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# 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[1]

## Scientific Opinion of the Panel on Animal Health and Welfare

(Question No EFSA-Q-2006-013)

Adopted on 06 December 2007

[1] For citation purposes: Scientific Opinion of the Panel on Animal Health and Welfare on a request from Commission on 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. *The EFSA Journal* (2007) 611, 1-13

## PANEL MEMBERS

The Scientific Panel for Animal Health and Welfare (AHAW) of the European Food Safety Authority adopted the current Scientific Opinion on 6 December 2007. The Members of the AHAW Scientific Panel were:

Bo Algers, Harry J. Blokhuis, Donald M. Broom, Patrizia Costa, Mariano Domingo, Mathias Greiner, Daniel Guemene, Jörg Hartung, Frank Koenen, Christine Muller-Graf, David B. Morton, Albert Osterhaus, Dirk U. Pfeiffer, Ron Roberts, Moez Sanaa, Mo Salman, J. Michael Sharp, Philippe Vannier, Martin Wierup, Marion Wooldridge.

## SUMMARY

Council Directive 91/630/EEC[2], as amended, laying down minimum standards for the protection of pigs, requires the Commission to submit to the Council a report, based on a scientific opinion of the European Food Safety Authority (EFSA), concerning the welfare various aspects of housing and husbandry systems for farmed pigs. Following a request from the European Commission, the Panel on Animal Health and Welfare was asked to deliver a Scientific Opinion on 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. The Scientific Opinion was adopted by the Panel on Animal Health and Welfare (AHAW) on 6 December 2007.

Based on the scientific data presented in the Scientific Report conclusions and recommendations were drawn, as well as some recommendations for future research.

Evidence indicates that tail-biting pigs are likely to be frustrated and hence experiencing reduced welfare. 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. Tail biting is associated with a variety of pathological changes ranging from spinal abscesses to pyaemia in different parts of the body. Such changes may be associated with reduced growth rate or in more severe cases, total carcass condemnation.

Tail biting is considered as an abnormal behaviour. The need to perform exploration and foraging behaviour is considered to be a major underlying motivation. The occurrence of tail biting has a multi-factorial origin and there is evidence in the report that some causal factors have more weight, such as the absence of straw, the presence of slatted floors and a barren environment. Absence of straw or a particulate, rootable substrate is an important hazard for tail biting. However, both the amount of straw (full bedding better than limited provision from a rack) and its form (long straw better than chopped) are also of importance. It was concluded that there is little evidence that provision of toys such as chains, chewing sticks and balls can reduce the risk of tail biting.

Heritability of tail-biting has been evaluated and its value found to be high enough for selection. Moreover, a phenotypic correlation between tail-biting behaviour and higher lean tissue growth rate has been reported.

A hazard for tail biting is competition for feed and/or inadequate feed intake, inadequate dietary sodium, deficiency of dietary essential amino acids, and a sudden change in diet composition, especially to a lower nutrient density.

In relation to climate condition, tail biting risk seems to be increased in autumn season, and hazards for tail biting are heat stress as well as cold stress and high airspeed.

Circumstantial data, anecdotal reports and practical experience strongly suggest poor health status to be a hazard for tail biting.

The efficacy of tail docking to reduce the frequency of tail biting is very difficult to estimate since it depends on the level of tail biting in control undocked pigs. Indeed, tail docking is all the more efficient in current intensive housing systems for pigs since environmental and possibly also genetic hazards for tail biting are prevalent. Under common intensive farming conditions, tail docking reduces the frequency of tail biting, but does not completely eliminate the problem when unfavourable conditions persist.


[2] E.C.O.J. n° L340 of 11/12/1991. p. 33.

In relation to the results obtained in the Risk Assessment process, some of the above mentioned hazards that have a high prevalence in the EU population came out as major risk factors for tail biting.

In order to further assess risks associated with tail biting and the severity of docking tails in pigs, research is needed that addresses, among others, the difference in prevalence of tail biting between docked and undocked pig populations in different housing systems, the severity and the duration of chronic pain, and the genetic, environmental, age and sex differences of tail-biting behaviour performance. Research is also needed to better understand the fundamental causal factors leading to tail biting and to define tools for early detection of tail biting in farms.

The methodology and the results (Conclusions and Recommendations) of this opinion as well as the previous opinions on Pig Welfare, should be further analysed identifying welfare indicators (in particular animal-based) suitable for the development of an animal welfare monitoring system.

