling, 2009). The resulting protocol was designed with the constraint that it could be carried out on a single farm visit by an independent assessor. Welfare Quality® proposed four welfare principles: good feeding, good housing, good health, and appropriate behaviour, which were subdivided into 12 criteria associated with the assessment of good welfare (Blokhuis et al., 2010). The objectives of the four principles have some similarities to the 5 Freedoms (FAWC, 2009) and the OIE description of animal welfare (OIE, 2011) and so can be considered as useful guidelines for achieving good welfare (Rushen et al., 2011). The 12 Welfare Quality® criteria included absence of hunger and thirst, comfort in relation to resting, thermal conditions and ease of movement, absence of injuries, disease and pain, expression of social and other behaviour, good human-animal relationship and positive emotional state. These welfare criteria were in turn linked, in the detailed Welfare Quality® documents, to a series of welfare measurements, such as the body condition of the pig (e.g. in paragraph 5.1.1.1, as an indicator of absence of hunger for sows), or panting or huddling behaviour (e.g. in paragraph 5.1.2.2, to indicate thermal discomfort). However, in general the concepts of animal welfare used by the Welfare Quality® project and the EFSA Scientific Opinions overlap considerably. The main exception being that Welfare Quality® includes explicit signs of good welfare (i.e. positive emotional state), whereas the risk analyses presented in the EFSA Opinions concentrate on the threats to poor welfare.

The Welfare Quality® project proposed that, since animal welfare is a multidimensional concept, all criteria are important and that good welfare in one dimension of welfare (e.g. the possibility to perform appropriate behaviour) only marginally compensates for poorer welfare in another (e.g. health), or *vice versa*. The Welfare Quality® project also proposed a formal model where the above mentioned welfare measures could be transformed into value scores that express compliance with the 12 criteria and then the four principles, although this aspect is not addressed further in this report. The relationship between the different welfare outcomes and the method of combining risks to welfare was not considered in the EU report (SVC, 1997) and EFSA Opinions (EFSA, 2004, 2005, 2007a, b, c).

There have been further developments in the terminology related to risk assessment since the pig welfare reports and Opinions, and in this Opinion the new terminology is used according to the Guidance on Risk Assessment for Animal Welfare (EFSA, 2012).

1.2. Concepts

In the previous EFSA Scientific Opinions on the welfare of pigs, the word 'hazard' is used to mean something that increases the risk of impaired welfare. The word 'hazard' is also used in the mandate for this Opinion. However, work in EFSA is increasingly moving towards assessment of both risks and benefits and it is recommended that the word 'factor' is used instead of 'hazard' in order to reflect this. The term 'factor' means any aspect of the environment or the animal, alterations in which may have the potential to improve or impair the welfare of animals. In this Opinion, the word 'factor' can be considered as synonymous with 'hazard' when addressing factors that have the potential only to impair welfare. There are also some differences in terminology related to animal welfare in the EU reports and Opinions and in the Welfare Quality® publications, although the underlying concepts are the same. A glossary at the end of this report lists all specific terminology used.

The factors that affect an animal's welfare (Figure 1) include the resources available to the animal (which are assessed with resource-based measures), such as space allocation, housing facilities, bedding material, etc., and the management practices of the farm (which are assessed with management-based measures), such as whether or not analgesics are used, age at weaning, etc. Depending on its characteristics (breed, sex, age, etc.) the animal will respond to these inputs and the animal's responses are assessed using animal-based measures. In risk assessment terminology, these responses are the 'consequences' of the 'factors' acting upon the animal, and both factors (sometimes called hazards) and consequences (sometimes also called adverse effects) can be characterised using appropriate resource-, management- and animal-based measures.

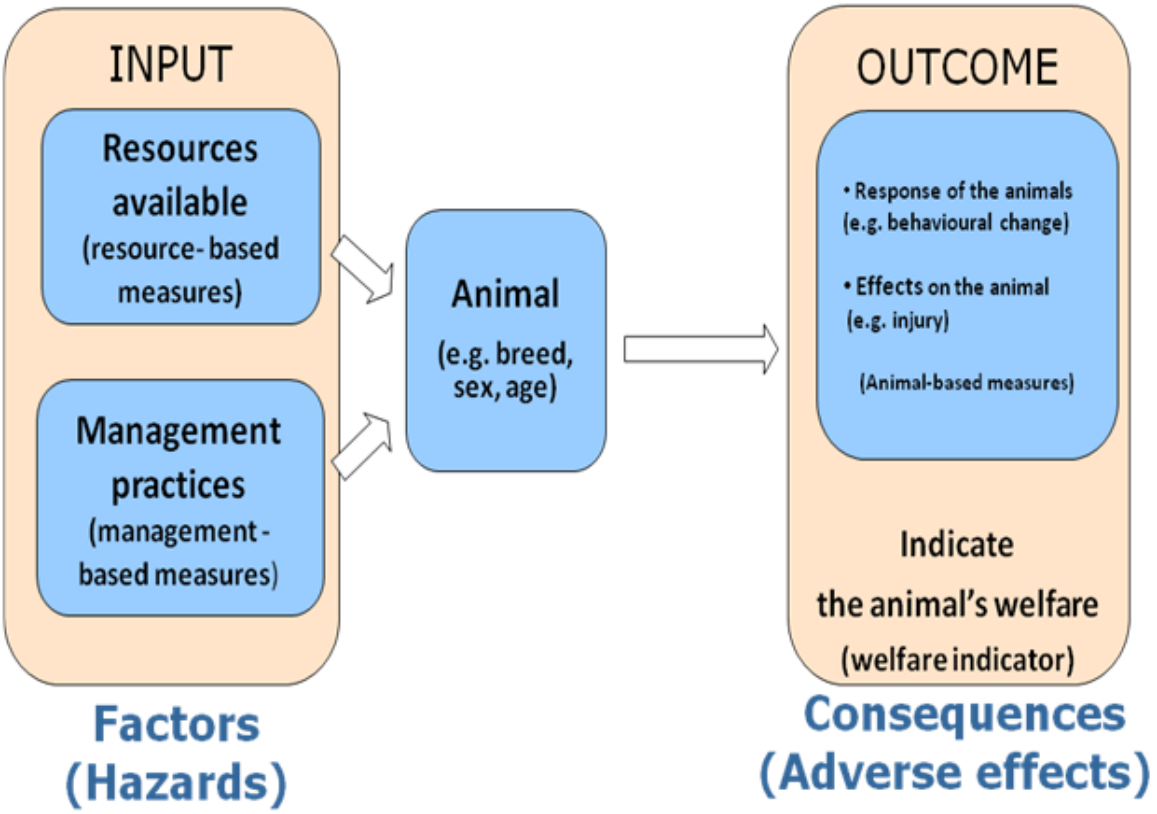

Figure 1: An overview of the terminology

In most cases, the responses of the animal are adaptive, with little impact on its welfare, which indicates that the animal can cope quite easily with the factors to which it is exposed. However, sometimes the response is of such magnitude that it indicates the animal has had difficulty in coping or was not able to cope with these factors and consequently the animal's welfare was impaired. In other cases, it is an effect on the animal rather than a response, for example, an injury. Sometimes, a major response can be the outcome of many days, weeks or months of more minor responses or effects, such as those that might follow chronic stress or prolonged lack of appropriate nutrient levels in the feed. The terms 'welfare outcome indicator', and even simply 'outcomes', are starting to be used in animal welfare science for these major changes in animal-based measures that clearly indicate that welfare has been affected (see the Glossary for definitions of animal-based measures and welfare outcome indicators). There is a continuum between these major responses, which indicate a clear increase or decrease in welfare, and more minor responses. Consequently, it may be difficult to set a threshold indicating whether or not a response is a sign that the animal is having difficulties coping with its environment.

Much of the research relevant to this Opinion addresses the need to identify valid and robust outcome-based indicators of pig welfare and, wherever possible, to allocate reliable scales to be used when scoring responses (e.g. loss of body condition, locomotor disorders). The overall welfare of an animal will be determined by the diversity of the responses, as well as by the magnitude of the responses and their consequences. However, the decision as to what is, and what is not, acceptable is a matter of ethics and can be expected to vary according to human values and attitudes towards animal welfare. Our aim is to ensure that ethical decisions as to the acceptability of husbandry inputs (resources and management) and about welfare outcomes are based on sound evidence.

Many of the animal-based measures discussed in this Opinion are based on the health, production and behaviour of pigs, as the aim of animal-based measures is to collect information about the response of the animal and the effects on it. Therefore, data can be collected either by direct observation or inspection of the animal, or indirectly from the effects of the animal's response to the environment (e.g. watery faeces on the floor reflecting diarrhoea). Data can also be collected through other sources, such as meat inspection, disease reporting systems (surveillance), production records, and so on.

1.3. Essential attributes of animal-based measures

As with diagnostic tests for disease, when using animal-based measures to assess welfare, quality criteria, assessment protocols and precise terms (see the Glossary) should be used. In this report, the word 'measure' is used to mean a form of evaluation rather than an intervention intended to deal with a problem. A 'measurement' is the result of this evaluation (e.g. size and depth of wounds, percentage of lame animals).

Measuring (outcome classification) approaches generally have to be fit for the intended purpose, that is to say they need to be valid (accurate and precise), reliable (repeatable, reproducible and robust) and feasible (practical, economical, etc.). In the context of diagnostic tests for animal diseases, specific validation protocols have been established to estimate key performance parameters, such as diagnostic sensitivity and specificity, against a defined reference standard. This requires an independent and correct test system in order to define disease in terms of an appropriate selection of measurable changes from reference points for good health (e.g. normal body temperature). The challenge for animal welfare assessors is to provide a comparably valid series of reference points from which to measure departures from good welfare. Animal-based measures, as indicators of animal welfare, are increasingly being tested for their 'fitness for purpose' according to these essential attributes.

Welfare, like health, is a characteristic of the individual at a stated time, and most animal-based measures are taken on individual animals. However, individual animal data can be aggregated to a herd/flock or even population level, expressed using summary measures such as proportions or means,

and interpreted against predefined threshold values. In cases where measurements are collected from a sample of animals, it is essential that the sample be unbiased and representative in terms of potential influencing characteristics, such as, for example, age, parity, body size, reproductive state, etc. This will depend on the epidemiological unit of analysis.

In the absence of systematically collected scientific study and field data that allow quantification of the association between the tests (animal-based measures) and welfare, the diagnostic quality of individual or combined animal-based measures to identify important welfare outcomes relies on expert opinion.

2. How we address the terms of reference

There are four terms of reference (ToRs) in this mandate and each is addressed in a separate section of the report, although there are links between them and information generated when answering one ToR is also used to answer another. To address ToR 1, a list of all recommendations from the EFSA Scientific Opinions was made and beside each recommendation any animal-based measure considered useful to detect the presence of the factor underlying that recommendation was listed. A special note was made if the measure was proposed in the Welfare Quality® protocol. If no animal-based measure had been proposed previously in the literature and none was considered obtainable from animal records, an attempt was made to propose a non-animal-based (resource- or management-based) measure. To address ToR 2, another table was developed, this time using the most important factors (hazards) identified in the three risk assessments in the EFSA Scientific Opinion on the welfare of pigs (EFSA, 2007a, b, c), considering the contents of the other two EFSA Opinions on castration and on floor and space allowance (EFSA, 2004, 2005) and the SVC report (SVC, 1997). In this way, the links between factors (hazards) and animal-based measures, including those proposed in the Welfare Quality® research project could be identified. Based on the available information in the source documents and the large number of factor-outcome and outcome-indicator links it was, in the context of this mandate, not possible to explore fully the diagnostic quality (i.e. validity, reliability and feasibility) of selected animal-based measures towards specific welfare outcomes - as is carried out in the validation of diagnostic tests.

Using the above mentioned tables, it was found that some of the identified factors that have impacts on animal welfare, as well as some of the recommendations in the EFSA Opinions, did not have any corresponding animal-based measures in the Welfare Quality® protocols or in the general animal welfare literature. An attempt was made to group these 'gaps' in order to identify any common features. In this way, it was possible to address ToR 3 in the mandate, which asked whether there are animal welfare issues that cannot be assessed using animal-based measures and what kind of alternative solutions are available to improve the situation.

ToR 4 asked for a list of factors in husbandry systems that have been shown to have a negative effect on the welfare of pigs and the extent to which such negative effects can be prevented by management. A Delphi approach was used to answer this ToR. Using the table developed to answer ToR 2 (listing the main factors, often hazards, identified in the EU reports and opinions affecting pig welfare), experts in the Working Group and external experts were asked to score, on a scale from 1-5, the extent to which they thought the negative effects could be prevented by management. Following standard Delphi methodology, this scoring was initially carried out independently. Experts then received the average score from the group of experts, and had a chance to modify their answer. Only in the final phase, and only for the factors where there was a difference in scores given by experts, were the results discussed.

2.1. How animal-based measures could be used to ensure the fulfilment of the recommendations of the EFSA Scientific Opinions on the welfare of pigs (ToR 1)

The fact that a recommendation from the EFSA Scientific Opinion is fulfilled does not necessarily mean that the intended welfare improvement for the animal is achieved. Most recommendations in the Scientific Opinions on pig welfare are phrased in terms of the specific resources to be supplied to the

animals or the types or quality of management to be used. A check on fulfilment of these recommendations is most easily achieved by using resource- or management-based measures. For example, if straw provision is recommended to reduce tail biting in finishing pigs it is easier to check for straw provision compared to scoring bite marks on tails.

On the other hand, as stated earlier, often the relationship between the factor and the consequence is far from clear, for example, the relationship between thirst and behaviour of the animal. In some cases, the decision as to whether an animal-based or a resource- or management-based measure is most appropriate to fulfil a particular recommendation may be easy. For example, if the animal-based measure is difficult to obtain or ambiguous, but the resource-based or management-based measure is simple to obtain and precise in the information it gives. In the above example on thirst, it is probably best to check for drinker availability. For other factors affecting welfare, the animal-based measure is clearly the more useful as it will give direct information about poor welfare that could not be obtained from any simple resource measure.

In summary, the exact formulation of the recommendation determines what type of measure (animal-, resource- or management-based) should be used to ensure the fulfilment of the recommendation, and this should be considered when formulating recommendations in future. In answering this ToR the focus has been on the use of animal-based measures.

It is likely that new measures will be developed in future. In some cases, the methodology has only recently become feasible. For example, the acute-phase-protein PigMAP can now be measured in a blood or meat juice sample using a dip test (Pineiro, 2011); therefore it is included in the tables. For some measures of relatively uncommon behaviours, for example, biting another pig's tail, an inspector may not see it during an inspection but if it were seen, it would be useful to record it. Hence, these too are included in the tables. An important area of animal welfare assessment is pain assessment. As pig mutilations such as castration and tooth grinding would not be seen by an inspector, animal-based measures of pain resulting from such mutilations are not included in the tables.

Animal-based measures of welfare that are signs of disease are important on-farm and in the slaughterhouse. They have been included in the tables, either as signs of specific disease conditions or as the general term "disease signs" where a wide range of pathologies is possible. Lists of signs that can be recorded from live animals and from slaughtered animals are included in Appendix 1 but since there are many signs of disease only a proportion of them are specified.

2.1.1. Procedures used to link measures to recommendations

Although implementation is a central issue to the question in this mandate, we have refrained from being specific about how animal-based measures are implemented or where a threshold between acceptable and unacceptable in a particular measure should be set, but have focused instead on which measures may be implemented and what aspects should be considered when deciding whether or not to implement them. Some of these points were already dealt with in the section on essential attributes of animal-based measures (see Section 1.3).

Each of the recommendations considered in the EU reports and EFSA Opinions on the welfare of pigs was considered in turn to determine measures, both animal-based and non-animal-based (see the Glossary), that would be appropriate to evaluate whether or not the recommendation is being fulfilled on the farm (Tables 1-5). In compiling the list, measures described by Welfare Quality® were associated with the EFSA recommendations where this was possible. When the measure has been described in detail in the Welfare Quality® Pig Protocol (Welfare Quality®, 2009) an abbreviated reference number relating to the relevant section is given (e.g. WQ: 6.1.3.1) so that more information can be found. In some cases, the appropriate welfare indicators are sufficiently described by Welfare Quality®. In most cases, where the source is elsewhere, this source is referenced in the Scientific Opinions on the welfare of pigs (EFSA, 2004, 2005, 2007a, b, c) or in other literature sources. The validity, reliability and feasibility of these measures (see Section 1.3) were based on scientific

evidence, although no formal, systematic and targeted literature review on these aspects was carried out.

Efforts have been made to propose measures that can be recorded by a veterinary or other inspector on-farm or at the slaughterhouse during ante-mortem or post-mortem inspection of the animal and carcass. For some recommendations, an initial measure can usefully be followed up by a more detailed investigation. For example, a visible condition in the animal might be better understood if a faecal sample is taken (e.g. to determine the pathogen involved).

The tables which follow were created according to the topic of the different Opinions (Table 1: Health and welfare aspects of pig castration; Table 2: Effect of space allowance and floor on weaners and rearing pigs; Table 3: Welfare aspects of tail biting and need for tail docking in pigs; Table 4: Animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, pregnant, farrowing sows and unweaned piglets; Table 5: Animal health and welfare of fattening pigs). In each table, the recommendations are numbered as they were ordered in the original Scientific Opinion. Following the outcomes of the two external technical reports (Spoolder et al., 2011a, 2011b) updating EFSA's Opinions, there were additions to existing recommendations (indicated as 19A, 23A, etc.) and new recommendations (indicated as N1, N2, etc.).

After each table there is a brief discussion of the measures and how they can provide an assessment of welfare outcomes. The welfare indicators identified in these tables (animal-based and non-animal-based) are described in broad terms (e.g. fertility records, metabolic profiles, feeding behaviour) to indicate which types of observation or measurement should be selected to address the specific objective (i.e. the recommendation).

The tables list welfare measures without ascribing values for the use of each one. As mentioned in Section 2.1., in some cases, one measure is likely to be much better than another that is mentioned. Comments on various aspects of their usage are in the text in Section 2.1.2. However, the careful analysis of the various factors and the different indicators is a substantial task that is outside the remit of this Opinion. Only some examples and general guidance are presented here.