**Key words: Pig Welfare, tail biting, tail docking, docked, undocked.**

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## BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Council Directive 2001/88/EC[3] amended Council Directive 91/630/EEC[4] laying down minimum standards for the protection of pigs and requires the Commission to submit to the Council a report, based on a scientific opinion of the European Food Safety Authority (EFSA), concerning various aspects of housing and husbandry systems for farmed pigs. In this context and upon requests from the Commission, EFSA has already issued opinions on welfare aspects of the castration of pigs and the animal welfare and health aspects of different space allowances and floor types for weaners and rearing pigs.

Council Directive 2001/88/EC also provides for the Commission to report to Council, on the basis of an EFSA scientific opinion, on numerous other aspects of housing and husbandry systems for farmed pigs, such as the effects of stocking density, including group size and methods of grouping the animals; the animal health and welfare implications of different space requirements, including the service area for individually housed adult breeding boars; the impact of stall design and different flooring types; the risk factors associated with tail biting and possible means to reduce the need for tail docking; the latest developments of group-housing systems for pregnant sows and also loose-house systems for sows in the service area and for farrowing sows which meet the needs of the sow without compromising piglet survival.

It should be noted that for weaners and rearing pigs EFSA has already issued a scientific opinion on the impact of different space allowances and flooring types, and so in respect of these two issues the new EFSA opinion should consider other categories of pigs (e.g. sows including farrowing sows, boars, pigs recruited for breeding programmes etc.). The Commission’s report to Council will be drawn up also taking into account socio-economic consequences, consumers’ attitudes and behaviour, sanitary consequences, environmental effects and different climatic conditions concerning this issue.

## TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

### Mandate 1: Request for a scientific opinion concerning animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, farrowing and pregnant sows

The opinion should consider, inter alia, the following specific issues:

- The effects of stocking density, including the group size and methods of grouping the animals, in different farming systems on the health and welfare of adult breeding boars, farrowing and pregnant sows.
- The animal health and welfare implications of space requirements; including the service area for individually housed adult breeding boars.
- The impact of stall design and different flooring types on the health and welfare of breeding boars, pregnant and farrowing sows with piglets through weaning taking into account different climatic conditions.
- The latest developments of group housing systems for pregnant and farrowing sows with piglets through weaning, taking account both of pathological, zootechnical, physiological and ethological aspects of the various inside/outside -systems and of their health and environmental impact and of different climatic conditions.

[3] E.C.O.J. n° L316 of 1/12/2001. p. 1.
[4] E.C.O.J. n° L340 of 11/12/1991. p. 33.

- The latest developments of loose-house systems for sows in the service area and for farrowing sows with piglets through weaning, which meet the needs of the sow without compromising piglet survival.

**Mandate 2: Request for a scientific opinion concerning animal health and welfare aspects of different housing and husbandry systems for farmed fattening pigs**

The opinion should consider, inter alia, the following specific issues:

- The effects of stocking density, including the group size and methods of grouping the animals, in different farming systems on the health and welfare.
- The animal health and welfare implications of space requirements.
- The impact of stall design and different flooring types on the health and welfare of fattening pigs taking into account different climatic conditions.

**Mandate 3: Request for a scientific opinion concerning the risks associated with pig tail biting and possible means to reduce the need for tail docking considering the different housing and husbandry systems**

**This report will refer only to mandate 3 as referenced above.**

## ACKNOWLEDGEMENTS

The European Food Safety Authority wishes to thank the members of the Working Group, chaired by the panel member Harry Blokhuis, for the preparation of the Scientific Report, which has been used as the basis of this Scientific Opinion: Telmo Nunes Pina and Moez Sanaa (Risk Assessors), Marc Bracke, Sandra Edwards, Michael Gunn, Guy Pierre Martineau, Mike Mendl, and Armelle Prunier.

The scientific co-ordination for this Scientific Report has been undertaken by the EFSA AHAW Panel Scientific Officers Elisa Aiassa, Sara Barbieri and Oriol Ribó.