It is not the intention, nor is it possible within these tables, to describe how the individual observations and measurements should be made or how they should be interpreted in the assessment of welfare, since that will depend on the purpose of the assessment. The amount of published scientific evidence and sound clinical practice underpinning the methodology for recording and interpreting these indicators is very large, and in most cases it would be inappropriate to link broad categories to individual scientific communications. For this reason, Appendix 1 presents a comprehensive list of all animal-based measures referred to in the following tables (Tables 1-5) and therefore in this report. This list can be regarded as a 'toolbox' from which potential measures can be selected. In most cases, directions for those seeking further details of methodology and interpretation can be obtained in the first instance from the comprehensive review publications (EFSA, 2004, 2005, 2007a, b, c; Broom and Fraser, 2007; Welfare Quality®, 2009). Original communications are quoted which describe what the measure is and give an example of how it may be scored. There may be other ways of scoring this measure but the best scoring system is not being specified in this Opinion. Some animal-based measures have already been tested for validity (accuracy and precision), reliability (repeatability, reproducibility and robustness) and feasibility (practicality and cost), but not all. Animal-based measures are best evaluated for these essential attributes before being added to the toolbox and before being used in practice to assess the welfare of pigs, so that informed decisions can be taken on their use in different contexts.

2.1.2. Welfare measure selection

It was concluded that the measures necessary to investigate and check the fulfilment of the recommendations in the EFSA Scientific Opinions (EFSA, 2004, 2005, 2007a, b, c) should consider

both input factors (resource- and management-based measures) and consequences (animal-based measures). These measures may be categorised as follows:

- Animal-based measures:
  - *Observations and measures* from the animals made during the welfare assessment on-farm, ante- or post-mortem, such as behaviour and body condition (direct indicators), some of which are veterinary procedures that can be obtained only by a veterinarian or other authorised individual (e.g. from a blood sample).
  - *Records* of animal breeding, growth, health, culling rate, abattoir condemnations, etc. These may include records of animal-based measures obtained using automated methods (indirect indicators), such as measurement of drinking from real-time water flow to drinkers.
- Non-animal-based measures (resource- and management-based measures):
  - *Observations and measures* of housing provided or of management used (e.g. floor type, feeding space, weaning age or the use of legally permitted mutilations, such as tail docking).
  - *Inspection of documentation* (e.g. food provision strategies, staff training records).

Table 1: Animal-based and non-animal-based measures linked to the recommendations of the Scientific Opinion on "Welfare aspects of the castration of piglets" (EFSA, 2004)

WELFARE ASPECTS OF THE CASTRATION OF PIGLETS			
	RECOMMENDATIONS	**ANIMAL-BASED MEASURES References in Appendix 1**	**NON-ANIMAL-BASED MEASURES**
1.	Because puberty is a gradual process and the development of boar taint variable, puberty should not be used as an indicator of the time of slaughter in order to avoid boar taint.	No relevant welfare measure.	
2.	Gaining information on castration rates, etc., may influence any decisions on management being undertaken at an EU wide level.	No relevant welfare measure.	
3.	Directive 2001/93/EC requiring training of all operatives likely to castrate pigs should be enforced.	No relevant welfare measure.	Records of training.
4.	Information on the possible detrimental effects on growth, on the immune system and hence on the health of animals should be collected in order to quantify the risk associated with castration.	Disease signs on-farm. Disease signs at slaughter. Presence and size of testes.	Records of treatments. Records of growth performance.
5.	The age limit of 7 days for castration without anaesthesia plus prolonged analgesia may need to be revised, including consideration of the neonatal period, as castration at any age is likely to be painful.	No relevant welfare measure.	
6.	Information on the welfare implications of the interactions of combined surgical procedures would be useful prior to recommendations being made on the advisability of combining such procedures.	No relevant welfare measure (see note on pain assessment; Section 2.1.).	
7.	Although it is not possible to recommend a method of general anaesthesia for pigs undergoing castration in commercial farms at the present time, local anaesthesia should be used for castration of piglets. Analgesia should be used to prevent pain in piglets which are castrated.	No relevant welfare measure (see note on pain assessment; Section 2.1.).	Manager inquiry about anaesthetic and analgesic treatments (WQ.6.1A.3.3). Records of treatments.
8.	If castration of female pigs is necessary for diagnostic reasons or therapeutic purposes, anaesthesia and	No relevant welfare measure (see note on pain assessment; Section 2.1.).	Manager inquiry about anaesthetic and analgesic

	analgesia should be used.		treatments. Records of treatments.
9.	It is important to avoid mixing of entire males as they are more aggressive and fight more than castrates.	Skin lesions on-farm or at slaughter. Aggression resulting in injury. Mounting behaviour score.	Records of management procedures, including grouping.
10.	Animals from different groups should not be mixed in preparation for or during transport and lairage.	Skin lesions on-farm or at slaughter. Aggression resulting in injury.	Records of management procedures, including grouping.
11.	Soft fat can be avoided by changing the fatty acid composition of the diet. However, such unsaturated fat may have nutritional advantages for human consumption.	No relevant welfare measure.	
12.	There is a need to evaluate and harmonize sensory evaluation and chemical measurements for boar taint.	No relevant welfare measure.	
13.	Criteria aimed at avoiding boar taint, for the acceptance or rejection of pig carcasses in slaughterhouses, should be revised as knowledge improves.	No relevant welfare measure.	
14.	Pigs should be mixed as little as possible - ideally litters should be kept intact from birth to slaughter.	Skin lesions on-farm or at slaughter. Aggression resulting in injury. Mounting behaviour score.	Records of management procedures, including grouping.
15.	With present knowledge, slaughtering pigs at a lower weight or age to avoid boar taint cannot be recommended.	No relevant welfare measure.	
16.	Pens floors should be kept clean, especially during the week before slaughter, and in warm periods pigs should have possibility for thermoregulation other than wallowing in excreta.	Panting. Manure on the body score. Lying location	Assessment of the existence of sprinklers or showers. Records of ambient temperature.
17.	It is necessary to decrease the frequency of genes causing high levels of boar taint.	No relevant welfare measure.	
18.	With the present state of knowledge, local destruction of testicular tissue by chemicals cannot be recommended because of the lack of information on possible pain inflicted to the animals and on the achieved reduction of boar taint.	No relevant welfare measure.	

19.	With the present state of knowledge, immunocastration, cannot presently be recommended, due to a number of concerns, for instance: • The effectiveness of immunocastration in EU pig populations for reducing boar taint in commercial EU pig populations is not known. • Immunocastrates should be individually checked on the slaughter line for the absence of boar taint. In this context, a possible goal could be to aim at levels of boar taint in immunocastrates which are similar to those presently observed as a result of surgical castration. • Operator safety • Resulting welfare should be at least as good as surgical methods However, if such concerns are addressed, immunocastration may prove to be a valuable tool in European pig farming.	No relevant welfare measure.
20.	No recommendation on the use of sexing of sperm and its insemination methods can be made at present.	No relevant welfare measure.
21.	Tests currently applied to fat from carcasses of entire males should continue to be used. Future development of harmonised on-line tests for use in slaughter houses should be encouraged.	No relevant welfare measure.
22.	The 80 kg carcass weight limit for obligatory detection of taint should be questioned.	No relevant welfare measure.
23.	The current practice of processing carcasses with low level of taint, on the assumption that this will completely mask boar taint, cannot be recommended.	No relevant welfare measure.
19. A	Since immunocastration is effective in reducing boar taint and it avoids the pain associated with surgical castration, its usage should be considered.	No relevant welfare measure.
23. A	In view of new information, the processing of carcasses with low levels of boar taint should be considered.	No relevant welfare measure.

N1	A standardised and harmonised method for quantification of skatole and androstenone should be established. A method harmonisation programme should be carried out, according to international harmonised validation protocols, to establish a standardised methodology in this field. There is a need for stable sample reference material that can be used to validate the method performance of laboratories analysing skatole and androstenone in pork carcasses. If feasible, a certified reference material (CRF) for this purpose should be developed.	No relevant welfare measure.
N2	Pan-European socio-economic research on the impact of alternatives for surgical castration is recommended, including economic feasibility studies, as well as consumer and stakeholder attitude surveys.	No relevant welfare measure.

Many of the recommendations from the report on castration (EFSA, 2004, Table 1) relate to issues associated with boar taint which have no direct relevance to animal welfare assessment, and are mainly consumer issues. No animal-based measures are therefore suggested for these recommendations. The occurrence of castration can be determined by a simple question on management, but can also be easily verified by observation of testes integrity on the live animal or carcass. At present, little or nothing can be discovered by an inspector about the age and exact method of castration, including use of anaesthesia and analgesia, using animal-based measures. Without being present during the process, only the use of farmer's records or management questionnaires are currently feasible. Thus, whilst animal-based measures of pain do exist and farmers could use these, only records are considered practicable to list in the table (see comment in Section 2.1. and 2.3.1.). The possible longer-term adverse effects of castration on immune function and health can be assessed by animal-based measures of disease states or by the current compulsory records of veterinary treatments and mortality. Most other welfare-related recommendations relate to the potential adverse effects of behaviours shown by entire males. These can be assessed by animal-based measures, particularly skin lesions on the live animal or carcass. Direct observations of aggression and mounting behaviour are possible, but unlikely to be meaningful in a limited inspection time period because of their sporadic nature.

Table 2: Animal-based and non-animal-based measures linked to the recommendations of the Scientific Opinion on "Effect of space allowance and floor on weaners and rearing pigs" (EFSA, 2005)

EFFECT OF SPACE ALLOWANCE AND FLOOR ON WEANERS AND REARING PIGS			
	RECOMMENDATIONS	**ANIMAL-BASED MEASURES References in Appendix 1**	**NON-ANIMAL-BASED MEASURES**
1.	Improved pen and building design, as well as management, should be considered so that all pigs are provided with a suitable lying area in addition to the dunging area. Both lying in the dunging area and fouling of the lying area should be minimised to avoid increased dirtiness of the pigs and increased odour and ammonia emission. This can be achieved by: (i) increasing the size of the entire pen, allowing for a better separation of the lying and the dunging area. These two areas can be of the same floor type but conditions should facilitate differentiation of lying and dunging areas; (ii) providing a dunging area of adequate size so that pigs are not forced to show eliminative behaviour in the lying area; (iii) by facilitating thermoregulation in the pigs, for example, when conditions are extreme, by means of sprinkling or improved airflow patterns.	Manure on the body score Huddling and shivering Panting Qualitative Behaviour Assessment score Disease signs on-farm Disease signs at slaughter Acute phase proteins Lying location	Cleanliness of the pen (Banhazi et al., 2008) Space allowance (WQ.6.1A.2.3) Air temperature (EFSA, 2007a, b, c) Air flow patterns (Velarde and Geers, 2007). Substrate provision (EFSA, 2007a, b, c) Presence of cooling down facilities (showers) Ammonia levels Provision of separate lying and dunging area
2.	Space allowances and floor quality in housing systems for both weaners and grower/finisher pigs should facilitate provision of adequate environmental enrichment, such as foraging material and material to explore, in order to reduce the risk of disturbed behaviour which might include belly-nosing or tail-biting.	Skin lesions Tail-biting Ear-biting Flank-biting Belly-nosing Persistent investigatory behaviour Exploratory behaviour Qualitative Behaviour Assessment score Tail posture Tail lesions on-farm or at slaughter	Presence of substrate (EFSA, 2007a, b, c) Amount and nature of substrate Space allowance (WQ.6.1A.2.3)
3.	All pigs should be provided with thermo-neutral conditions or adequate opportunities to regulate their body temperature, such as heated areas or provision of bedding in cold conditions and	Manure on the body score Huddling and shivering Panting	Cleanliness of the pen (Banhazi et al., 2008) Air temperature (EFSA, 2007a, b, c)

	increased air velocity, showering or misting systems, or opportunities for lying without body contact in warm conditions.	Qualitative Behaviour Assessment score Lying posture Lying location Body temperature	Air flow patterns (Velarde and Geers, 2007). Substrate provision (EFSA, 2007a, b, c) Presence of cooling down facilities (showers)
4.	Overcrowding is a risk factor for disease expression, and other causes of poor welfare, and should be avoided. For pigs of up to 110 kg, the minimum space allowance should be equivalent to k = 0.036, where ambient temperature will not exceed 25 ºC. If the ambient temperature is likely to exceed 25 ºC, a space allowance equivalent to k = 0.047 should be used. For pigs of more than 110 kg, a space allowance equivalent to k = 0.047 should be used at all times.	Skin lesions Tail lesions Ear lesions Mortality rate Disease signs on-farm Disease signs at slaughter Panting Lying posture Lying location Manure on the body score Tail biting Ear biting Flank biting Aggression Qualitative Behaviour Assessment score	Space allowance (WQ.6.1A.2.3) Cleanliness of the pen (Banhazi et al., 2008)
5.	In order to minimise disease in pigs, especially where animal numbers are large, where possible, animals of different ages should be segregated, the design of the buildings should facilitate age-segregated rearing and an all-in all-out policy should be used.	Disease signs on-farm Disease signs at slaughter Acute phase protein	Pigs of similar age in a room All-in all-out management policy
6.	In order to minimise the risk of infection, pigs kept outdoors should be protected from contact with wild mammals and wild boars in particular, for example, by the use of appropriate double fences. Outdoor units are difficult to protect. The invasion of birds and rodents should be kept to a minimum.	Disease signs on-farm Disease signs at slaughter Acute phase protein	Lay-out of outdoor unit
7.	Mixing of unfamiliar pigs should be kept to a minimum, as they are likely to fight and will then have temporarily increased space requirements and an increased risk of diseases, floor-induced claw and limb lesions.	Skin lesions Locomotion score Aggression resulting in injury Foot lesions	Frequency of mixing (Sherritt et al., 1974)

8.	When designing or managing pig systems, efforts should be made to minimise aerial pollutants, including dust. ADOPTED BY BIOHAZ.	Coughing Sneezing Laboured breathing Twisted snouts Lung and respiratory tract pathologies Tear staining Acute phase protein	Level of ammonia, H_2S, dust and total microbial count (Velarde and Geers, 2007) Records of treatments
9.	Pig housing systems should be operated and designed to the highest standard of Good Farming Practices. ADOPTED BY BIOHAZ.	No relevant welfare measure	Compare with GFP standard
10.	The construction, in particular of slatted floors, should facilitate the effective cleaning and disinfection necessary for the control and possible eradication of pathogens that cause infectious diseases of significant importance (e.g. foot and mouth disease and classical swine fever), as well as enzootic diseases, like swine dysentery.	Disease signs on-farm Disease signs at slaughter Manure on the body score Acute phase protein	Microbial count Pen cleanliness (Banhazi et al., 2008) Records of treatments
11.	Efforts should be in place to prevent disease, in particular by maintaining good hygiene, such as minimising the exposure of the pigs to their faeces and urine. This is of particular importance during the post weaning period.	Disease signs on-farm Disease signs at slaughter Manure on the body score Acute phase protein	Records of frequency of cleaning Pen cleanliness (Banhazi et al., 2008) Records of treatments
12.	Slatted flooring should be used in the dunging area as it is found to result in better pen hygiene and a lower morbidity and mortality in comparison with solid flooring. A successful design for partly-slatted floor systems has been to have the slatted part at a raised level, to allow for straw use.	Disease signs on-farm Disease signs at slaughter Manure on the body score Acute phase protein	Design of pen floor (EFSA, 2007a, b, c) Pen cleanliness (Banhazi et al., 2008) Use of substrate (EFSA, 2007a, b, c)
13.	After the EU ban from the year 2006 (Regulation EC No 1831/2003[9]) on the use of antibiotics as a general feed additive to pigs, the implementation of management routines, including space allowances and good pen hygiene, as well as other efforts that include selection of floor types that prevent post weaning diarrhoea in particular, is urgently needed as a replacement for the	Disease signs on-farm Disease signs at slaughter Acute phase protein	Records of treatments Pen cleanliness (Banhazi et al., 2008) Design of pen floor (EFSA, 2007a, b, c) Space/pig (WQ.6.1A.2.3)

[9] Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition. OJ L 268, 18.10.2003, p. 29–43.

	disease preventive effect of antibiotic usage.		
14.	Straw and other bedding material should be of good hygienic and "physical" quality to avoid negative influence on the health of the pigs, including the effects of mycotoxins and other possible contaminants.	Disease signs on-farm Disease signs at slaughter Acute phase protein	Quality of straw (EFSA, 2007a, b, c) Records of treatments
15.	Small quantities of adequately structured straw or other materials for manipulation as environmental enrichment for the pigs to meet their needs can be used on solid or slatted floors. If manipulable material is not provided poor welfare is caused in pigs so it is recommended that this should be provided.	Skin lesions on body Tail lesions Ear lesions Foot or claw lesions Tail-biting Ear-biting Flank-biting Exploratory behaviour Belly nosing Qualitative Behaviour Assessment score	Presence of substrate (EFSA, 2007a, b, c)
16.	When deep litter bedding is used it should be properly managed to avoid the build up of an infectious load of viral, bacterial and parasitological agents, in particular of enteric organisms and pathogens, in the pig accommodation. It should be added top and be replaced regularly before it becomes a focus for holding faeces.	Disease signs on-farm Disease signs at slaughter Acute phase protein Manure on the body score	Quality of bedding (EFSA, 2007a, b, c) Records of treatments Cleanliness of the pen (Banhazi et al., 2008)
17.	Washing and disinfection of floors should be carried out effectively. Fresh and dry faeces and bedding material, such as straw, wood shavings, etc., should be removed before cleaning and disinfection. Disinfection without thorough previous cleaning is not useful. The design and the material of the floors and the coving between the walls and floors should allow these operations effectively; therefore, surfaces should be smooth and impervious to facilitate free drainage and cleansing of the effluents.	Disease signs on-farm Disease signs at slaughter Acute phase protein	Quality of the floor (EFSA, 2007a, b, c) Cleanliness of the floor (Banhazi et al., 2008) Records of treatments Cleanliness of the pen (Banhazi et al., 2008)
18.	In order to maintain good hygiene, slatted (perforated) floors in the dunging area should permit faeces and fluids to pass through the gaps.	Manure on the body score Disease signs on-farm Disease signs at slaughter Acute phase protein	Cleanliness of the pen (Banhazi et al., 2008) Records of treatments
19.	When flooring systems for pigs are designed, building management should provide optimal conditions for	Manure on the body score Huddling and shivering	Cleanliness of the pen (Banhazi et al., 2008)

	thermoregulation. Account should be taken of all of the needs of pigs, including those for effective thermoregulation and to ensure access to manipulable materials.	Panting Qualitative Behaviour Assessment score Exploratory behaviour Lying posture Lying location	Air temperature (EFSA, 2007a, b, c) Air flow patterns (Velarde and Geers, 2007) Substrate provision (EFSA, 2007a, b, c) Presence of cooling down facilities (showers)
20.	Metal mesh floors should not be used for pigs because of their low slat to gap ratio, and often also the cross-sectional profile of the solid part, causes higher levels of claw injury.	Skin lesions Locomotion score Slipping and falling animals Foot lesions	Floor design (EFSA, 2007a, b, c)
21.	Those floors which cause injuries to the pig (e.g. to the claw or leg), to a greater extent than those caused by good quality floors, should not be used.	Skin lesions Locomotion score Slipping and falling animals Foot lesions	Floor design (EFSA, 2007a, b, c)
22.	Where slatted floors are used the gap should not be so large that the claw can become trapped or the legs and feet injured. The slat should also be wide enough to adequately support the whole foot of the pig.	Skin lesions Locomotion score Slipping and falling animals Foot lesions	Floor design (EFSA, 2007a, b, c)
23.	In slatted (perforated) floors for pigs, according to one model, the recommendation for the maximum percentage of the floor which is occupied by gaps should be 60 % of the usable floor area for an 8 kg weaner, 51 % for a 100 kg finisher and 40 % for heavier pigs.	Skin lesions Locomotion score Slipping and falling animals Foot lesions	Floor design (EFSA, 2007a, b, c)
24.	Efforts should be made to produce a floor surface which is non-slippery and not too abrasive. Gaps or drains should not have sharp edges.	Skin lesions Locomotion score Slipping and falling animals Foot lesions	Floor design (EFSA, 2007a, b, c)
25.	When new kinds of flooring are developed, these should be fully tested to find out their effects on pig welfare, including effects on the claws and legs of pigs, before they are used commercially.	Skin lesions Locomotion score Slipping and falling animals Foot lesions	Floor design (EFSA, 2007a, b, c)
26.	The design, the size of slats and gaps, and the type of floors should be adequate for effective drainage or removal of fluids and faeces. Any adverse effects of flooring on the welfare of pigs, including injury and animal health, should be prevented.	Skin lesions Locomotion score Slipping and falling animals Foot lesions Manure on the body score	Floor design (EFSA, 2007a, b, c)