## CONCLUSIONS AND RECOMMENDATIONS

### CONCLUSIONS

- Tail biting is considered as an abnormal behaviour. The need to perform exploration and foraging behaviour is considered to be a major underlying motivation. The occurrence of tail biting has a multi-factorial origin and there is evidence in the report that some causal factors have more weight, such as the absence of straw, the presence of slatted floors and a barren environment.
- Evidence indicates that tail-biting pigs are likely to be frustrated and hence experiencing reduced welfare. Pigs receiving gentle chewing of their tails appear not to be adversely affected by this, but those whose tails have been injured or who are subject to vigorous biting are likely to be in pain and distress. The affective experiences of pigs in pens where tail-biting is occurring but who have not themselves been bitten is unclear.
- Tail biting is associated with a variety of pathological changes ranging from spinal abscesses to pyaemia in different parts of the body. Such changes may be associated with reduced growth rate or in more severe cases, total carcase condemnation.
- While the whole procedure (of being picked up by the farmer and being tail docked) is probably highly aversive to the young piglet (given the strong behavioural and vocal responses it elicits), it seems likely that tail-docking of day-old piglets does not induce a major physiological stress response, although these animals may be capable of showing such a response.
- Pain induced by tail docking seems moderate on a short-term (hours) basis but animals may suffer from pain due to neuroma formation on a long-term (days and weeks) basis.
- It can be concluded that there is little evidence that provision of toys such as chains, chewing sticks and balls can reduce the risk of tail biting.
- Heritability of tail-biting has been evaluated and its value found to be high enough for selection. Moreover, a phenotypic correlation between tail-biting behaviour and higher lean tissue growth rate has been reported.
- There is a consistent suggestion from a range of abattoir-based studies that males may be more at risk of incurring tail-biting damage than females. However, experimental studies looking at the effects of sex composition are not conclusive.
- In general, tail-in-mouth is seen early in life in pigs kept under farming conditions, soon after weaning, and appears to decline as pigs grow older, while tail-biting usually starts to occur later. It is possible that these behaviours are not directly related, they have different time courses and there is a suggestion from one or two studies that tail-in-mouth may be lower in pens where there is tail-biting, and vice versa.
- Although tail-in-mouth behaviour and tail-biting outbreaks show some relationship to pig age, it is difficult to disentangle maturational effects, due to biological and behavioural development, from environmental effects, such as alterations to husbandry and housing, that are associated with different stages of the pig rearing cycle.
- There is no clear evidence that lowering weaning age has a strong effect on the propensity to show tail-in-mouth type behaviours or enhances levels of tail biting.
- Historical studies and field studies as well as industry experience indicate that increased stocking density may lead to a greater risk of tail-biting, but more recent studies are not as clear cut.

- Although no clear and consistent picture emerges from the research conducted so far, anecdotal evidence and industry opinion suggests that mixing may act to trigger tail-biting under commercial conditions.
- Absence of straw is an important hazard for tail biting. However, both the amount of straw (full bedding better than limited provision from a rack) and its form (long straw better than chopped) are also of importance.
- Maintaining pigs in systems on floors without straw bedding is a major hazard for tail biting. In unbedded systems, a higher proportion of slatted flooring is an additional hazard.
- Absence of a particulate, rootable substrate is a significant hazard for tail biting.
- A hazard for tail biting is competition for feed and/or inadequate feed intake.
- There is no convincing evidence for a consistent hazard associated with feed form (e.g. dry, wet, pelleted or meal feed).
- A hazard for tail biting is inadequate dietary sodium (salt).
- A hazard for tail biting is deficiency of dietary essential amino acids.
- There is insufficient evidence that excessive or insufficient level of dietary fibre is a consistent hazard for tail biting.
- There is insufficient evidence that any specific dietary raw material is a hazard for tail biting.
- There is limited evidence that presence or absence of specific feed additives is a hazard for tail biting, although the absence of specific feed additives may become a hazard for tail biting in the case of sub-clinical disease.
- A hazard for tail biting may be a sudden change in diet composition, especially to a lower nutrient density.
- There is limited evidence for a hazard associated with water provision, although impaired quality of drinking water or a cut in water provision can become a hazard for tail biting during summer.
- Circumstantial data, anecdotal reports and practical experience strongly suggest poor health status to be a hazard for tail biting.
- Tail biting risk seems to be increased in autumn season.
- Hazards for tail biting are (1) heat stress, (2) cold stress and (3) high airspeed.
- Despite strong commercial opinion, there is insufficient experimental evidence that poor air quality is a hazard for tail biting.
- The evidence of artificial ventilation being a hazard for tail biting is limited and probably confounded.
- The evidence of the absence of natural light being a hazard for tail biting is limited and probably confounded.
- Under common intensive farming conditions, tail docking reduces the frequency of tail biting, but does not completely eliminate the problem when unfavourable conditions persist.
- The efficacy of tail docking to reduce the frequency of tail biting is very difficult to estimate since it depends on the level of tail biting in control undocked pigs. Indeed, tail docking is all the more efficient in current intensive housing systems for pigs since environmental and possibly also genetic hazards for tail biting are prevalent.

- The existence of tail lesions is probably a stimulating factor for further biting.
- With few hard experimental data available on therapeutic effects of treatments in case of tail biting cases, at present the most rational intervention appears to be to counteract known risk factors as much as possible, including the removal of biters and victims and hygienic measures to limit secondary infections where necessary. It is evident that good stockmanship, given adequate working time and not too high pig:stockperson ratio, is essential to detect and address the presence of risk factors and to act before severe outbreaks become established.

### CONCLUSIONS FROM THE RISK ASSESSMENT

Due to the limited amount of quantitative data related to effects of potential hazards on pig welfare, the risk assessment was mainly based on expert opinion. The methodology used does not give a precise estimate of the risk attributed to certain hazards; however the output can be used to designate areas of concern, as well as, guidance for future research.

At present, most of the pigs in Europe belong to the docked population. Therefore, more information is available from this population compared with the undocked. On the undocked population, the RA was mainly focused on being tail bitten because there are no available quantitative data on the prevalence of being a tail biter.

It should be noted that because we are dealing with a single 'outcome' (i.e. being tail bitten) the RA calculations are most heavily influenced by the exposure assessment. Therefore, hazards that have a high prevalence in the EU population come out as high risk factors in the RA.

According to the results of the RA and the graphs in the Annex, the following potential hazards show the major risks:

*Docked Population:*

- Lack of straw and absence of adequate enrichment. No particulate rooting substrate, no destructible toy,
- Lack of long straw,
- Lack of straws and 100% slatted floor;

*Undocked population:*

- Lack of long straw,
- Castration in males,
- Absence of bedding having previously had bedding since weaning,
- Genotype with high lean tissue growth rate (low fatness),
- Presence (no removal) of tail bitten and tail biting animals.

- Within the current pig population (docked and undocked), the largest risk for being tail bitten is the lack of appropriate enrichment. This is a compound risk where many factors (material properties) are often involved for example lack of adequate substrate (particle rooted substrate or destructible toy) and fully slatted floor.
- Stocking density, associated with lack of enrichment and fully slatted floors, is a significant risk for tail biting.
- A high lean tissue growth, influenced by genetic selection which is commonly practised in Europe, was indicated in the Risk Assessment as a major risk factor to being tail bitten.

- High prevalence of endemic and occasional epidemic diseases makes poor health status a high risk factor for tail biting.
- Competition for feed is the most prevalent and therefore constitutes one of the major risks for tail biting.
- The acute aspects of welfare risks from tail docking may seem to be less than the welfare risks from tail biting related to the factors discussed above. However the balance between the welfare effects of tail biting and tail docking heavily depends on the tentative assumption discussed above, i.e. of linearity of the intensity score (see chapter 9 of the Scientific Report). It also depends on the extent (severity and duration) of chronic pain arising from tail docking and other aspects of uncertainty inherent in this qualitative risk assessment.
- The prevalence of undocked pigs in the EU is currently very low (5-10 %). The systems in which undocked pigs are kept are not equivalent to the systems of the wider population (of docked pigs) in the EU since undocked pigs generally live in systems where hazards for tail biting are less prevalent (e.g. more often having access to enrichment materials such as straw and additional space).
- The risks of tail biting for a given hazard are higher in the population of undocked pigs than in docked pigs.
- The highest risks for poor welfare from tail biting in both populations encompass the same hazards.
- Lack of adequate enrichment is a higher risk for poor welfare from tail biting in the docked pig population than in the undocked pig population because of the large difference in the exposure to this circumstance.

**RECOMMENDATIONS**

- Accurate data on the entire range of deleterious effects on pig health associated with tail biting should be collated.
- It is important to monitor the pigs closely at times of life when husbandry is changing in order to possibly prevent tail-biting outbreaks.
- 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.
- 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 implemented to control tail-biting and its adverse effects for welfare.
- 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.
- Monitoring at slaughter of lesions related to tail biting is suggested as a mean to identify herds with such problems as guidance for the implementation of preventive actions.

- The methodology and the results (Conclusions and Recommendations) of this opinion as well as the previous opinions on Pig Welfare, should be further analysed identifying welfare indicators (in particular animal-based) suitable for the development of an animal welfare monitoring system.