27.	The type of floor used for pigs should allow maintenance of good hygiene and good air quality. Any bedding which is used should be managed so as to avoid the introduction of undesirable pathogens into herds and to minimise ammonia emissions which can cause environmental and health problems. ADOPTED BY BIOHAZ.	Disease signs on-farm Disease signs at slaughter Lung and respiratory tract pathologies Manure on the body score Tear staining Acute phase proteins	Ammonia level, H_2S (Velarde and Geers, 2007)
28.	Flooring and housing systems for pigs should be designed and managed so that fluids, manure, materials for manipulation by pigs and any bedding are adequately removed from pig accommodation before they pose a significant health or environmental risk. It may be necessary that shredding systems for solid material to be used.	Manure on the body score Disease signs on-farm Disease signs at slaughter Acute phase protein	Pen cleanliness (Banhazi et al., 2008) Adequate slurry/dung removal
29.	Where partly-slatted, unbedded floors are used for pigs, the solid floor should have efficient drainage.	Manure on the body score Slipping and falling animals	Pen cleanliness (Banhazi et al., 2008) Adequate slurry/dung removal
30.	The principle for determining gap width is that the claw should not go into the gap. The type of material (quality, physical properties, edges, etc.) and the design should be considered when determining the gap width. The actual dimensions of the claw of the pigs in the pen should be of critical importance in determining the gap width. In order to minimise the likelihood of a claw going into a gap, the width of a gap should not exceed half the width of the contact area between the foot and the floor and the solid area between the gaps should be sufficient to support the foot.	Skin lesions Locomotion score Manure on the body score Foot lesions	Floor design (EFSA, 2007a, b, c) Pen cleanliness (Banhazi et al., 2008)
N1	A well maintained substratum, such as straw, should be used to reduce the risk of leg problems, gastric lesions and behavioural disorders.	Locomotion score Gut pathologies Tail lesions Shoulder sores Ear lesions Foot lesions Tail-biting Ear-biting Flank-biting Belly-nosing Exploratory behaviour Swollen bursae	Pen cleanliness (EFSA, 2007a, b, c)

		Tail posture Skin lesions	
N2	The use of mats made of rubber or other synthetic material in the lying area, in order to reduce the incidence of skin lesions from poor quality flooring, should be considered.	Skin lesions	

All recommendations from the report on flooring and space allowance (EFSA, 2005; Table 2), except those relating to BIOHAZ, have good animal-based measures which are likely to be more meaningful than many resource-based measures. The consequences of inappropriate flooring for hygiene, lameness and skin damage can all be well assessed by scores of cleanliness and thermoregulatory behaviour, disease, lameness and skin lesions. Resource measures describing floor material, slat design or environmental temperature will be less specific to each combination of interacting farm circumstances to determine the welfare outcome. However, specification of some characteristics of floors, such as slipperiness or having inappropriate slot size, is a useful predictor of the risk of poor welfare. Although space allowance is easy to measure as a resource, and minimum space allowances are also useful safeguards against the risk of poor welfare, the consequences for welfare depend on many other interacting factors which are best assessed through animal-based measures of health, aggression and thermoregulation. One deficiency in animal-based measures of the environmental adequacy (e.g. thermal comfort) is that they only give a snapshot of the time of inspection, whereas the thermal environment can vary widely during the day and season. In this respect, a resource-based measure of maximum and minimum temperatures, or better still an electronic record of daily temperature profiles, is superior. Hence, it is best to use a combination of animal-based and resource-based measures.

Table 3: Animal-based and non-animal-based measures linked to the recommendations of the Scientific Opinion on "Welfare aspects of tail biting and need for tail docking in pigs" (EFSA, 2007c)

TAIL BITING AND NEED FOR TAIL DOCKING IN PIGS			
	RECOMMENDATIONS	**ANIMAL-BASED MEASURES** **References in Appendix 1**	**NON-ANIMAL-BASED MEASURES**
1.	Accurate data on the entire range of deleterious effects on pig health associated with tail biting should be collated.	Tail lesions on-farm or at slaughter Mortality rate Local infection sign Acute phase protein Locomotion score Lung and respiratory tract pathologies in slaughtered pigs Joint pathologies in slaughtered pigs Other pathologies in slaughtered pigs Body condition score	Records of veterinary treatment, euthanasia
2.	It is important to monitor the pigs closely at times of life when husbandry is changing in order to possibly prevent tail-biting outbreaks.	Tail lesions on-farm Tail biting Activity level Tail posture	Records of inspection
3.	Those housing and management procedures that are found to prevent tail biting should be applied and, if tail biting occurs, such management interventions that prevent an escalation of the problem and the negative consequences of poor welfare in victim pigs should be applied. The importance of good stockmanship is emphasized.	Tail lesions on-farm (Potentially all animal-based measures indicating adequacy of housing and management)	Space (WQ.6.1A.2.3) Temperature Airspeed Enrichment Diet Health management Feeder space Drinker provision Stockperson training records [there are other resource-based measures]
4.	Since tail biting can cause very poor welfare and tail docking is likely to be painful, both in the short term and as a result of possible long-term pain from neuroma formation, measures other than tail-docking should be	Docked tail Tail lesions on-farm and at slaughter Tail-biting (Potentially all animal-based measures indicating adequacy of housing and management)	Tail docking practice (WQ.6.1A.3.3) Space (WQ.6.1A.2.3) Temperature Airspeed Enrichment Diet

	implemented to control tail-biting and its adverse effects for welfare.		Health management Feeder space Drinker provision [there are other resource-based measures]
5.	To minimise the risk of tail-biting, it is recommended to address the following major risk factors: (i) provision of straw, preferably as bedding, and (ii) proportion of slatted floors in housing systems for fattening pigs. Due to the severe adverse effects for pigs of tail biting inducing poor welfare, when tail biting incidence increases in a farm, other factors which have also effect on the likelihood of tail biting (e.g. air speed, health status, high temperatures) should be considered.	Tail lesions on-farm and at slaughter Tail-biting Exploratory behaviour Disease signs on-farm Disease signs at slaughter Acute phase protein Body condition score Panting Lying location Manure on the body score Lying posture (Potentially all animal-based measures indicating adequacy of housing and management)	Type of floor (% slats) Presence of straw Quantity of straw Space (WQ.6.1A.2.3) Temperature Airspeed [there are other resource-based measures]
6.	Monitoring at slaughter of lesions related to tail biting is suggested as a means to identify herds with such problems as guidance for the implementation of preventive actions.	Tail lesions at slaughter Intact or docked tail Ear lesions	
7.	The methodology and the results (Conclusions and Recommendations) of this Opinion as well as the previous opinions on pig welfare, should be future analysed identifying welfare indicators (in particular animal-based) suitable for the development of an animal welfare monitoring system.	(Potentially all animal-based measures indicating adequacy of housing and management)	
6.A	Monitoring at slaughter should include whether the tail is intact, tail length (in addition to tail lesions), as well as missing parts of the ears and biting wounds on flanks and legs.	Intact or docked tail Ear lesions Skin lesions at slaughter Tail lesions	

7.A	An intact curly tail should be considered as an important animal-based welfare indicator for weaned, growing and finishing pigs on farm.	Intact or docked tail Ear lesions Tail lesions	
N1	Decision support tools utilising the full range of information on how to reduce the risk of tail biting should be used to promote adoption of preventive measures.	(Potentially all animal-based measures indicating adequacy of housing and management)	Space (WQ.6.1A.2.3) Temperature Airspeed Enrichment Diet Health management Feeder space Drinker provision Stockperson training records Evidence of using a decision support tool [there are other resource-based measures]
N2	Long term strategies to reduce tail biting should be aimed at developing new housing systems which not only allow good economic performance but also fulfil all of the needs of the animals.	Exploratory behaviour Qualitative Behaviour Assessment score (Potentially all animal-based measures indicating adequacy of housing and management)	Performance records

All recommendations from the report on tail-biting and the need for tail-docking (EFSA, 2007c; Table 3) have an animal-based measure of the ultimate welfare outcome, which is tail-biting itself. This can be measured as bitten tails on-farm or less precisely, because of on-farm euthanasia of seriously affected individuals, at the slaughterhouse. However, many recommendations relate to resource-based measures known to be significant risk factors. Due to the multifactorial nature of tail-biting, the use of animal-based measures to assess risk due to environmental adequacy would necessitate a full spectrum of animal-based measures regarding health, thermal comfort, social harmony, etc. The risk level could therefore be more simply assessed by a checklist of resource measures. This is the logic behind the recommendation (N1) for development and use of a Decision Support Tool. While resource-based measures are better for risk assessment, they do not guarantee that tail-biting will not occur.

Table 4: Animal-based and non-animal-based measures linked to the recommendations of the Scientific Opinion on "Animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, pregnant, farrowing sows and unweaned piglets" (EFSA, 2007a)

ANIMAL HEALTH AND WELFARE ASPECTS OF DIFFERENT HOUSING AND HUSBANDRY SYSTEMS FOR ADULT BREEDING BOARS, PREGNANT, FARROWING SOWS AND UNWEANED PIGLETS			
	RECOMMENDATIONS	**ANIMAL-BASED MEASURES** **References in Appendix 1**	**NON-ANIMAL-BASED MEASURES**
1.	Whenever injuries (foot lesions and lameness) are observed, appropriate flooring conditions in combination with management procedures should be applied to avoid that situation.	Shoulder sores on-farm or at slaughter Foot lesions on-farm or at slaughter Locomotion score Swollen bursae Slipping or falling	Floor type (EFSA, 2007a, b, c) Bedding (EFSA, 2007a, b, c) Claw trimming procedures (EFSA, 2007a, b, c)
2.	The housing systems should enable sows and boars to minimize the risk of becoming faecal contaminated.	Manure on the body score	Score for pen cleanliness (Banhazi et al., 2008)
3.	All pigs should have access to a sufficient quantity of material to avoid problems due to lack of investigation and manipulation activities.	Stereotypies Persistent investigatory behaviour Skin lesions Vulva-biting Vulva lesions	Amount of appropriate material available (EFSA, 2007a, b, c)
4.	New handling systems for manure should ensure the provision of destructible materials.	No relevant welfare measure	Amount and nature of appropriate material available (EFSA, 2007a, b, c) Manure system recognised to be able to handle at least 100 g straw/animal/day (EFSA, 2007a, b, c)
5.	Sows, piglets and boars should be housed in conditions where either climate can be controlled to be in the comfort zone of the pigs or when needed in conditions where they are able to regulate their thermal comfort (e.g. through showering facilities or sufficient space to lie separate when it is hot or through straw or shelter when it is cold).	Panting Huddling and shivering Lying location Lying posture	Records of: - Temperature - Cooling facilities (yes/no) - Freedom of animals to move to different thermal zone (yes/no)

6.	In group housing systems mixing of animals of larger difference in size or age at breeding should be avoided as much as possible.	Aggression resulting in injury Skin lesions	Asking manager for mixing procedures
7.	Mixing of unfamiliar sows and gilts should be avoided as much as possible.	Aggression resulting in injury Skin lesions	Asking manager for mixing procedures
8.	It is the expert opinion of the WG that farrowing systems should allow for the handling of destructible nest material to enable investigation and manipulation activities.	Persistent investigatory behaviour	Records of amount and nature of nesting materials during nest building period
9.	The ability for nest building should also take into consideration the welfare of the piglets.	Mortality rate Huddling and shivering Lying posture	Records of amount and nature of nesting materials during nest building period
10.	The use of loose farrowing systems should be implemented only if piglet mortality in them is no greater than the mean level of mortality where the sows are kept in non-loose farrowing systems. Efforts should be made to reduce piglet mortality.	Mortality rate	Records of farrowing system
11.	Genetic selection for litter size should not aim at exceeding having, on average, 12 piglets born alive in a litter.	No relevant welfare measure	Record of litter size
12.	A decision to grind corner teeth should be made taking into account the welfare of piglets, as well as that of the sow	Clipped or ground teeth Skin lesions	Asking the manager for procedures (WQ.5.1.3.3)
13.	Pens for farrowing sows should be designed to allow contact between sow and piglets shortly after birth in order to ensure an early intake of colostrum.	Mortality Disease signs Acute phase protein	Design of farrowing crate, rails and equipment (Fraser and Thompson, 1986)
14.	Creep feed for piglets should be	Feeding and drinking behaviour	Creep feed provision

	provided before weaning takes place to prepare the further feed consumption of piglets and improve the gut development. According to common practices, creep feed should be provided at least one week before weaning.	Scouring Coughing Body condition score	Creep feed quality (EFSA, 2007a,b,c)
15.	Weaning of piglets should not be carried out before they have a significant feed intake from creep feed and not before 4 weeks of age.	Feeding and drinking behaviour Scouring Coughing Body condition score	Records of weaning age (WQ.5.1.1.1) Creep feed provision Creep feed quality (EFSA, 2007a,b,c)
16.	Boars should be provided with sufficient space to allow all normal movement including those involved in mating.	Observation that the boar is able to mate without undue restriction of movement	Measuring sufficient space for standing, lying, turning around (WQ.5.1.3.2) Width and length of mating pen at least twice the length of the boar when standing (EFSA, 2007a,b,c)
17.	Animal handlers should not just be trained on technical aspects, but any pig management course should also target their attitude towards livestock keeping and increase their awareness that their actions affect animal welfare (and production).	Approach to humans score	Ask manager about training records
5.A	Measures to alleviate heat stress by provision of cooling facilities or genetic selection strategies should be promoted.	Panting Lying location Lying posture Mortality rate	Provision of cooling facilities (yes/no)(EFSA, 2007a,b,c) Ask manager about genetic choice
7A	When mixing of unfamiliar sows and gilts does occur, in order to minimise negative consequences: 1) sufficient space should be provided to allow submissive behaviour or escape, 2) flooring should minimise the risk of slipping e.g. by the use of bedding.	Skin lesions Locomotion score Aggression resulting in injury Slipping and falling	Measure space available per sow Describe floor/bedding (KilBride et al., 2009a, 2010)

8A	Farrowing systems should allow for the use of material of suitable structure to enable nest building behaviour by the sow, including carrying, pawing and rooting.	Persistent investigatory behaviour Stereotypies	Records on: - Manure system - Floor system - Amount of material provided (EFSA, 2007a, b, c)
10A	Given the significant developments in the design of loose-farrowing systems, the use of those systems should be encouraged if they have a net benefit for sow and piglet welfare. Efforts should be made to further reduce piglet mortality in loose-farrowing systems considering both management and breeding aspects that result in high piglet viability and good maternal behaviour.	Mortality rate Persistent investigatory behaviour Exploratory behaviour (nest building) Body condition score (both sow and piglets) Shoulder sores Skin lesions Unresponsiveness	Pen design records (EFSA, 2007a, b, c) Ask manager about genotype choice
11A	In the genetic selection of pigs, traits which promote the prenatal and postnatal survival of piglets, such as birth weight, should be included in the breeding goal.	Mortality rate Body condition score Unresponsiveness	Ask manager about genotype choice
11B	Management strategies to safeguard the welfare of piglets, if they are born in large litters, should be developed. One such strategy is cross-fostering.	Mortality rate Body condition score	Records of number of cross-fostered piglets (Price et al., 1994) Provision of supplementary piglet nutrition (EFSA, 2007a, b, c)
N1	The thermally controlled lying area for suckling piglets should provide sufficient space for all piglets to lie at the same time.	Mortality Lying location Lying posture	Records of area per piglet of thermally controlled lying area
N2	Genetic selection strategies should be used to reduce aggression in groups of pigs.	Skin lesions Aggression resulting in injury	Ask manager about genotype choice
N3	High fibre diets or forage should be provided in order to improve sow welfare.	Stereotypies Gut pathologies in slaughtered pigs Constipation sign	Records of fibre content of feed provided and amount of forage given (Bergeron et al., 2000).

		Skin lesion Aggression Feeding and drinking behaviour (abnormal)	
N4	Supervision of sows and piglets around the time of farrowing should be encouraged in order to facilitate interventions that increase piglet survival.	Mortality	Employment records
N5	Research is required to assess boar welfare and how to improve it.	No relevant welfare measure	

Recommendations from the Opinion on sows, boars and suckling piglets (EFSA, 2007a; Table 4) cover many diverse topics. Some relate very specifically to housing systems, such as confinement in crates, and can therefore only be covered by the relevant resource measure. However, where the recommendations give the welfare objective of a housing recommendation, this can in all cases be monitored through one or more animal-based measures. Most of these are direct assessments on the animal, but some, such as piglet mortality, can only be achieved through records over a longer time period. Inspection of the animals can give some indication of the impact of genetics and breeding on welfare, but the largest amount of information can be gained from inspection of records of health, fertility and lifetime performance. Issues relating to social behaviour and stockmanship, aggression associated with feed competition, ease of movement and human-animal relationships can be obtained mostly from animal-based observations. These are well described by Welfare Quality®. Assessment of issues relating to the quality of farm management requires a combination of observations and records, backed up on occasion by veterinary procedures. The quality of biosecurity and health planning is a long-term issue, which can only be assessed from inspection of records of disease outcome, or by management-based measures.

Table 5: Animal-based and non-animal-based measures linked to the recommendations of the Scientific Opinion on "Animal health and welfare of fattening pigs in relation to housing and husbandry" (EFSA, 2007b)

HEALTH AND WELFARE OF FATTENING PIGS			
	RECOMMENDATIONS	**ANIMAL-BASED MEASURES** **References in Appendix 1**	**NON-ANIMAL-BASED MEASURES**
1.	Pigs should be provided with such an environment and management that the negative consequences of poor welfare such as injurious behaviours, physiological problems and immunosuppression, caused in barren environments are avoided.	Mortality Skin lesions on-farm or at slaughter Tail lesions on-farm and at slaughter Ear lesions on-farm and at slaughter Tail-biting Ear-biting Flank-biting Disease signs on-farm Disease signs at slaughter Acute phase protein Social isolation Feeding and drinking behaviour Body condition score (Potentially all animal-based measures indicating adequacy of housing and management)	Records of veterinary treatment, euthanasia Space (WQ.6.1A.2.3) Temperature Airspeed Enrichment Diet Health management Feeder space Drinker provision [there are other resource-based measures]
2.	In order to provide for the need to root with the nose and manipulate destructible materials, each pig should have access to manipulable, destructible material, such as straw or other fibrous material, that does not harm the pigs if ingested to such an extent that negative effects do not occur.	Exploratory behaviour Persistent investigatory behaviour Tail-biting Ear-biting Flank-biting	Nature of enrichment
3.	Since indestructible objects, such as chains or tyres, are not sufficient to provide for the manipulatory need of pigs, they may be used as a supplement to destructible and rooting materials but	Exploratory behaviour Persistent investigatory behaviour Tail-biting Ear-biting Flank-biting	Nature of enrichment

	not as a substitute for them.		
4.	Pen surfaces suitable for body rubbing and, wherever possible, wallows, should be provided for pigs for grooming purposes.	Skin inflammation and discoloration	Presence of rubbing surface Presence of wallow
5.	Where the ambient temperature around the pigs is below the lower critical temperature, shelter for outdoor pigs and an insulated lying area should be available to the pigs. At such temperatures inside the building, insulating bedding should be provided. Since huddling behaviour disrupts sleep in pigs, the necessity for huddling should be minimised by bedding provision or ambient temperature control.	Huddling and shivering Body temperature Lying posture Lying location	Environmental temperature Shelter provision Bedding provision Presence of temperature control system
6.	Where the ambient temperature around the pigs is above 19 ºC in pigs of over 50 kg and above 25 ºC in weaned pigs once established on solid feed, measures should be taken to facilitate heat loss in the pigs. This is best achieved by allowing the pigs to take action to cool themselves by visiting a wallow or other place where they can cool themselves, such as a cool floor, shower, or place of greater air flow. Above these temperatures, each pig should be able to lie so that it is not in contact with any other pigs.	Panting Body temperature Manure on the body score Lying location Lying posture	Environmental temperature Provision of cooling Space allowance (WQ.6.1A.2.3)
7.	In order to minimise disease in pigs, and hence poor welfare, effective disease preventive and management procedures should be in place. In addition to health	Mortality rate Skin lesions on-farm or at abattoir Tail lesions on-farm and at abattoir Ear lesions on-farm and at abattoir	Records of veterinary treatment, euthanasia Records of inspection

	control and health service these procedures include e.g. avoiding mixing of animals, daily inspection of all the pigs so that sick or injured animals can be identified and more intensive inspections when infectious diseases, injury due to aggression, belly nosing or tail biting is occurring.	Tail-biting Ear-biting Flank-biting Disease signs on-farm Disease signs at slaughter Acute phase protein Social isolation Feeding and drinking behaviour (absence) Body condition score	
8.	The lighting in pig houses should not be flashing and should be of a wavelength and intensity during the light period that allows pigs to discriminate the behaviour of other pigs and materials, such as straw, and to show normal diurnal rhythms. The light level and distribution at times of inspection should be sufficient to allow each pig to be seen.	Skin lesions on-farm or at slaughter Aggression resulting in injury	Light level (lux) Photoperiod Light spectrum Window area Number of artificial lights + wattage
9.	The design of accommodation for pigs should be such that the pigs have sufficient exercise for normal bone and muscle development and opportunities to avoid or hide from other pigs that may show aggression, belly nosing or tail biting to them.	Locomotion score Skin lesions on-farm or at slaughter Tail lesions on-farm and at slaughter Ear lesions on-farm and at slaughter Tail-biting Ear-biting Flank-biting Aggression resulting in injury Joint pathologies	Space allowance (WQ.6.1A.2.3) Visual barriers
10.	Breeding of pigs in order to eradicate halothane gene has significantly improved pig welfare. There should be future efforts in selection and breeding methods so that the likelihood of	Locomotion score Mortality rate Joint pathologies in slaughtered pigs	Records of veterinary treatment, euthanasia Breeding index weightings

	problems of pig welfare, including cardiovascular malfunction, risk of early death and leg disorders, is maintained at a low level. Welfare outcomes concerning the frequency of cardiovascular malfunction, mortality rate and prevalence leg disorders should be defined.		
11.	Pigs should be exposed to appropriate human contact early in their lives so that later they are less fearful, and negative effects on their welfare during the handling of the animals are minimised and there are associated benefits for production.	Approach to humans score	Records of stockperson training Production records
12.	All pigs should be provided with water of good quality, sufficient for their needs. Water supply systems should be well-maintained and their efficiency regularly checked.		Water supply (WQ.6.1A.1.2) Water quality Water flow rate
2. A	Pigs should have enrichment, such as straw, starting early in life to reduce subsequent risk of aggression and tail biting.	Exploratory behaviour Skin lesions on-farm or at slaughter Tail lesions on-farm and at slaughter Ear lesions on-farm and at slaughter Tail-biting Ear-biting Flank-biting Aggression resulting in injury	Nature of enrichment in early life
6. A	Since pigs have limited abilities to lose heat (they cannot sweat), they should have the opportunity to seek cooling when overheated, not only in case of elevated ambient temperatures, but also in cases of elevated activity, fever and	Panting Body temperature Manure on the body score Lying location Lying posture	Provision of cooling

	high metabolism.		
10. A	Genetic selection of pigs should include traits such as reduced fearfulness and harmful injurious behaviour. Efforts to reduce osteochondrosis and arthritis should involve a better understanding of environmental influences as well as genetic selection.	Approach to humans score Skin lesions on-farm or at slaughter Tail lesions on-farm and at slaughter Ear lesions on-farm and at slaughter Tail-biting Ear-biting Flank-biting Aggression resulting in injury Locomotion score Mortality rate Joint pathologies in slaughtered pigs	Breeding index weightings
N1	Animal-based measures of positive affective state in pigs should be validated and used to assess welfare.	Qualitative Behaviour assessment score Play behaviour score Exploratory behaviour	
N2	Prolonged noise levels in pig housing of more than 80 dBA should be avoided.		Noise level
N3	Diets provided for weaned piglets should be formulated to reduce the risk of post-weaning diarrhoea.	Scouring	Diet composition
N4	Appropriate biosecurity and vaccination protocols should be implemented to safeguard pig health.	Disease signs on-farm Disease signs at slaughter Acute phase protein Social isolation Feeding and drinking behaviour Body condition score	Presence of fences, wheel dips, foot baths, disinfection, visitor policy Isolation facilities for new stock Wildlife control protocol Records of vaccination
N5	Ammonia levels in pig housing should not exceed 20 ppm	Coughing Sneezing Laboured breathing Twisted snout Lung and respiratory tract pathologies Tear staining	Level of ammonia

N6	Sick and injured pigs should be hospitalised or, if necessary, euthanised as quickly as possible.	Disease signs on-farm Locomotion score Skin lesion on-farm Tail lesions on-farm Social isolation Feeding and drinking behaviour (absence) Body condition score	Presence of hospital pens Records of treatment and euthanasia

Recommendations from the Opinion on fattening pigs (EFSA, 2007b; Table 5) also present a similar situation of diverse topics. Once again, most recommendations, with the exception of water provision and excessive noise levels, have one or more relevant animal-based measures of the desired welfare outcome(s). The majority of the animal-based measures are consistent with those identified by Welfare Quality®. However, a number of these measures, such as thermal comfort or adequacy of lighting, might be time specific, and better monitored by an additional resource measure.

The animal-based measures in Appendix 1 were categorized according to the type of measure. The number of citations in Tables 1 to 5 was counted with a view to identifying animal-based measures that were appropriate for the largest number of different recommendations and it is shown in Appendix 1. The most frequently cited measures were skin lesions, the group of measures relating to disease (sneezing, coughing, scouring), manure on the body, tail lesions, locomotion score, mortality rate, behaviour (social behaviour both positive and negative, tail-biting) and general appearance (wounds on body, body condition score). The frequency with which a measure is mentioned is influences by the specific topics of the various opinions on pig welfare and the number of recommendations relating to each topic. Also, the frequency with which an animal-based measure is mentioned in the tables does not necessarily indicate the extent to which the measure is fit for purpose, according to the attributes named above, or how important this particular welfare outcome is to the animal. For this reason a list of measures taken from Appendix 1 deemed to be the most useful has been prioritised by a panel of experts based on their evaluation of scientific evidence. These measures are:

- Fattening pigs[10]: disease signs, skin lesions, tail and ear lesions, exploratory behaviour, and the group of measures related to thermoregulation.

- Sows and boars: skin lesions, body condition, persistent investigatory behaviour and stereotypies, locomotion score, and disease signs.

- Piglets: mortality, the group of measures related to thermoregulation, disease signs, and the group of measures related to mutilation.

2.1.3. Interpretation and implementation

The complete list of animal-based measures of welfare and resource-based measures of husbandry provisions is long and it would be quite unrealistic to recruit all these measures on every occasion that the welfare of pigs is to be assessed. They should be considered as a comprehensive toolbox, from which to select the range of measures necessary to address the specific objectives of a specific assessment. For example, extensive investigation of issues relating to the welfare of pigs (e.g. those that form part of an ongoing health plan) requires that observations of animals be supported by records of performance, fertility and health (e.g. medication records). These are necessary because it is not possible to obtain sufficient indication of welfare and the quality of husbandry on a pig farm from observations made during a short visit, either for the creation of a farm-specific welfare plan to support farm management, or for purposes of legislation. In contrast, as illustrated in Table 2, an assessment of the impact of floor and space allowance on pig productivity and welfare, including health, would result in a very different selection of measures from the toolbox. Furthermore, an assessment made for legislative purposes, especially when intended for presentation as evidence in support of a ban on a particular management practice or failure of resource, would need to provide forensic evidence, including that from veterinary procedures, which may not normally be obtained from a routine welfare inspection.

The animal-based measures highlighted in this Opinion are often general in their nature and in practice they would be developed according to SOPs (Standard Operating Procedures) leading to more detail about how to carry them out. The first stage in a programme of general welfare assessment, whether for the purposes of quality control, or as the foundation for implementation of a welfare or disease management policy, employs a broad spectrum of animal-based measures to highlight the most important problems for that particular farm. Subsequent assessments could then concentrate on more detailed inspections to measure change.

Some of the changes in pig management that would be needed in order to improve welfare can be achieved quite rapidly in a period of hours or days. Housing modifications may, however, take some

[10] The category “fattening pigs” includes weaned, growing and finishing pigs, whereas “farrowing sows” includes lactating sows.

weeks or months, and changes in genetic selection may take several months or years. For example, a farm buying in weaned pigs to finish can select a different genetic source and repopulate with this within 3-6 months. However, a breeding herd producing its own replacement animals will take more than 15 months before the first gilts of a new genotype start to produce progeny. The potential of management to reduce or prevent negative welfare effects and the rather low chance of compensating for problems resulting from genetic selection is discussed in Section 2.4. of this Opinion.

Within the EU there is increasing emphasis on changing the official control according to the estimated risk. This is specified within the 'hygiene package' of legislation (Regulation EC No 854/2004[11] and Regulation EC No 882/2004[12]) to verify compliance with animal disease control and welfare rules. It is stated that the frequency with which these official controls of animal welfare are carried out shall be proportionate to the risk but, again, the precise details of any risk assessment will need to be determined.

Below is a list of some of the potential areas of implementation of protocols for assessment of pig welfare:

- By a farmer to inform management decisions
- By a farmer to track changes in welfare as a result of changes in management or environment
- By an animal scientist or veterinary adviser to the farmer
- By breeding companies as part of their selection procedures
- By an auditing or accreditation organisation to check that a farm satisfies the necessary criteria to be part of a quality assurance or labelling scheme
- By the competent/responsible authority to check that a farm satisfies minimum animal welfare requirements according to legislation and evaluate effects in practice of changes in animal welfare legislation
- By the competent/responsible authority as part of pre-testing the welfare consequences of any future housing or technical development before it goes on the market
- By scientists during an experiment so that their results can be compared with the results collected by other scientists.

2.2. How the assessment protocols suggested by the Welfare Quality® project cover the main hazards identified in EFSA Scientific Opinions and *vice versa* for an overall classification of the welfare situation (ToR 2)

2.2.1. Procedures to address this question

This term of reference deals with how the pig assessment protocol suggested by the Welfare Quality® project covers the main hazards that were identified in five EFSA Scientific Opinions on the welfare of pigs: (i) Animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, pregnant, farrowing sows and unweaned piglets (EFSA, 2007a); (ii) Animal health and welfare in fattening pigs in relation to housing and husbandry (EFSA, 2007b); (iii) The risks

[11] Regulation (EC) No 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption. OJ L 226, 25.6.2004, p. 83–127.

[12] Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules, OJ L 191, 28.5.2004, p. 1-52.

associated with tail biting in pigs and possible means to reduce the need for tail docking considering the different housing and husbandry systems (EFSA, 2007c). In these EFSA Opinions, 103 unique hazards were identified. In addition, the SVC report and the EFSA 2004 and 2005 Opinions were examined and new hazards were identified (Table 6) for a total of 115 hazards (SVC, 1997).

Table 6: Numbers of unique hazards by the respective category of animals in the five EFSA Opinions and the SVC report.

Opinions and report	Boars	Piglets	Sows	Growing pigs (weaners + fatteners)	Age not specified	Total
EFSA, 2007a	7	17	15			39
EFSA, 2004, 2005, 2007b				39		39
EFSA, 2007c				25		25
SVC, 1997					12	12
Total	7	17	15	64	12	115

Very often, one hazard was related to more than one adverse effect and, by combining hazards with adverse effects, a total of 176 hazard-effect combinations were listed. Many of these were mentioned more than once, being described slightly differently in the various reports or parts of reports. For example, environmental temperature outside the thermoneutral zone (#11 in Appendix 2) was described by EFSA (2007c) as:

- “Poor thermal environment”,
- “Poor thermal environment (lack of possibility for thermal regulation)”,
- “Cold stress”, “Heat stress”.

Similarly, insufficient access, insufficient quality or quantity of foraging/exploration material was described (#2 in Appendix 2) by:

- “Insufficient access to foraging/exploration material” (EFSA, 2007a),
- “Absence of enrichment material”,
- “Too low quality of enrichment material (not edible, not changeable, not suitable for rooting, not destructible, not complex), for instance, chain, tyre” (EFSA, 2007b),
- “Absence of bedding having previously had bedding since weaning”,
- “Lack of long straw” (EFSA, 2007c).

Therefore, the list of hazards was carefully examined during meetings, and hazards were grouped together when they were closely related.

Some adverse effects were also described in different ways in the various reports and/or parts of reports. For example, the adverse effects of “insufficient access, insufficient quality or quantity of foraging/exploration material” (hazard #2 in Appendix 2) were described by:

- “Frustration (stereotypies, aggression). Lack of positive emotions” (EFSA, 2007a),
- “Damaging behaviour from pen mates (biting, massaging, belly nosing, etc.)” (EFSA, 2007b),
- “Being tail-bitten” (EFSA, 2007c).

Therefore, the list of adverse effects was also carefully examined during meetings and adverse effects were grouped together whenever possible.

This process reduced the original list of hazards to a short list of 52 unique hazards and only 6 of them had more than one adverse effect. These are presented in Appendix 2. For simplicity of presentation in the appendix, the age-group, specific housing system or particular EFSA Opinion are not referred to.

The measures used in the on-farm Welfare Quality® Pig Protocol (Welfare Quality®, 2009), which addressed different hazards characterized in the EFSA Scientific Opinions (EFSA, 2007a, b, c), and *vice versa*, were identified. Differentiation was made between the measure of the hazard itself and the measure of the adverse effects related to the hazard. No judgement was made of whether the Welfare Quality® measure was the most appropriate measure for that adverse effect. The results of this exercise are also presented in Appendix 2.

2.2.2. Main findings and issues

Hazards can be covered either directly by a resource-based or a management-based measures or indirectly by an animal-based measure related to one of their adverse effects. In Welfare Quality®, most of the measures are animal-based measures, but some of them are resource-based or management-based. Therefore, this Opinion has distinguished between these two types of measures and, in Appendix 2, resource-based or management-based measures are represented with the sign "1", whereas animal-based measures are represented with the sign "2".

From the total of 52 hazards, 43 were not covered directly by a resource-based or a management-based Welfare Quality® indicator and the remaining 9 are covered (Table 7). For example, the hazards "Too short period of light" (#15 in Appendix 2) or "Inappropriate feeding, lack of fibrous diet" (#24 in Appendix 2) are not covered by a Welfare Quality® indicator, since there is no measure of light duration or of the fibrous content ratio. On the other hand, the hazards "Confinement in crates" (#4) or "Nose ringing" (#48) are covered by a Welfare Quality® indicator, since the observation of farrowing crates or the occurrence of nose ringing are included in the Welfare Quality® protocol.

Table 7: Number of hazards in each category defined by the number of Welfare Quality® indicators covering the hazard (0 to >10) or the adverse effects of the hazard (yes or no).

	Number of times a Welfare Quality® indicator is used								
	0	**1**	**2**	**3**	**4**	**5**	**6 to 10**	**> 10**	**Total**
Animal-based measure of an adverse effect	5	8	12	2	1	4	17	3	52
Resource- or management-based measure of an adverse effect	43	9	0	0	0	0	0	0	52

Only 5 hazards are not covered by an animal-based Welfare Quality® measure related to one of their adverse effects:

- "No comfortable lying place, insufficient solid floor or no bedding material, such as straw" (#5),
- "Inappropriate pen design: inadequate separation of dunging and lying area and other inadequacies (feeders, drinkers, etc.)" (#6),
- "Inappropriate pen lay out: open sides to pens" (#7),
- "Too short period of darkness" (#16),
- "Tooth resection (grinding or clipping)" (#45).