**RECOMMENDATIONS FOR FUTURE RESEARCH**

- In order to be able to assess properly the severity of docking tails in pigs research is needed that addresses the severity and duration of chronic pain.
- Objective assessment of the prevalence and extent of chronic pain resulting from tail docking should be investigated.
- There is a need for more quantitative data on the difference in prevalence of tail biting between populations of docked and undocked pigs in the different housing systems prevalent in the EU.
- There is a need to understand the fundamental mechanistic level of what causes an individual pig to bite tails.
- Developing a (ethically acceptable) model that generates tail-biting with a known probability, to allow study of influential factors.
- More knowledge is required to fully understand the role of the selection for fatter animals as means to reduce tail biting.
- Differences in susceptibility to being tail bitten between castrated and entire males should be further investigated.
- The deleterious effects of poor health in pigs on tail biting should be studied.
- Further research is required to elucidate the causes of the apparent higher levels of tail damage in males and to provide more information on whether there are any sex differences in performance of tail-biting behaviour.
- Experiments to disentangle the effect of age and the environment need to be done, because it remains a possibility that environmental factors are as important in determining the occurrence of tail-biting as age-related maturational or developmental processes per se.
- Studies should be carried out regarding long-term effects of early weaning on tail-in-mouth and tail-biting, especially for non-docked pigs.
- Studies on the effect of increasing group size on tail biting are recommended.
- Further studies of the effects of mixing, particularly on commercial farms are recommended.
- Research is needed to determine effective and feasible enrichment strategies which can be used to reduce tail biting risk in prevalent (part/fully slatted) housing and without compromising slurry management.
- Effective substitutes for straw, allowing appropriate foraging and exploration, should be investigated.
- Further research is required on the role of dietary fiber on tail biting risk.
- An objective assessment of the effect of tail docking on tail biting under different housing and management systems is recommended.
- The cues involved in the stimulating effect of the presence of tail lesions are not known and require new research to be elucidated.

- The inclusion of known risk factors as described in this report and elsewhere into the methodology sections of research studies on tail biting is recommended.
- A detailed checklist, or more sophisticated computer-based decision support system (such as a Bayesian network or relational database), should be developed further for use in counselling in case of tail biting outbreaks/problems on farms.
- As an adequate management would benefit from improved early detection of tail biting outbreaks, research on the better understanding of the causal factors leading to tail biting and tools for detecting causal factors on farms should be encouraged.

European Food Safety Authority

*Annex to the EFSA Journal* (2007) 611, 1-13

# Scientific Report on

# 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

**(Question No EFSA-Q-2006-013)**

**WORKING GROUP MEMBERS**

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**PANEL MEMBERS**

This Scientific Report was peer-reviewed by the Members of the Scientific Panel for Animal Health and Welfare (AHAW) of the European Food Safety Authority. The Scientific Report was used as the basis for a Scientific Opinion adopted on 6 December 2007. The Members of the AHAW Scientific Panel were:

Bo Algers, Harry J. Blokhuis, Donald M. Broom, Patrizia Costa, Mariano Domingo, Mathias Greiner, Daniel Guemene, Jörg Hartung, Frank Koenen, Christine Muller-Graf, David B. Morton, Albert Osterhaus, Dirk U. Pfeiffer, Ron Roberts, Moez Sanaa, Mo Salman, J. Michael Sharp, Philippe Vannier, Martin Wierup, Marion Wooldridge.

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### BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Council Directive 2001/88/EC[1] amended Council Directive 91/630/EEC[2] laying down minimum standards for the protection of pigs and requires the Commission to submit to the Council a report, based on a scientific opinion of the European Food Safety Authority (EFSA), concerning various aspects of housing and husbandry systems for farmed pigs. In this context and upon requests from the Commission, EFSA has already issued opinions on welfare aspects of the castration of pigs and the animal welfare and health aspects of different space allowances and floor types for weaners and rearing pigs.

Council Directive 2001/88/EC also provides for the Commission to report to Council, on the basis of an EFSA scientific opinion, on numerous other aspects of housing and husbandry systems for farmed pigs, such as the effects of stocking density, including group size and methods of grouping the animals; the animal health and welfare implications of different space requirements, including the service area for individually housed adult breeding boars; the impact of stall design and different flooring types; the risk factors associated with tail biting and possible means to reduce the need for tail docking; the latest developments of group-housing systems for pregnant sows and also loose-house systems for sows in the service area and for farrowing sows which meet the needs of the sow without compromising piglet survival.