However, it should be mentioned that the last one is covered directly by a management-based Welfare Quality® measure describing the occurrence of tooth resection. Concerning the others, an adverse

effect mentioned in the EFSA Opinions that cannot be easily measured is "Rest and sleep disruption". To assess disruption of behaviour would require extensive and time consuming behavioural observations to detect. This is probably the reason why it is not covered by any of the measures within the Welfare Quality® protocol, which was designed to be carried out during a visit of less than one day duration. However, it highlights the problem that limitations imposed on a protocol will ultimately limit which hazards can be detected. Eight hazards are covered by only one animal-based Welfare Quality® measure, 19 hazards by 2 to 5 measures, 17 hazards by 6 to 10 measures, and only 3 hazards by 10 or more measures (Table 7). These three hazards are relatively general ("Poor hygiene: cleanliness of pen, buildings", "Poor individual or herd health status", "Environmental temperature outside the thermoneutral zone") and have many potential effects on health.

There were 10 measures in the Welfare Quality® Pig Protocol that were not marked as being appropriate to detect any of the EFSA identified unique hazards (Table 8). However, 8 of these measures (age of weaning, water provision, space allowance, farrowing crates, tail-docking, castration, nose ringing and teeth clipping) are very useful since they are resource- or animal-based measures for the hazard. The 2 others (uterine prolapse, ruptures and hernias) corresponded to adverse effects that are relatively rare in pigs. Two Welfare Quality® measures are appropriate to measure adverse effects of only one hazard, 12 measures were appropriate for 2 to 5 hazards, 7 measures were appropriate for 6 to 10 hazards and 9 measures for more than 10 hazards. These 9 measures were related to health (sneezing, coughing, scouring, mortality), behaviour (social behaviour -positive and negative- tail-biting) and general appearance (wounds on body, body condition score). Therefore, they have the potential to detect various types of adverse effects.

Table 8: Number of Welfare Quality® animal-based measures in each category defined by the number of times it is related to an adverse effect

	Number of times a Welfare Quality® animal-based measure was used to detect a hazard-related adverse effect									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**9**	**> 10**
Number of Welfare Quality® animal-based measures	10	2	5	2	4	1	2	2	3	9

An EFSA identified hazard may lead to several consequences and a measure in the Welfare Quality® protocol could have several underlying causes. For example, the hazard "Environmental temperature outside the thermoneutral zone" has consequences on the physiology, health and behaviour of the animals. These consequences can be detected by Welfare Quality® measures related to thermal comfort (shivering, panting and huddling), health (coughing, sneezing, pumping -laboured breathing- twisted snouts, scouring, mastitis, mortality) and behaviour (tail-biting, social behaviour -positive and negative). Reciprocally, all these measures can be related to several hazards. For example, coughing is marked for 13 hazards (#1: Poor hygiene: cleanliness of pen, buildings; #12: Inadequate air quality; #27: Inappropriate materials in feed; #34 and 35: Poor biosecurity, etc.). Similarly, social behaviour is related to 22 hazards (#2: Insufficient access, insufficient quality or quantity of foraging/exploration material; #3: Insufficient space or too high stocking density; #15: Too short period of light; #20: Mixing of unacquainted animals, etc.).

The above discussion should not be taken as a criticism of either the EFSA Scientific Opinion or the Welfare Quality® protocols because, as stated earlier, these two reports had different starting points. It was not a stated requirement in the EFSA Opinions that the measure to assess a hazard must be specified. When developing the Welfare Quality® protocol, it was specified that measures should be of a type that did not require a trained veterinarian or ethologist to be able to record them. The aim was that any person with a good animal knowledge could perform them reliably after training. The adverse

effects in the EFSA Scientific Opinion are often expressed in terms of a veterinary diagnosis or experimental studies.

Furthermore, as stated previously, the Welfare Quality® protocol was designed to be carried out for a series of on-farm animals within one day. This time pressure means that, when appropriate, a resource-based measure is used instead of an animal-based measure. Therefore, some hazards like castration (one Welfare Quality® measure) or tooth resection (no Welfare Quality® measure) can easily be detected by interviewing the unit manager, as described in Welfare Quality®, or by observing animals (cf. Appendix 1), whereas measuring adverse effects, such as pain or inflammation, would be much more difficult and time consuming. The time constraint in Welfare Quality® also explains why some hazards with adverse effects on the behavioural pattern (e.g. sleep and rest disruption) are not covered by Welfare Quality® measures. However, these hazards may have other adverse effects that were not mentioned in the EFSA Opinions (EFSA, 2007a, b, c), and therefore they may exist. For example, hazards #5 (No comfortable lying place, insufficient solid floor or no bedding material, such as straw) and #6 (Inappropriate pen design: inadequate separation of dunging and lying area and other inadequacy - feeders, drinkers, etc.) are likely to have adverse effects not only on the sleep and rest pattern but also on social behaviour and skin lesions that can be measured by existing Welfare Quality® measures.

The degree of overlap between the main hazards identified in the EFSA Scientific Opinion and the ability of Welfare Quality® protocol to highlight these hazards is large.

2.3. Identify which relevant animal welfare issues cannot be assessed using animal-based measures for pigs and what kind of alternative solutions are available to improve the situation (ToR 3)

2.3.1. Procedure to address this question

To address ToR 3, the tables developed for ToR 1 (how animal-based measures can be used to fulfil recommendations) and ToR 2 (linking assessment protocols and hazards) were studied. The focus was on identifying hazards for which there were no corresponding animal-based measures or the available measures did not adequately link welfare to the hazard causing it.

In Tables 1-5, ‘gaps’ were no practicable animal-based measures could address the recommendation were: avoiding hunger and thirst, prolificacy resulting from genetic selection and pain due to deletions.

In Appendix 2, adverse effects that did not have appropriate Welfare Quality® based measures were: rest and sleep disruption, fear and acute pain, chronic pain, infection and inflammation after teeth clipping or grinding.

Considering these and other animal welfare issues, the following are examples of animal states or assessment situations where animal-based measures of welfare my not be practicable or adequate in pigs (A-G below). Genetic selection is discussed in Sections 2.1.3. and 2.4.

- (A) Pain.

  Whilst some animal based measures of pain do exist, their interpretation is still problematic, particularly in the case of chronic pain. In addition, many hazards causing pain (e.g. mutilations) often occur at times when inspection may not be carried out. Management-based measures may be used as an alternative in many of these situations.

- (B) Identifying hunger and thirst.

  Pigs may be experiencing states of hunger even when adequately nourished. For example, research has demonstrated that the pregnant sow may be in optimal body condition but experiencing hunger. The occurrence of many lean animals of course indicates more problems

with hunger than the occurrence of many animals in good body condition. However, it has been shown in several experimental studies that even sows in good body condition can suffer from hunger a few hours after the meal and during the majority of the day. Resource-based measures of the amount and composition of feed, as well as the availability of other satiating materials, such as roughage, need to be taken to predict welfare problems. Thirst is difficult to assess without physiological measures, but may be indicated by a measure of water flow which has the potential to be automated for individual animals.

- (C) Some aspects of frustration.

  Difficulty of measurements has resulted in the various situations leading to frustration in pigs being under-emphasised in EFSA Opinions. Physiological measures have demonstrated that frustration is not always reliably detected by behavioural indicators. For example, sows confined in barren housing are unable to express nest building motivation, and behavioural consequences may not be exhibited or seen, due to their time dependent nature. The frustration of exploratory motivation in fattening pigs may sometimes be detected by measures such as tail-biting but may also be present in the absence of such behavioural signs.

  Animal-based measures, such as lameness, skin and shoulder lesions, to some extent cover the adverse effect of impaired getting up and down movements. However, the movements are impaired in all animals, while only a subset will develop skin or shoulder lesions. For the other animals, the frustration of not being able to get up and lay down with ease and to express social and exploratory behaviour is still present. Increased lying duration and reduced exploratory and social behaviours may to some extent indicate this frustration but may not occur sufficiently frequently, and not in all animals, to allow easy detection during an inspection. Using automated sampling from sensors and *a priori* knowledge of the undisturbed pattern in loose housed sows may increase the probability that the lying and movement patterns could be used to detect this problem. However, knowledge of the biologically normal range which encompasses individual variability is necessary to detect states that indicate adverse effects. Frustration may in many cases only result in physiological stress responses that are difficult to measure in a simple way and, therefore, it is not possible to use it as a simple and valid animal-based measure.

- (D) Other positive and negative emotions.

  As with frustration, many others forms of suffering and all positive emotions are little discussed in EFSA Opinions. In addition, to the negative states previously highlighted, there is a current lack of measures to indicate other negative and positive emotional states reliably. Qualitative Behaviour Assessment is currently proposed by Welfare Quality® but its validity is still subject to debate. Cognitive bias is a potential measure which is currently the subject of research, but not yet practicable.

- (E) Time dependent problems which may not be seen during inspection.

  There are different aspects of time dependency which give problems for welfare assessment. In addition to the short term hazards which may not occur at the time of inspection (see pain) there are other behaviours which are associated with a particular time of day, such as night predation of outdoor piglets. There are also behaviours which can only be meaningfully interpreted after a long duration of observation because of low frequency, such as play behaviour, or the need to record sequences, such as rest and sleep patterns.

  Time dependent problems may be overcome by the use of automated analyses, for example, of activity, feeding and drinking patterns. However, methods for modelling automated data from sensors to detect specific behavioural patterns still need to be developed. Also, much work needs to be done in order to improve the durability of the sensors under rough farming

conditions (dirt, humidity, ammonium, etc.) and important issues concerning battery durability and wireless signalling under farm conditions also need to be solved.

Unlike for cattle, very few automated recording and analysis systems for individual animal-based welfare indicators exist for commercial pig farm application. Such methods need to be available at a relatively low price to be implemented on farms. The likelihood that automated methods are developed for commercial use depends either on whether the animal-based measures have value for the farmer in improving profitability, or on legislation stating that such surveillance systems should be available on farms for documenting welfare status.

- (F) Problems that require prevention rather than just detection after the event.

  It is often the case that welfare problems have environmental risk factors which are well documented, such as tail-biting or infectious disease. Most of the welfare issues under this category relate to features of the environment that are either inappropriate in their original design or in the way they are used or provided to the animals. This category is also characterised by factors that, through experimental studies, have been shown to result in unambiguous adverse effects. The occurrence of the adverse effects in relation to the hazard may or may not be possible to measure as an animal-based measure. However, the suggested animal-based measures demand much time and knowledge to measure or should be measured at specific times of the day or stage of the reproductive cycle. In addition, the animal-based measures may be ambiguous in terms of linking the adverse effect to the hazard causing it. In these cases, the most efficient way to predict welfare problems would be to measure the presence or absence of the hazard through resource- or management-based measures, and to use *a priori* knowledge of the welfare consequences. However, animal-based measures can be early indicators of a later, more substantial problem.

- (G) Measures that require expertise, facilities or equipment that is not available.

  It is particularly important that the person knows how to take the measure in the correct way, and is competent to do so. Some of the animal-based measures may require the services of a veterinarian (e.g. taking a blood sample or other invasive procedure). Thus, whether or not this animal-based measure is taken will depend on the availability of that expertise. The attitude to animal-based measures of the person taking the measure can also influence the quality of recording. Other measures require specialised equipment or resources, such as many physiological measures, and are therefore not practicable in most situations at present.

Therefore, although animal-based measures are available to address welfare issues in almost all cases, it is sometimes more efficient to use a resource- or management-based measure to address the issue. In such cases, the welfare issue needs to be addressed by setting legislative minimum standards for farms, such as: 1) sows should have adequate space to be able to perform unimpaired getting up and down movements, and 2) a minimum, specific amount of nesting material should be provided.

2.4. List the main factors in the various husbandry systems which have been scientifically proven to have negative effects on the welfare of pigs and to what extent these negative effects can be or not prevented through management (ToR 4)

2.4.1. Approach to address the question

The information compiled in the previous EFSA Scientific Opinions on the welfare of pigs provided some indications as to which hazards can be controlled through management. However, this specific aspect was not considered further in those Opinions.

It was decided to use a modified Delphi approach to compile the relevant information for each of those hazards. The Delphi technique (Rowe and Wright, 1999; Yousuf, 2007) is a group process used to

survey and collect the opinions of experts on a particular subject, and has been used in various contexts in which it was deemed necessary to combine expert opinion from different individuals in a formalised and transparent way.

The Delphi approach consists of three steps:

- The selection of relevant questions to be asked (step 1),
- Individual scoring of these questions by experts (step 2),
- Option for changing the initial scores after being provided with the scores of the other experts, and consensus discussion (step 3).

Application to this ToR

Step 1

All hazards from the SVC report and EFSA Opinions on pig welfare were collated into a single table (see Section 2.2.1.). Similar hazards between the Opinions were collapsed, and the subdivision between animal (age) categories (boars, farrowing sows, dry sows, piglets, weaning, growing and fattening) was initially kept, resulting in 52 hazards. If the Working Group concluded that a specific hazard did not apply to a pig category, this hazard was omitted from the scoring process for this category of pigs. This resulted in 438 hazard/pig category combinations.

Expert selection

The experts who participated in the scoring steps of the Delphi exercise were the Working Group members, those who had been in the working groups of the SVC report and EFSA Opinions, and experts recommended by members of the Working Group. A total of 38 experts were asked to compile the scoring sheet, of which 19 completed the scoring.

Step 2

The scoring sheet with all hazard/pig class combinations was sent out to the selected experts along with the description of the approach and the scoring system, as well as a definition on what the Working Group considered as a manageable hazard in the context of this mandate. Experts were asked to complete the scoring sheet within 20 days. Each person was asked to consider the extent to which management by farm staff could result in good welfare given that the specified hazard existed.

The management definition given was:

a) management is anything that the responsible person (be it animal owner or stockperson) could easily do themselves (e.g. moving barriers/gates) but should exclude major activities, such as new buildings or replacing structural features of existing stables;

b) changes could be made in the short term (to be implemented and consequences seen within a short period but excluding long term management plans);

c) without consideration of potential financial constraints (i.e. assuming that the manager could always take the decision to change if they wanted).

Scoring scale

A numerical scoring system ranging from 0 (impossible to prevent hazard through short-term management – as defined above) to 5 (full prevention possibility) was used. For each hazard row, the

expert was asked to check the respective score and was given the option to provide a justification for or comment on the given score.

Step 3

After receiving and analysing the scores from the first 13 experts it was clear that scores differed substantially between hazards and experts, but were very similar for a given hazard/expert combination across pig categories. Therefore, it was decided to shorten substantially the table by collapsing pig classes whenever biologically feasible. This resulted in 66 hazard/pig category combinations. The average scores were calculated by hazard/expert combination over pig categories for those experts that had already responded. Those experts who had not yet responded were asked to use the shortened table and to provide an "average" management score across the pig categories to which the hazard was considered applicable. For a small number of hazards, the possibility exists that management is easier for one category of pig than for another so a hybrid score would be entered. Similarly (point c. below), the possibilities for management may be different for different systems. This was the subject of comments by some experts, but only a mean figure is included in the analysis shown here.

In an intermediate analysis, average management scores for each hazard (across all experts), as well as the score range (maximum – minimum) were calculated and screened by the working group. A substantial number of hazards had very wide score ranges (4 or 5 score units difference were recorded on some management scores for a particular hazard), indicating that there was either a substantial variability in management potential for a given hazard due to inherent variability in the (pig) production system, or due to different interpretation of the management definition provided by the Working Group. A revised definition of management was therefore sent as detailed below:

a) Only short-term management is to be included. This means changes in management that could be carried out to affect existing pigs in the unit. The consequences of these management changes will often appear later or last for longer. Long-term management plans should not be considered;

b) No potential financial constraints on management action should be considered (i.e. assume that the manager could always take the decision to change if they wanted);

c) In your answers, please try to enter an average for the pigs kept in the various pig management systems that can be encountered in the EU. It may be that your answer would be 0 for one system but 5 for another and you finally decide to put in an intermediate figure;

d) In the new table we provide you with your previous score and the average score (together with minimum and maximum) of all participating experts. If you – in the light of this information and the updated definition on management – want to modify your scores, please do this by inserting the new score into the provided column – otherwise just repeat/leave the original score;

e) Provide a brief justification if you changed your previous score substantially or if your new score differs substantially (2+ score units) from the average value.

New scoring tables were generated that included the same list of hazards as used in the final phase of step 2, the average, minimum and maximum score from step 2 (calculated from all expert scores), and for each expert her/his individual scores. Experts were, in the light of the more precise definition, as well as the results from the previous scoring round, asked to either maintain their original score or update it. It was explained that this was especially relevant for those hazards where the individual expert scores deviated substantially from the average. In those instances, experts were asked to provide a brief explanation or justification either for their decision to keep a score very different from the majority of the other experts (minority statement) or their reasoning as to why they changed scores.

Final analysis

In the final analysis, updated potential management scores were collated by experts and descriptive statistics (means, medians, range, etc.) derived for each hazard.

2.4.2. Results of Delphi exercise

Assessment of management scores by hazard category and hazard risk estimates/magnitude

After the final Delphi round, updated scores were available from 16 experts. Three experts did not provide updated scores and were excluded from the exercise.

The results are presented in Table 9 in descending order, according to the mean score for management possibility, that is to say the most easily managed hazards are presented first.

Table 9: Mean score for the extent to which adverse effects can prevented using management.

Hazard description	Adverse effect	Animal class	Score	SD
Too short a period of darkness	Rest and sleep disruption	All pigs	4.75	0.46
Too short a period of light	Inability to carry out some normal perception behaviour	All pigs	4.63	0.52
Inadequate quantity of food	Hunger, irritability	All pigs	4.59	0.58
Poor stockmanship: inadequate or inappropriate contact, inadequate inspection	Fear and stress, lack of appropriate care of sick or injured animals	All pigs	4.44	1.05
Unbalanced diet (e.g. amino acids or micronutrients)	Stereotypies, other abnormal behaviour, being tail bitten, pathological consequences, hunger, irritability	All pigs	4.40	0.45
Environmental temperature outside the thermoneutral zone (no heater at birth place and no straw or insufficient space for lying down in heated areas)	Cold stress	Piglets	4.38	0.52
Exposure to intense sunlight	Sunburn leading to pain and stress	All pigs	4.31	0.46
Abrupt change from lactation diet to post-weaning diet	Malaise due gastrointestinal disease and undernutrition	Weaning	4.25	0.89
Environmental temperature outside the thermoneutral zone (no heater at birth place and no straw or insufficient space for lying down in heated areas)	Death	Piglets	4.25	0.71
Light intensity too low	Inability to carry out some normal perception behaviour	All pigs	4.25	0.71
Inappropriate materials in feed (e.g. toxins, antinutrients or microbiological	Reduced growth, organ damage, enteric diseases	All pigs	4.06	0.56

contaminants)				
Tail docking with or without pain treatment	Infection with inflammation	Piglets, weaning	4.00	0.76
Tooth resection (grinding or clipping)	Infection and/or inflammation	Piglets, weaning	4.00	0.76
Inappropriate feeding, lack of fibrous diet	Frustration (hunger, stereotypies, aggression). Lack of positive emotions. Pain (stomach ulcers, skin lesions), death	All pigs	3.95	0.71
Presence (no removal) of bitten tail and tail biting animals	Being tail-bitten	Weaning, growing, fattening	3.94	0.86
Ear tagging or ear notching	Infection and/or inflammation	Boars, dry sows, farrowing sows, weaning growing, fattening	3.88	0.83
Nose ringing	Infection and/or inflammation	Boars, dry sows, farrowing sows, growing, fattening	3.88	0.83
Surgical castration with or without pain treatment	Infection and/or inflammation	Piglets, weaning	3.88	1.13
Tooth resection (grinding or clipping)	Fear and acute pain	Piglets	3.88	0.99
Inadequate management leading to prolonged farrowing with birth intervals of more than 2 h	Death	Piglets, dry sows	3.75	0.71
Tooth resection (grinding or clipping)	Chronic pain	Piglets	3.75	0.89
Environmental temperature outside the thermoneutral zone	Death	All pigs	3.71	0.89
Mixing of unacquainted animals	Lameness due to muscle and joint injuries, aggression leading to stress	All pigs	3.67	0.66
Poor hygiene: cleanliness of pen, buildings, etc.	Diseases	All pigs	3.61	0.88
Exposure to endo/ectoparasites	Reduced growth, organ damage, disease, irritation	All pigs	3.54	0.68
Ear tagging or ear notching	Fear and acute pain	Boars, dry sows, farrowing sows, weaning growing, fattening	3.50	0.93
Nose ringing	Fear and acute pain	All pigs	3.50	1.20
Nose ringing	Chronic pain	Boars, dry sows, farrowing	3.50	1.41

		sows, growing, fattening		
Poor biosecurity, infectious agents transmitted by other pigs	Diseases	All pigs	3.46	1.18
Inadequate air quality (carbon dioxide level above 3,000 ppm, carbon monoxide level above 10 ppm, hydrogen sulphide level above 0.5 ppm or ammonia level above 10 ppm at the pig level, dust, high airspeed)	Health disorders (e.g. respiratory) and behavioural disorders, being tail-bitten	All pigs	3.46	0.73
Inadequate access to feed (colostrum)	Malaise due to respiratory or gastrointestinal disease	Piglet, weaning, growing, fattening	3.44	0.73
Inappropriate system for water provision and poor microbiological quality of water	Dehydration, reduced growth, gastrointestinal troubles, irritability, nervous diseases, death	All pigs	3.29	0.81
Environmental temperature outside the thermoneutral zone	Heat or cold stress, discomfort, behaviour disruption and disease consequences	All pigs	3.27	0.91
Early weaning procedures (weaning before suckling motivation ceases)	Frustration and stress (sow still motivated to nurse her offspring), piglet undernutrition, increased susceptibility to disease (especially enteric) and increased prevalence of abnormal behaviour (belly nosing)	Farrowing sows, weaning	3.25	1.39
Surgical castration with or without pain treatment	Fear and acute pain	Piglets	3.25	1.39
Inadequate management leading to excessive mating behaviour between group housed sows in oestrus	Pain due to leg problems and stress	Dry sows, farrowing sows	3.13	0.99
Insufficient access, insufficient quality or quantity of foraging/exploration material	Frustration (stereotypies, aggression). Lack of positive emotions. Damaging behaviour from pen mates (biting, massaging, belly nosing, etc.) Being tail bitten	All pigs	3.08	1.27
Poor individual or herd health status	Diseases, being tail-bitten	All pigs	3.06	0.78
Inadequate food provision method and management	Excessive competition, aggressive behaviour, frustration, insufficient nutrient intake	All pigs	3.00	1.18
Ear tagging or ear notching	Chronic pain	Boars, dry sows, farrowing sows, weaning	3.00	1.51

		growing, fattening		
Environmental temperature outside the thermoneutral zone	Being tail-bitten	All pigs	3.00	0.76
Large litter size, more piglets than productive teats	Excessive competition at the teat by suckling piglet, udder lesions, low birth weight, starvation	Farrowing sow, piglets	3.00	0.76
Tail docking with or without pain treatment	Fear and acute pain	Piglets	3.00	1.51
Poor biosecurity: infectious agents transmitted by humans or wildlife	Diseases	All pigs	2.94	0.95
Surgical castration with or without pain treatment	Chronic pain	Piglets	2.88	1.55
Inadequate management leading to savaging of piglets by lactating sow	Stress and death	Piglets	2.75	1.28
Tail docking with or without pain treatment	Chronic pain	All pigs	2.67	1.32
Predation	Stress, pain and death	All pigs	2.63	0.74
High level of noise (e.g. above 85 dB)	Behavioural disorders (e.g. rest and sleep disruption	All pigs	2.50	0.71
Insufficient space or too high a stocking density	Rest and sleep disruption. Stress and lesions. Behavioural restriction. Disturbed bone growth. Damaging behaviour from pen mates (biting, massaging, belly nosing, etc.). Pain due to leg problems. Stress (inability to resolve social conflicts in dry sow groups). Being tail-bitten	All pigs	2.48	1.09
Large group size >40 animals/group resulting in management difficulties	Behaviour disorders, stress and lesions	Dry sows, weaning, growing, fattening	2.42	0.85
Insufficient/inappropriate nest building material	Frustration, stress and behaviour problems	Farrowing sows	2.25	1.67
Inappropriate pen layout: open sides to pens	Rest and sleep disruption	All pigs	1.96	0.82
Fully slatted floor during suckling period	Being tail-bitten	Weaning, growing, fattening	1.94	1.24
Poor flooring condition (e.g. slippery, bare concrete floor, slatted floor, slat slot dimension, too abrasive)	Teat damage, pain (leg injuries), lameness, claw damage, shoulder lesions, stress (lack of good lying facilities, aggression due to)	All pigs	1.92	1.09
Absence of bedding having previously had bedding since weaning	Being tail-bitten	Weaning, growing, fattening	1.88	1.46
Genotype problems: infectious disease susceptibility	Infectious diseases	All pigs	1.78	1.30

Inappropriate pen design: inadequate separation of dunging and lying area and other inadequacy (feeders, drinkers, etc.)	Rest and sleep disruption	All pigs	1.74	0.81
Genotype problems: body form and growth	Locomotor disorders	All pigs	1.72	1.24
Genotype problems: body form and growth	Cardiovascular disorders	All pigs	1.72	1.24
Genotype selection for high lean tissue growth rate (low fatness)	Being tail-bitten	All pigs	1.70	1.06
Gestation stall design	Aggression leading to stress	Dry sows	1.56	1.01
No comfortable lying place, insufficient solid floor or no bedding material, such as straw	Rest and sleep disruption	All pigs	1.42	0.90
Inappropriate design of farrowing system (e.g. poor access to udder due to bars, etc.)	Frustration due to aggression, starvation, dehydration, death	Piglets	1.33	1.00
Absence of wallow	Skin irritation and infections. Thermo-regulatory difficulty	All pigs	1.00	0.76
Confinement in crates	Frustration (no opportunity to move, to act socially, to show oestrus behaviour). Impaired getting up and down movements. Skin lesions	Farrowing, dry sows	0.69	0.80

Construction-related housing had the lowest management potential, and agreement between experts was high (low variability), for example, confinement in crates (score 0.69; s.d. 0.80). Genotypic problems also had low scores for management potential but agreement between experts was lower, for example, genotype problems causing locomotory and cardiovascular problems (both scored 1.72; s.d. 1.24). For nutrition-related and other hazards, a higher management potential was usually evident, for example, inadequate quantity of food (score 4.59; s.d. 0.58), too short a period of darkness (score 4.75; s.d. 0.46), exposure to intense sunlight (score 4.31; s.d. 0.46). Hazards scored at intermediate management potential sometimes had low standard deviation (e.g. environmental temperature outside the thermoneutral zone, being tail-bitten, - score 3.00; s.d. 0.76 - and large litter size - score 3.00; s.d. 0.76 - indicating good agreement on this, but they sometimes had high standard deviations suggesting different interpretation by different experts, such as for insufficient/inappropriate nest building material – score 2.25; s.d. 1.67), and surgical castration with or without pain treatment (score 2.88; s.d. 1.55). The management potential for a given hazard, in some cases, differed according to the adverse effect (e.g. tail docking with or without pain treatment: score 4 for infection with inflammation, and score 2.67 for chronic pain).

3. General discussion of issues related to the use of animal-based measures to assess on-farm animal welfare

From the previous sections, it is clear that potentially there are many different animal-based measures that can be used to assess the welfare of pigs. Which measure is the most appropriate for a particular situation will therefore depend on a number of different factors (e.g. the purpose of the assessment, the skill of the person collecting the measure, the conditions under which it is to be gathered, and the time available to collect it, as well as financial constraints). Other data may also be necessary, for example

the value of using animal-based measures, taken at the slaughterhouse to assess on-farm welfare or during transport, depends on the traceability of individual or specified groups of animals.

Several times in this report, the possibility of a 'toolbox' of validated, reliable welfare outcome measures to assess pig welfare has been mentioned. It has been suggested that, depending on the reason for assessing the welfare, the most appropriate 'tools' can be selected from this box and used for that specific purpose. For example, a farmer wanting to improve one specific aspect of pig welfare on his farm, a legislator wanting to evaluate whether changes in the legislation lead to improved pig welfare in general, or a breeding company wanting to achieve a specific welfare related breeding goal, may all take different tools. There are, however, certain basic similarities in how this system would work and these are highlighted below, but all involve the process of monitoring.

The first step is the identification of the goal. The second step is the identification of the population concerned and the definition and selection of the survey population. The third step is the selection of a combination of measures from the toolbox and the systematic collection of data. Following the analyses of the data, the results are interpreted. In some cases, a recommendation for action is developed and implemented. The goal and the survey population are reappraised and, when necessary, adapted and then more data is collected on the same measures in order to verify whether the action has resulted in the intended effect. In many respects, this is similar to what is being used with regard to animal health monitoring (Salman, 2003).

It became very clear from the work to answer ToRs 1 and 2, that there are interactions between hazards and measures (e.g. restlessness of the group and levels of skin lesions). However, in most cases these interactions are complex, and some of these complexities are listed below.

Hazards are not necessarily additive, nor of the same strength. In several cases, different hazards lead to the same welfare outcome (i.e. to the same consequence). In other cases, the same hazard may lead to several different welfare outcomes. Welfare outcomes can sometimes be assessed in a valid, accurate and robust way from one animal-based measure. Other welfare outcomes may require a combination of animal-based measures. A single animal-based measure may reflect several related welfare outcomes and so not be specific to any single consequence.

The work on ToR 1 and ToR 2 presented in Sections 2.1. and 2.2., the Welfare Quality ® protocols and the EU reports and Opinions on pig welfare can all help when selecting appropriate welfare outcome measures to detect the presence of, or measure the factors that affect welfare and to monitor animal welfare in general. Visualisations of the links, as suggested in the previous section, help us to identify interactions within welfare measures, outcomes and hazards on the one hand, and associations between welfare measures and outcomes, measures and hazards, and hazards and outcomes on the other hand. This is important for anybody wanting to assess or monitor animal welfare using animal-based welfare measures, as it provides evidence of which combination(s) of measures might be chosen from the toolbox for a certain monitoring goal. However, establishing only links, but not the predictive capacities of animal-based welfare measures or combinations thereof still does not allow us to select the most effective combination of measures for a specific goal. Two approaches to achieve this are expert elicitation and using databases. The expert elicitation approach is limited by the time and resources available to "score" the potentially large number of paired links. The database approach is limited by the lack of systematically collected field data, at the animal, herd and farm level, captured in a centralised database, from which to explore interactions between hazards, welfare outcomes and measures using specific statistical tools (Presi and Reist, 2011). Issues related to the selection of experts and the lack of transparency in the final risk assessment are further disadvantages of the expert elicitation approach. The database approach carries the theoretical advantage of improved transparency and consistency of results based on objective data and the increasing possibility to move towards quantitative risk assessment in animal welfare.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Animal-based measures can be used effectively in the evaluation of the on-farm welfare of pigs in relation to laws, codes of practice, quality assurance schemes and management. Some of these measures are also appropriate for ante-mortem inspection and there are additional post-mortem animal-based measures which can be taken at the slaughterhouse.

2. Non-animal-based measures can be used when the association between them and the welfare outcome is strong and when they are more efficient than animal-based measures as a means to safeguard welfare.

3. For an overall assessment of welfare a wide range of measures is needed. However, to assess an aspect of welfare it is unnecessary to use all animal-based measures on every occasion. The choice of animal-based measures will depend upon the specific objectives of the assessment. The full list is comparable to a 'toolbox', from which the appropriate range of measures can be selected.

4. The list of animal-based measures shown in Appendix 1 is an attempt, based on currently available information, to develop this 'toolbox' from which to select the animal-based measures that are most appropriate for the objectives of the assessment of pig welfare.

5. The animal-based measures considered to address the largest number of poor welfare outcomes identified from the recommendations and hazards in the previous EFSA Scientific Opinions were related to health (sneezing, coughing, scouring, mortality), behaviour (social behaviour -positive and negative- tail-biting) and general appearance (wounds on body, body condition score).

6. There is usually no simple one-to-one relationship between animal-based measures and input factors. Hence, to identify the cause of a specific welfare outcome several non-animal-based measures need to be used.

7. Some animal-based measures are early indicators (e.g. tail posture, changes in drinking and feeding behaviour) and can be used to predict those animals at risk of poor welfare if no change or intervention is made.

8. Some animal-based measures can only be used for welfare outcome assessment if collected over a long period (e.g. growth rate), in which case they are often best taken from historical records or recording systems.

9. Animal-based measures are taken directly from the animal or indirectly, for example using records. They can also be aggregated to give a herd or population level animal-based measure. Some animal based measures are practicable for experimental use only, whilst others can be reliably used as welfare outcome indicators on-farm or in the slaughterhouse.

10. Animal-based measures indicate the prevalence, incidence and intensity of welfare problems, whereas non-animal-based measures indicate the potential for welfare problems. Some non-animal-based measures (e.g. having access to water) are easy to measure and, if the association between them and animal-based measures is strong, they may be used.

11. Since most recommendations in the EFSA Scientific Opinions and the SVC report on the welfare of pigs concern resources and management, these non-animal-based measures are necessary to evaluate the extent to which recommendations have been fulfilled. However, in almost all cases, animal-based measures are necessary to determine whether or not the consequences for welfare intended by the recommendations have been achieved.

12. Some animal-based measures (e.g. body condition, tail damage) can be a consequence of the impact of a number of factors and so can contribute more to an overall welfare assessment than measures that are a consequence of a single factor. Others (e.g. mortality rate) reflect a number of adverse outcomes, such as poor health, extreme hypothermia, aggression, and so can contribute more to an overall welfare assessment than measures that are a consequence of a single outcome.

13. Across all categories of pigs, the most frequently cited measures were skin lesions, the group of measures relating to disease, manure on the body, tail lesions and locomotion score, and mortality rate. The frequency with which an animal-based measure is mentioned in the tables does not necessarily indicate how important this particular welfare outcome is to the animal. A proposed list of measures deemed to be useful for each category of pigs is:

    - Fattening pigs: disease signs, skin lesions, tail and ear lesions, exploratory behaviour, the group of measures related to thermoregulation.

    - Sows and boars: skin lesions, body condition, persistent investigatory behaviour and stereotypies, locomotion score, disease signs.

    - Piglets: mortality, the group of measures related to thermoregulation, disease signs, the group of measures related to mutilation.

14. There are complex links and interactions between factors and their welfare outcomes. Statistical models are available to analyse these links but it is important to define at the outset the specific objectives of the statistical analysis. Systematic recording of non-animal-based measures (factors) and animal-based measures (welfare outcomes) is needed to generate the database which should be used to help unravel and quantify the complex links and interactions between factors and their welfare outcomes and so identify optimum combinations of measures in future welfare assessments.

15. The Welfare Quality® protocol provides information on the majority of the welfare outcomes of the main hazards identified in the EFSA Scientific Opinions. However, the limited time available during a single short visit means that there may not be sufficient behavioural observations in the Welfare Quality® protocol to address some of the adverse effects identified in the EFSA Opinions (e.g. time constraints on ability to measure rest and sleep disruption).

16. There are not currently adequate animal-based measures to address all issues of pain, frustration and other negative emotional states, as well as positive emotional states, so that they can be used as welfare outcome indicators on-farm or in the slaughterhouse.

17. At present, there are a few automatic recording systems that could feasibly be used by farmers to gather data on animal-based measures that are otherwise too time consuming or difficult to gather.

18. The extent to which the negative effects of hazards arising from genetic selection (e.g. large muscle mass associated with cardiovascular disorders) can be prevented through short-term management is extremely limited.

19. The negative welfare outcomes of most housing-related hazards, such as confinement in individual crates, cannot be prevented through short-term management.

20. Management and nutrition-related hazards have substantial potential for alleviation by short-term management.

21. The attitudes of those involved and the ability to implement change are important with regard to the extent to which negative welfare outcomes can be prevented by management change. Even

potentially easy management changes in husbandry systems may not be implemented in practice if the responsible person is not able or willing to make the change.

22. The value of using animal-based measures, taken at the slaughterhouse to assess welfare on-farm or during transport, depends on the traceability of individual or specified groups of animals.

23. Taking an adequate array of measures of animal welfare, in particular animal-based measures, requires specific training and competence.

RECOMMENDATIONS

1. Combinations of animal- and non-animal-based measures should be appropriate to meet the specific objectives of the assessment (e.g. legislation, management support, compliance with a Quality Assurance scheme).

2. Identification and selection of the factors and animal-based measures that are most important and appropriate to the objectives of the assessment should be made on the basis of scientific evidence.

3. Animal-based measures should be used wherever possible, as they are the best indicators of pig welfare. The validity, reliability and feasibility of the measure should be known before it is used. Non-animal-based measures can be used when the association between these and welfare outcomes is strong and when it is more efficient as a means to safeguard the welfare.

4. The first stage in any programme to assess the welfare of pigs should employ a range of animal-based measures that highlight the most important problems, while ensuring that no major criterion of welfare is overlooked. A recommended short list of measures deemed to be useful for each category of pigs is:

    - Fattening pigs: disease signs, skin lesions, tail and ear lesions, exploratory behaviour, the group of measures related to thermoregulation.

    - Sows and boars: skin lesions, body condition, persistent investigatory behaviour and stereotypies, locomotion score, disease signs.

    - Piglets: mortality, the group of measures related to thermoregulation, disease signs, the group of measures related to mutilation.

5. The development and implementation of automatic data recording systems for animal-based measures should be encouraged, as well as information on appropriate analyses and interpretation of the collected data, to allow the early detection of potential problems and benchmarking of important welfare outcomes.

6. Clear ways to identify and quantify the complex links between (input) factors and welfare outcomes (consequences) should be developed. Such analyses will require access to large data sets.

7. There should be collaboration between farmers, breeding companies and building engineers to prevent negative outcomes of less easily managed hazards, such as those related to genetics and housing.

8. Herd monitoring and surveillance programmes should be implemented within the pig industry using a range of appropriate animal-based measures to document welfare changes over time.

9. Recommendations in codes of practice or laws related to animal welfare should, whenever possible, be phrased directly in terms of the responses of the animal or the effects on the animal

(i.e. the outcome), so that the extent to which the recommendation is fulfilled can be assessed using the appropriate animal-based measure.

10. There should be information dissemination and training for farmers and their advisors concerning easily manageable hazards, such as those related to nutrition, feeding and daily routines, in order to prevent their negative consequences.

11. The assessment of pig welfare in a systematic fashion by the use of animal-based measures, including inspection of records, the use of measures recorded automatically or derived from veterinary procedures, should be made by competent persons.

12. There should be systems for tracing the origin of all individual pigs (including batches for fattening pigs) when they are moved from farm to farm or from farm to slaughterhouse, to facilitate analysis of animal-based outcome indicators and to guide any subsequent actions.

13. There should be both initial and ongoing training of assessors to ensure valid and reliable welfare measurement.

14. Research is needed to develop new ways to identify and quantify the complex links between (input) factors and welfare outcomes (consequences). This research would help in the choice of optimum combinations of measures for future welfare assessments. Such analyses will require access to large data sets.

15. There should be development of animal-based measures to address the issues of pain, frustration and other positive and negative emotional states so that these can be used as welfare outcome indicators on-farm or in the slaughterhouse.

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APPENDICES

A. APPENDIX 1

A list of animal-based measures from Tables 1-5 in the text has been collected into a single table to give an overview of the measures identified as being useful to ensure the fulfilment of the recommendations. It can be considered as a 'toolbox' of potential animal-based measures.

In most cases, the observations and measures are made on individual animals and interpreted at the farm or group level (e.g. percentage of animals with tail lesions resulting from biting). It is expected that other animal-based measures will be identified in future. The methodology for recording and interpreting these measures is based on published scientific evidence and sound clinical practice. The science that underpins most of these indicators is derived from a large number of original communications and it would be unhelpful to cite only a few. For the most part therefore it is suggested that readers seeking further details of methodology and interpretation make reference in the first instance to comprehensive review publications (e.g. SVC, 1997; EFSA, 2004, 2005, 2007a, b, c; Welfare Quality®, 2009). Original communications are quoted which describe what the measure is and that give an example of how it may be scored. There may be other ways of scoring this measure but the best scoring system is not specified in this Opinion.

All of these animal-based measures are those that could be used by a farmer, veterinarian or other inspector checking animals on-farm or at a slaughterhouse. However, it is likely that new measures will be developed in future. In some cases, the methodology has only recently become feasible for use. For example, the acute-phase-protein PigMAP can now be measured in a blood or meat juice sample using a dip test, and therefore it is included in this Appendix table. For some measures of relatively uncommon behaviours, for example, biting another pig's tail, an inspector may not see it during an inspection but if it were seen, it would be useful to record it. Hence, these too are included in this table. An important area of animal welfare assessment is pain assessment. As pig mutilations, such as castration and tooth grinding, would not always be seen by an inspector, animal-based measures of pain resulting from such mutilations are not included in the table.

Animal-based measures of welfare that are signs of disease are important on-farm and in the slaughterhouse. They have been included in the tables, either as signs of specific disease conditions or under the general term "disease signs" where a wide range of pathologies is possible. Lists of signs that can be recorded from live animals and from slaughtered animals are included in Appendix 1. However, as there are numerous signs of disease, only a proportion of these are specified.

The animal-based measures are listed with a count of how many times they were mentioned in Tables 1-5 in the Opinion and a list of the relevant recommendations are subdivided by table. The animal-based measures in Appendix 1 were categorized according to the type of measure. The number of citations in Tables 1 to 5 was counted with a view to identifying animal-based measures that were appropriate for the largest number of different recommendations and they are shown in Appendix 1. The most frequently cited measures were skin lesions, the group of measures relating to disease, manure on the body, tail lesions and locomotion score, as well as mortality rate. The frequency with which an animal-based measure is mentioned in the tables does not necessarily indicate the extent to which the measure is fit for purpose, according to the attributes named above, or how important this particular welfare outcome is to the animal. The frequency with which a measure is mentioned is influenced by the specific topics of the various opinions on pig welfare and the number of recommendations relating to each topic. For this reason a list of measures taken from Appendix 1 deemed to be the most useful has been prioritised by a panel of experts based on their evaluation of scientific evidence.

These measures are[13]:

- Fattening pigs[14]: disease signs, skin lesions, tail and ear lesions, exploratory behaviour, the group of measures related to thermoregulation.
- Sows and boars: skin lesions, body condition, persistent investigatory behaviour and stereotypies, locomotion score, disease signs.
- Piglets: mortality, the group of measures related to thermoregulation, disease signs, the group of measures related to mutilation.

Animal-Based Measure Category	Animal-Based Measure (extracted from Tables 1-5)	Pig Category (to which the animal-based measure applies)	Reference	Which recommendations refer to this measure	Times mentioned in Tables 1-5
Lesions	Skin lesions (excluding tail lesions, ear lesions, vulva lesions and shoulder sores) on-farm or at slaughter	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.1 with modifications Turner et al., 2006 WQ 5.1.3.1 Lewis et al., 2005a and b WQ 6.3.3.1 EFSA, 2011 (Meat inspection)	Table 1: 9, 10, 14 Table 2: 2, 4, 7, 15, 20, 21, 22, 23, 24, 25, 26, 30, N1, N2 Table 3: 6A Table 4: 3, 6, 7, 12, 7A, 10A, N2, N3 Table 5: 1, 7, 8, 9, 2A, 10A, N6	33
	Tail lesions on-farm or at slaughter	Fattening pigs	On-farm: WQ 6.1A.3.1 In abattoir: Hunter et al., 1999	Table 2: 2, 4, 15, N1 Table 3: 1, 2, 3, 4, 5, 6, 6A, 7A Table 5: 1, 7, 9, 2A, 10A, N6	18
	Shoulder sores on-farm or at slaughter	Farrowing sows, dry sows, boars	WQ 5.1.2.1 In abattoir: Hunter et al., 1999	Table 2: N1 Table 4: 1, 10A	3
	Vulva lesions on-farm or at slaughter	Farrowing sows, dry sows	WQ 5.1.3.1. In abattoir: Hunter et al., 1999	Table 4: 3	1
	Ear lesions on-farm or at slaughter	Fattening pigs	On-farm: WQ 6.1A.3.1 In abattoir: Hunter et al.,	Table 2: 4, 15, N1 Table 3: 6, 6A, 7A	11

[13] There are also clinical signs of disease that are not listed.
[14] The category "fattening pigs" includes weaned, growing and finishing pigs, whereas "farrowing sows" includes lactating sows.

			1999	Table 5: 1, 7, 9, 2A, 10A	
	Foot lesions on-farm or at slaughter	Farrowing sows, dry sows, boars, fattening pigs, piglets	Bonde et al., 2004 KilBride et al., 2009a, b	Table 2: 7, 15, 20, 21, 22, 23, 24, 25, 26, 30, N1 Table 4: 1	12
Mortality	Mortality rate	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2 Damm et al., 2005 Piglet neonatal mortality: Jensen et al., 2010	Table 2: 4 Table 3: 1 Table 4: 9, 10, 13, 5A, 10A, 11A, 11B, N1, N4 Table 5: 1, 7, 10, 10A	15
Disease signs on-farm or ante-mortem	Coughing	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13, 14, 15 Table 5: 1, 7, N4, N5, N6	25
	Sneezing	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N5, N6	23
	Laboured breathing	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N5, N6	23
	Twisted snout	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N5, N6	23

	Rectal prolapse	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N6	21
	Scouring	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13, 14, 15 Table 5: 1, 7, N3, N4, N6	24
	Constipation sign	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13, N3 Table 5: 1, 7, N4, N6	22
	Metritis sign	Farrowing sows, dry sows	WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N6	21
	Mastitis sign	Farrowing sows	WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N6	21
	Uterine prolapse	Farrowing sows, dry sows	WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13	21

				Table 5: 1, 7, N4, N6	
	Skin inflammation or discolouration	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 4, 7, N4, N6	22
	Ruptures and hernias	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N6	21
	Local infection sign	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 1, 5 Table 4: 13 Table 5: 1, 7, N4, N6	22
	Neurological disorder sign (tremor)	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.2 WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N6	21
	Splayed legs	Piglets	WQ 5.1.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4, N6	21
	Tear staining (indicating eye irritation, for example, by ammonia)	Farrowing sows, dry sows, boars, fattening pigs, piglets	Kahn and Line, 2010	Table 1: 4 Table 2: 1, 4, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13	23

				Table 5: 1, 7, N4, N5, N6	
	Swollen bursae (resulting from excessive pressure on bony areas)	Farrowing sows, dry sows, boars, fattening pigs	WQ 5.1.2.1 WQ 6.1A.2.1	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28, N1 Table 3: 5 Table 4: 1, 13 Table 5: 1, 7, N4, N6	23
Disease sign in slaughtered pigs	Lung and respiratory tract pathologies in slaughtered pigs	Dry sows, boars, fattening pigs	WQ 6.1B.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 1, 5 Table 4: 13 Table 5: 1, 7, N4, N5	23
	Gut pathologies in slaughtered pigs	Dry sows, boars, fattening pigs	EFSA, 2007a (Chapters 7-8) EFSA, 2007b (Chapter 7)	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28, N1 Table 3: 5 Table 4: 13, N3 Table 5: 1, 7, N4	22
	Heart pathologies in slaughtered pigs	Dry sows, boars, fattening pigs	WQ 6.1B.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4	20
	Liver pathologies in slaughtered pigs	Dry sows, boars, fattening pigs	WQ 6.1B.3.2	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 5 Table 4: 13 Table 5: 1, 7, N4	20
	Joint pathologies in slaughtered pigs	Dry sows, boars, fattening pigs	EFSA, 2007b (Chapter 7) Frantz et al., 2010	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16,	24

				17, 18, 27, 28 Table 3: 1, 5 Table 4: 13 Table 5: 1, 7, 9, 10, 10A, N4	
	Other pathologies in slaughtered pigs (e.g. lymph node infection, abscesses)	Dry sows, boars, fattening pigs	EFSA, 2011 (Meat inspection)	Table 1: 4 Table 2: 1, 4, 5, 6, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 1, 5 Table 4: 13 Table 5: 1, 7, N4	21
Injurious behaviours	Tail-biting	Fattening pigs	WQ 6.1A.4.1 EFSA, 2007c (Chapters 3-5)	Table 2: 2, 4, 15, N1 Table 3: 2, 4, 5 Table 5: 1, 2, 3, 7, 9, 2A, 10A	14
	Ear-biting	Fattening pigs	WQ 6.1A.4.1 EFSA, 2007c (Chapter 3)	Table 2: 2, 4, 15, N1 Table 5: 1, 2, 3, 7, 9, 2A, 10A	11
	Flank-biting	Fattening pigs	WQ 6.1A.4.1 EFSA, 2007c (Chapter 3)	Table 2: 2, 4, 15, N1 Table 5: 1, 2, 3, 7, 9, 2A, 10A	11
	Vulva-biting	Dry sows	WQ 5.1.4.1 EFSA, 2007a (Chapter 7)	Table 4: 3	1
	Aggression resulting in injury	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.4.1 WQ 5.1.4.1 EFSA, 2007a (Chapter 7), b (Chapter 7)	Table 1: 9, 10, 14 Table 2: 4, 7 Table 4: 6, 7, 7A, N2, N3 Table 5: 8, 9, 2A, 10A	14
	Belly- nosing	Fattening pigs	WQ 6.1A.4.1 EFSA, 2007b (Chapters 5-7)	Table 2: 2, 15, N1	3
Other behaviours	Persistent investigatory behaviour (directed at pen-mates or pen-fittings)	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.4.2. WQ 5.1.4.2 EFSA, 2007a (Chapter 7), b (Chapter 7), c (Chapter 8)	Table 2: 2 Table 4: 3, 8, 8A, 10A Table 5: 2, 3	7
	Exploratory behaviour (involving diverse behavioural elements,	Farrowing sows, dry sows, boars, fattening	WQ 6.1A.4.2 WQ 5.1.4.2 EFSA, 2007a	Table 2: 2, 15, 19, N1 Table 3: 5, N2	10

	for example, directed towards manipulable materials, not pen mates)	pigs, piglets	(Chapter 7), b (Chapter 7), c (Chapter 8)	Table 5: 2, 3, 2A, N1	
	Stereotypies	Farrowing sows, dry sows, boars	WQ 5.1.4.2 Zonderland et al., 2004	Table 4: 3, 8A, N3	3
	Activity level (increased in specific circumstances as predictor of tail-biting)	Fattening pigs	Zonderland et al., 2011	Table 3: 2	1
	Unresponsiveness (associated with reduced activity level)	Dry sows	EFSA, 2007a (Chapter 7)	Table 4: 10A, 11A	2
	Mounting behaviour score	Fattening pigs	Cronin et al., 2003	Table 1: 9, 14	2
	Play behaviour score	Farrowing sows, dry sows, boars, fattening pigs, piglets	Nakamura et al., 2011	Table 5: N1	1
	Social isolation (self separation from the group as indicator of illness or pain)	Farrowing sows, dry sows, boars, fattening pigs, piglets	EFSA, 2004 (Chapter 4)	Table 5: 1, 7, N4, N6	4
	Feeding and drinking behaviour – abnormal or presence or absence - (from automated records)	Farrowing sows, dry sows, boars, fattening pigs	Bird and Crabtree, 2000	Table 4: 14, 15, N3 Table 5: 1, 7, N4, N6	7
	Qualitative behaviour assessment score	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.4.4 WQ 5.1.4.4	Table 2: 1, 2, 3, 4, 15, 19 Table 3: N2 Table 5: N1	8
Thermoregulation	Panting	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ.6.1A.2.2 WQ 5.1.2.2.	Table 1: 16 Table 2: 1, 3, 4, 19 Table 3: 5 Table 4: 5, 5A Table 5: 6, 6A	10
	Huddling and shivering	Fattening pigs, piglets	WQ 6.1A.2.2 WQ 5.1.2.2 Berthon et al., 1994	Table 2: 1, 3, 19 Table 4: 5, 9 Table 5: 5	6
	Body temperature	Farrowing sows, dry sows, boars, fattening pigs, piglets	Renaudeau et al., 2010	Table 2: 3 Table 5: 5, 6, 6A	4
	Lying location (lying in dunging or other inappropriate area due to spatial or thermal inadequacy)	Farrowing sows, dry sows, boars, fattening pigs, piglets	Vasdal et al., 2009 EFSA, 2005 (Chapters 9-10) EFSA, 2007a (Chapter 5), b	Table 1: 16 Table 2: 1, 3, 4, 19 Table 3: 5 Table 4: 5, 5A, N1 Table 5: 5, 6,	12

			(Chapter 7)	6A	
	Lying posture (sternal lying due to spatial or thermal inadequacy)	Farrowing sows, dry sows, boars, fattening pigs, piglets	EFSA, 2005 (Chapter 9) EFSA, 2007a (Chapter 5), b (Chapter 7)	Table 2: 3, 4, 19 Table 3: 5 Table 4: 5, 9, 5A, N1 Table 5: 5, 6, 6A	11
Mutilations	Clipped or ground teeth	Fattening pigs, piglets	WQ 5.1.3.3 (management-based measure only)	Table 4: 12	1
	Tail intact or docked	Fattening pigs, piglets	WQ 6.1A.3.3 (management-based measure only) EFSA, 2007c (Chapters 3-5-7-8)	Table 3: 4, 6, 6A, 7A	4
	Presence and size of testes (small size of testes for some immune-castrated pigs) in live or slaughtered pigs	Fattening pigs	EFSA, 2004 (Chapters 4-5-7) Dunshea et al., 2001	Table 1: 4	1
Other measures	Approach to humans score (fear of humans or positive reaction to humans)	Farrowing sows, dry sows, boars, fattening pigs	WQ 5.1.4.3 WQ 6.1A.4.3	Table 4: 17 Table 5: 11, 10A	3
	Acute phase proteins (at present only pigMAP in blood or meat juice is practicable)	Farrowing sows, dry sows, boars, fattening pigs, piglets	Pineiro, 2011	Table 2: 1, 5, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 27, 28 Table 3: 1, 5 Table 4: 13 Table 5: 1, 7, N4	20
	Manure on the body score	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.2.1 WQ 5.1.2.1	Table 1: 16 Table 2: 1, 3, 4, 10, 11, 12, 16, 18, 19, 26, 27, 28, 29, 30 Table 3: 5 Table 4: 2 Table 5: 6, 6A	19
	Locomotion score	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 6.1A.3.1 WQ 5.1.3.1. Main et al., 2000	Table 2: 7, 20, 21, 22, 23, 24, 25, 26, 30, N1 Table 3: 1 Table 4: 1, 7A Table 5: 9, 10, 10A, N6	17
	Slipping and falling	Farrowing sows, dry sows,	WQ 6.3.2.3	Table 2: 20, 21, 22, 23, 24,	10

		boars, fattening pigs		25, 26, 29 Table 4: 1, 7A	
	Body condition score (undernutrition or sickness leading to a low score or incorrect feeding leading to a very high score)	Farrowing sows, dry sows, boars, fattening pigs, piglets	WQ 5.1.1.1 WQ 6.1A.1.1 EFSA, 2007a (Chapter 7), b (Chapter 7)	Table 3: 1, 5 Table 4: 14, 15, 10A, 11A, 11B Table 5: 1, 7, N4, N6	11
	Observation that the boar is able to mate without undue restriction of movement	Boars	Petchey and Hunt, 1990a, b EFSA, 2007a (Chapter 7)	Table 4: 16	1
	Tail posture (as predictor of tail-biting or indicator of disease)	Fattening pigs, piglets	Zonderland et al., 2011	Table 2: 2, N1 Table 3: 2	3

B. APPENDIX 2

Table comparing the 40 measures included in the Welfare Quality® Pig Protocol (as described in Section 1.1. of this Opinion and in Welfare Quality®) and the 52 main hazards from the EFSA Scientific Opinions obtained as described in Section 2.2.1. In Welfare Quality®, most of the indicators are animal-based indicators but some of them are resource-based or management-based indicators. Therefore, we have distinguished between these two types of indicators and, in Appendix 2, resource-based or management-based indicators are represented by the sign "1", whereas animal-based indicators are shown with the sign "2".

			N	Hazard description	
				Adverse effect	Hazard characterization
			Animal categories		
Good feeding	Absence of prolonged hunger	Body condition score			
		Age of weaning			
	Absence of prolonged thirst	Water provision			
Good housing	Comfort around resting	Bursitis			
		Shoulder sores			
		Absence of manure on the body			
	Thermal comfort	Shivering			
		Panting			
		Huddling			
	Ease of movement	Space allowance			
		Farrowing crates			
Good health	Absence of injuries	Lameness			
		Wounds on body			
		Tail biting (tail lesions)			
		Vulva lesions			
	Absence of disease	Mortality			
		Coughing			
		Sneezing			
		Pumping (laboured breathing)			
		Twisted snouts			
		Rectal prolapse			
		Scouring			
		Constipation			
		Metritis			
		Mastitis			
		Uterine prolapse			
		Skin condition			
		Ruptures and hernias			
		Local infections			
		Neurological disorder (tremor)			
		Splay leg			
	Absence of pain induced by management procedures	Tail docking			
		Castration			
		Nose ringing			
		Teeth clipping			
Appropriate behaviour	Expression of social behaviours	Social behaviour (positive and negative)			
	Expression of other behaviours	Stereotypies			
		Exploratory behaviour			
	Good human-animal relationship	Fear of humans			
	Positive emotional state	Qualitative behaviour assessment			
Number of animal-based measures covering the adverse effect related to this hazard			**11**	1 Poor hygiene: cleanliness of pen, buildings, etc.	2 Insufficient access, insufficient quality or quantity of foraging/exploration material
Number of resource-based or management-based measures related to the hazard			**0**		
Total number of measures related to the hazard and its effects			11		

			N	Hazard description	
				Adverse effect	Hazard characterization
			Animal categories		
Good feeding	Absence of prolonged hunger	Body condition score			
		Age of weaning			
	Absence of prolonged thirst	Water provision			
Good housing	Comfort around resting	Bursitis			
		Shoulder sores			
		Absence of manure on the body	2		
	Thermal comfort	Shivering			
		Panting			
		Huddling			
	Ease of movement	Space allowance			
		Farrowing crates			
Good health	Absence of injuries	Lameness			
		Wounds on body			2
		Tail biting (tail lesions)			2
		Vulva lesions			2
	Absence of disease	Mortality	2		
		Coughing	2		
		Sneezing	2		
		Pumping (laboured breathing)	2		
		Twisted snouts	2		
		Rectal prolapse			
		Scouring	2		
		Constipation			
		Metritis	2		
		Mastitis	2		
		Uterine prolapse			
		Skin condition	2		
		Ruptures and hernias			
		Local infections	2		
		Neurological disorder (tremor)			
		Splay leg			
	Absence of pain induced by management procedures	Tail docking			
		Castration			
		Nose ringing			
		Teeth clipping			
Appropriate behaviour	Expression of social behaviours	Social behaviour (positive and negative)			2
	Expression of other behaviours	Stereotypies			2
		Exploratory behaviour			2
	Good human-animal relationship	Fear of humans			
	Positive emotional state	Qualitative behaviour assessment			2
Number of animal-based measures covering the adverse effect related to this hazard			**11**	1 Poor hygiene: cleanliness of pen, buildings, etc.	2 Insufficient access, insufficient quality or quantity of foraging/exploration material
Number of resource-based or management-based measures related to the hazard			**0**		
Total number of measures related to the hazard and its effects			11		

			N	Hazard description	
				Adverse effect	Hazard characterization
			Animal categories		
Good feeding	Absence of prolonged hunger	Body condition score			
		Age of weaning			
	Absence of prolonged thirst	Water provision			
Good housing	Comfort around resting	Bursitis			
		Shoulder sores			
		Absence of manure on the body			
	Thermal comfort	Shivering			
		Panting			
		Huddling			
	Ease of movement	Space allowance			
		Farrowing crates			
Good health	Absence of injuries	Lameness			
		Wounds on body			
		Tail biting (tail lesions)			
		Vulva lesions			
	Absence of disease	Mortality			
		Coughing			
		Sneezing			
		Pumping (laboured breathing)			
		Twisted snouts			
		Rectal prolapse			
		Scouring			
		Constipation			
		Metritis			
		Mastitis			
		Uterine prolapse			
		Skin condition			
		Ruptures and hernias			
		Local infections			
		Neurological disorder (tremor)			
		Splay leg			
	Absence of pain induced by management procedures	Tail docking			
		Castration			
		Nose ringing			
		Teeth clipping			
Appropriate behaviour	Expression of social behaviours	Social behaviour (positive and negative)			
	Expression of other behaviours	Stereotypies			
		Exploratory behaviour			
	Good human-animal relationship	Fear of humans			
	Positive emotional state	Qualitative behaviour assessment			
Number of animal-based measures covering the adverse effect related to this hazard			**11**	1 Poor hygiene: cleanliness of pen, buildings, etc.	2 Insufficient access, insufficient quality or quantity of foraging/exploration material
Number of resource-based or management-based measures related to the hazard			**0**		
Total number of measures related to the hazard and its effects			11		

3	Insufficient space or too high stocking density	Rest and sleep disruption. Stress and lesions. Behavioural restriction. Disturbed bone growth. Damaging behaviour from pen mates (biting, massaging, belly nosing, etc.). Pain due to leg problems. Stress (inability to resolve social conflicts in dry sow groups). Being tail bitten.	All pigs				2						1		2		2	2																					2		2		2	**7**	**1**	8
4	Confinement in crates	Frustration (no opportunity to move, to act socially, to show oestrus behaviour, stereotypies). Impaired getting up and down movements. Skin lesions.	Farrowing, dry sows					2						1	2																								2	2	2		2	**6**	**1**	7
5	No comfortable lying place, insufficient solid floor or no bedding material like straw	Rest and sleep disruption	All pigs																																									**0**	**0**	0
6	Inappropriate pen design: inadequate separation of dunging and lying area and other inadequacy (feeders, drinkers, etc.)	Rest and sleep disruption	All pigs																																									**0**	**0**	0

7	Inappropriate pen lay out: open sides to pens	Rest and sleep disruption	All pigs																																									**0**	**0**	0
8	Inappropriate design of farrowing system (e.g. poor access to udder due to bars, etc.)	Frustration due to aggression, starvation, dehydration, death	Piglets	2												2			2	2	2																							**5**	**0**	5
9	Poor flooring condition (e.g. slippery, concrete bare floor, slatted floor, slat slot dimension, too abrasive)	Teat damage, pain (leg injuries), lameness, claw damage, shoulder lesions, stress (lack of good lying facilities, aggression due to)	All pigs				2	2							2	2	2																2											**6**	**0**	6
10 A	Environmental temperature outside the thermoneutral zone	Heat or cold stress, discomfort, behaviour disruption and disease consequences	All pigs							2	2	2				2	2			2	2	2	2		2			2											2					**12**	**0**	12
10 B	Environmental temperature outside the thermoneutral zone	Death	All pigs																2																									**1**	**0**	1
10 C	Environmental temperature outside the thermoneutral zone	Being tail bitten	All pigs														2																						2					**2**	**0**	2
11 A	Environmental temperature outside the thermoneutral zone (no heater at birth place and no straw or insufficient space for lying down in heated areas)	Cold stress	Piglets							2		2								2	2				2																			**5**	**0**	5

11 B	Environmental temperature outside the thermoneutral zone (no heater at birth place and no straw or insufficient space for lying down in heated areas)	Death	Piglets																2																									**1**	**0**	1
12	Inadequate air quality (carbon dioxide level above 3,000 ppm, carbon monoxide level above 10 ppm, hydrogen sulphide level above 0.5 ppm or ammonia level above 10 ppm at the pig level, dust, high airspeed)	Health disorders (e.g. respiratory and behavioural disorders, being tail bitten)	All pigs														2			2	2	2	2																2					**6**	**0**	6
13	Absence of wallow	Skin irritation and infections. Thermo-regulatory difficulty	All pigs								2																			2														**2**	**0**	2
14	Light intensity too low	Inability to carry out some normal perception behaviour	All pigs																																				2		2			**2**	**0**	2
15	Too short period of light	Inability to carry out some normal perception behaviour	All pigs																																				2		2			**2**	**0**	2
16	Too short period of darkness	Rest and sleep disruption	All pigs																																									**0**	**0**	0

17	Exposure to intense sunlight	Sunburn leading to pain and stress	All pigs																											2														**1**	**0**	1
18	High level of noise (e.g. above 85 dB)	Behavioural disorders (e.g. rest and sleep disruption)	All pigs																																				2					**1**	**0**	1
19	Gestation stall design	Aggression leading to stress	Dry sows													2																							2					**2**	**0**	2
20	Mixing of unacquainted animals	Lameness due to muscle and joint injuries, aggression leading to stress	All pigs												2	2		2																					2					**4**	**0**	4
21	Insufficient/ inappropriate nest building material	Frustration, stress and behaviour problems	Farrowing sows																																					2	2			**2**	**0**	2
22	Fully slatted floor during suckling period	Being tail bitten	Weaning, growing, fattening														2																						2					**2**	**0**	2
23	Absence of bedding having previously had bedding since weaning	Being tail bitten	Weaning, growing, fattening														2																						2					**2**	**0**	2
24	Inappropriate feeding, lack of fibrous diet	Frustration (hunger, stereotypies, aggression). Lack of positive emotions. Pain (stomach ulcers, skin lesions), death	All pigs													2	2	2	2							2													2	2	2		2	**9**	**0**	9
25	Unbalanced diet (e.g. amino acids or micronutrients)	Stereotypies, other abnormal behaviour, being tail bitten, pathological consequences, hunger, irritability	All pigs													2	2	2							2														2	2	2			**7**	**0**	7

26	Inadequate quantity of food	Hunger, irritability	All pigs	2												2	2	2																					2	2	2			**7**	**0**	7
27	Inappropriate materials in feed (e.g. toxins, antinutrients or microbiological contaminants)	Reduced of growth, organs damage, enteric diseases, abnormal fœtal development	All pigs	2															2	2	2			2	2								2	2										**8**	**0**	8
28	Inadequate food provision method and management	Excessive competition, aggressive behaviour, frustration, tail biting, insufficient nutrient intake	All pigs	2												2	2	2																					2	2	2			**7**	**0**	7
29	Large litter size, more piglets than productive teats	Excessive competition at the teat by suckling piglet, udder lesions, low birth weight, starvation	Farrowing sow, piglets	2												2			2																									**3**	**0**	3
30	Inadequate access to feed (colostrum)	Malaise due to respiratory or gastrointestinal disease	Piglet, weaning, growing, fattening	2					2	2									2	2	2	2	2		2																			**9**	**0**	9
31	Abrupt change from lactation diet to post-weaning diet	Malaise due to gastrointestinal disease and undernutrition	Weaning	2					2	2									2						2																			**5**	**0**	5
32	Inappropriate system for water provision and poor microbiological quality of water	Dehydration, reduced growth, gastrointestinal troubles, irritability, nervous diseases, death	All pigs	2		1			2										2						2								2											**5**	**1**	6
33	Poor stockmanship: inadequate or inappropriate contact, inadequate inspection	Fear and stress, lack of appropriate care of sick or injured animals	All pigs																																							2		**1**	**0**	1

34	Poor biosecurity: infectious agents transmitted by other pigs	Diseases	All pigs	2															2	2	2	2	2		2		2	2				2												**10**	**0**	10
35	Poor biosecurity: infectious agents transmitted by humans or wildlife	Diseases	All pigs	2															2	2	2	2	2		2		2	2				2												**10**	**0**	10
36	Exposure to endo/ectoparasites	Reduced growth, organ damage, disease, irritation	All pigs	2															2	2					2					2		2								2				**7**	**0**	7
37	Large group size >40 animals/group resulting in management difficulties	Behaviour disorders, stress and lesions	Dry sows, weaning, growing, fattening													2		2																					2					**3**	**0**	3
38	Poor individual or herd health status	Diseases, being tail bitten	All pigs	2													2			2	2	2	2		2		2	2				2							2				2	**12**	**0**	12
39	Inadequate management leading to prolonged farrowing with birth intervals more than 2 h	Death	Piglets, dry sows																2																									**1**	**0**	1
40	Excessive mating behaviour between group housed sows in oestrus	Pain due to leg problems and stress	Dry sows, farrowing sows												2	2																												**2**	**0**	2
41	Inadequate management leading to savaging of piglets by lactating sow	Stress and death	Piglets																2																									**1**	**0**	1

42	Early weaning procedures (weaning before suckling motivation ceases)	Frustration and stress (sow still motivated to nurse her offspring), piglet undernutrition, increased susceptibility to disease (especially enteric) and increased prevalence of abnormal behaviour (belly nosing)	Farrowing sows, weaning	2	1														2	2	2	2	2		2														2					**8**	**1**	9
43	Predation	Stress, pain and death	All pigs																2																									**1**	**0**	1
44 A	Tail docking with or without pain treatment	Fear and acute pain	Piglets																																1									**0**	**1**	1
44 B	Tail docking with or without pain treatment	Infection with inflammation	Piglets, weaning																														2			1									**1**	**1**	2
44 C	Tail docking with or without pain treatment	Chronic pain	All pigs																																1									**0**	**1**	1
45 A	Tooth resection (grinding or clipping)	Fear and acute pain	Piglets																																			1						**0**	**1**	1
45 B	Tooth resection (grinding or clipping)	Infection and inflammation	Piglets, weaning																																			1						**0**	**1**	1
45 C	Tooth resection (grinding or clipping)	Chronic pain	Piglets																																			1						**0**	**1**	1
46 A	Surgical castration with or without pain treatment	Fear and acute pain	Piglets																																	1								**0**	**1**	1

46 B	Surgical castration with or without pain treatment	Infection and/or inflammation	Piglets, weaning																													2				1								**1**	**1**	2
46 C	Surgical castration with or without pain treatment	Chronic pain	Piglets																																	1								**0**	**1**	1
47 A	Ear tagging or ear notching	Fear and acute pain	Boars, dry sows, farrowing sows, weaning growing, fattening																																							2		**1**	**0**	1
47 B	Ear tagging or ear notching	Infection and inflammation	Boars, dry sows, farrowing sows, weaning growing, fattening																													2												**1**	**0**	1
47 C	Ear tagging or ear notching	Chronic pain	Boars, dry sows, farrowing sows, weaning growing, fattening																																									**0**	**0**	0
48 A	Nose ringing	Fear and acute pain	All pigs																																		1					2		**1**	**1**	2
48 B	Nose ringing	Infection and inflammation	Boars, dry sows, farrowing sows, growing, fattening																													2					1							**1**	**1**	2
48 C	Nose ringing	Chronic pain	Boars, dry sows, farrowing sows, growing, fattening																																		1							**0**	**1**	1

49	Presence (no removal) of tail bitten and tail biting animals	Being tail bitten	Weaning, growing, fattening														1 and 2																						2					**2**	**1**	3
50 A	Genotype problems: body form and growth	Locomotor disorders	All pigs				2								2																									2		2	**4**	**0**	4
50 B	Genotype problems: body form and growth	Cardiovascular disorders	All pigs																2																								**1**	**0**	1
51	Genotype problems: infectious disease susceptibility	Infectious diseases	All pigs	2															2	2	2	2	2																					**6**	**0**	6
52	Genotype selection for high lean tissue growth rate (low fatness)	Being tail-bitten	All pigs														2																						2					**2**	**0**	2
HOW MANY HAZARDS ARE COVERED BY THIS WQ INDICATOR?				**14**	**0**	**0**	**3**	**2**	**4**	**4**	**2**	**2**	**0**	**0**	**6**	**13**	**15**	**8**	**19**	**13**	**12**	**9**	**9**	**1**	**13**	**1**	**4**	**5**	**0**	**4**	**0**	**9**	**2**	**2**	**0**	**0**	**0**	**0**	**22**	**8**	**11**	**3**	**6**			

C. GLOSSARY

Accuracy: the overall correctness of an animal-based measure in identifying a welfare outcome.

Animal-based measure: a response of an animal or an effect on an animal. It can be taken directly from the animal or indirectly and includes the use of animal records. The measure may, for example, be intended to: (i) assess the degree of impaired functioning associated with injury, disease, and malnutrition; (ii) provide information on animals' needs and affective states such as hunger, pain and fear, often by measuring the strength of animals' preferences, motivations and aversions; or (iii) assess the physiological, behavioural and immunological changes or effects that animals show in response to various challenges.

Factor: any aspect of the environment of the animal, in relation to housing and management, genetic selection of animals, transport and slaughter, which may have the potential to improve or impair the welfare of animals.

Hazard: a factor with the potential to cause poor welfare.

Management-based measure: an evaluation of what the animal unit manager or stockperson does and which management processes or tools are used.

Measure: a form of evaluation rather than an intervention intended to deal with a problem.

Measurement: the result of the above evaluation (e.g. size and depth of wound, percentage of lame animals).

Non-animal-based measure: a measure of factors (resources or the management) in the environment of the animal that may be linked to the likelihood of good or poor welfare.

Reliability: a general term referring to the ability of a measure to be applied under various conditions, and by different personnel, while still providing similar results.

Repeatability: the level of agreement between repeated measurements of the animal-based measure on the same "sample" by the same assessor, on different occasions.

Resource-based measure: an evaluation of a feature of the environment in which the animal is kept or to which it is exposed.

Robustness: the extent to which a measure is affected by changes in variables, such as environment, time of day, etc.

Sensitivity: the minimum level of welfare outcome change that will be detected by the measure.

Specificity: the extent to which a measure is specific for one welfare outcome, or relates to several outcomes.

Threshold: a cut-off value when a measure is considered to be indicative of a defined welfare outcome.

Tooth resection: reduction of the length of piglets' teeth by clipping or grinding.

Validity: the fitness for purpose of a measure that has been properly developed, optimised, and standardised for an intended purpose. Validation includes estimates of the analytical and diagnostic performance characteristics of the measure/indicator (i.e. sensitivity and specificity).

Welfare: The welfare of an individual is its state as regards its attempts to cope with its environment.

Welfare indicator: an observation, a record or a measurement used to obtain information on an animal's welfare (see also welfare measure). An indicator is not necessarily measured and it may show a trend.

Welfare measure: a category of observation, recording or evaluation used to assess an animal's welfare. These are in general animal-based but measures of housing and management may be predictors of changes in welfare.

Welfare outcome: a consequence for the welfare of an individual or group of animals of genetic selection or modification or of a period of housing, management, handling, transport, stunning or other treatment.

Welfare outcome indicator: an observation, a record or a measurement used to obtain information on an individual animal's welfare that can be reliably used in practice by trained people. It may be the outcome of genetic selection or modification or of a period of housing, management, handling, transport, stunning or other treatment.

Welfare outcome measure: a category of welfare measure that can be reliably used in practice by trained people.