It should be noted that for weaners and rearing pigs EFSA has already issued a scientific opinion on the impact of different space allowances and flooring types, and so in respect of these two issues the new EFSA opinion should consider other categories of pigs (e.g. sows including farrowing sows, boars, pigs recruited for breeding programmes etc.). The Commission's report to Council will be drawn up also taking into account socio-economic consequences, consumers' attitudes and behaviour, sanitary consequences, environmental effects and different climatic conditions concerning this issue.

### TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

**Mandate 1:**

**Request for a scientific opinion concerning animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, farrowing and pregnant sows**

The opinion should consider, inter alia, the following specific issues:

- The effects of stocking density, including the group size and methods of grouping the animals, in different farming systems on the health and welfare of adult breeding boars, farrowing and pregnant sows
- The animal health and welfare implications of space requirements; including the service area for individually housed adult breeding boars.
- The impact of stall design and different flooring types on the health and welfare of breeding boars, pregnant and farrowing sows with piglets through weaning taking into account different climatic conditions.
- The latest developments of group housing systems for pregnant and farrowing sows with piglets through weaning, taking account both of pathological, zootechnical, physiological and ethological aspects of the various inside/outside -systems and of their health and environmental impact and of different climatic conditions.

[1] E.C.O.J. n° L316 of 1/12/2001. p. 1.
[2] E.C.O.J. n° L340 of 11/12/1991. p. 33.

- The latest developments of loose-house systems for sows in the service area and for farrowing sows with piglets through weaning, which meet the needs of the sow without compromising piglet survival.

**Mandate 2: Request for a scientific opinion concerning animal health and welfare aspects of different housing and husbandry systems for farmed fattening pigs**

The opinion should consider, inter alia, the following specific issues:

- The effects of stocking density, including the group size and methods of grouping the animals, in different farming systems on the health and welfare
- The animal health and welfare implications of space requirements
- The impact of stall design and different flooring types on the health and welfare of fattening pigs taking into account different climatic conditions.

**Mandate 3: Request for a scientific opinion concerning the risks associated with pig tail biting and possible means to reduce the need for tail docking considering the different housing and husbandry systems**

**This report will refer only to mandate 3 as referenced above.**

# 1. Scope and Objectives of the Report

In 1997, the Scientific Veterinary Committee (SVC) of the European Commission published the report "The Welfare of Intensively Kept Pigs". The SVC (1997) Report contains information on the biology and behaviour of pigs in natural and semi-natural conditions, an overview of production systems and an analysis of the effects of specific husbandry factors on pig welfare. Moreover, different production systems were compared regarding their effect on pig welfare and socio-economic aspects were considered. In that report conclusions and recommendations were made and topics which required further research were listed.

The present "Scientific Report on 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" updates the earlier report (SVC, 1997) excluding economic aspects which are not in the mandate for this report but including a risk assessment. This report more extensively reviews the available scientific literature and assesses the causal factors (hazards) known to be involved in the tail biting problem, with a view of proposing possible solutions that do not require tail docking.

It is one of five EFSA Reports on the welfare of pigs: "Welfare aspects of the castration of piglets (July 2004a); "The welfare of weaners and rearing pigs: effects of different space allowances and floor types" (March 2005); "Welfare and disease in boars, sows and unweaned piglets in relation to housing and husbandry" (September 2007); and "Scientific Report on animal health and welfare in fattening pigs in relation to housing and husbandry" (September 2007).

This report will first describe current production systems for fattening pigs in the EU. Then it will introduce tail biting issues, picture the current situation in the EU on tail biting and consider welfare and health aspects of tail biting. Further it considers the current situation in the EU on tail docking and the welfare and health consequences of this practice. Hazards such as substrate, space, feeding and (not) tail docking, will be described in detail in the second part of the report. In a qualitative way the hazards are characterised (hazard characterisation) and their level of exposure in the population of farms in Europe (exposure assessment) is determined. Finally, the risks associated with these hazards are characterised, the management of tail biting outbreaks, food safety considerations and research priorities are discussed in separate chapters of this report.

# 2. Current production systems for fattening pigs in the EU

## 2.1. European Pig Production

The enlargement of the European Union from 15 to 25 Member States, which occurred in 2004, influenced the European pig production figures. This chapter aims to provide a general overview of the main statistical data currently available and to analyse the trend of the European pig production, which has a great importance in a world context.

In the 25 member countries of the European Union more than 150 million pigs are slaughtered annually (data refer to the number of pigs processed in the slaughterhouses), which is approximately 30 million more than in the EU 15 (Figure 1).

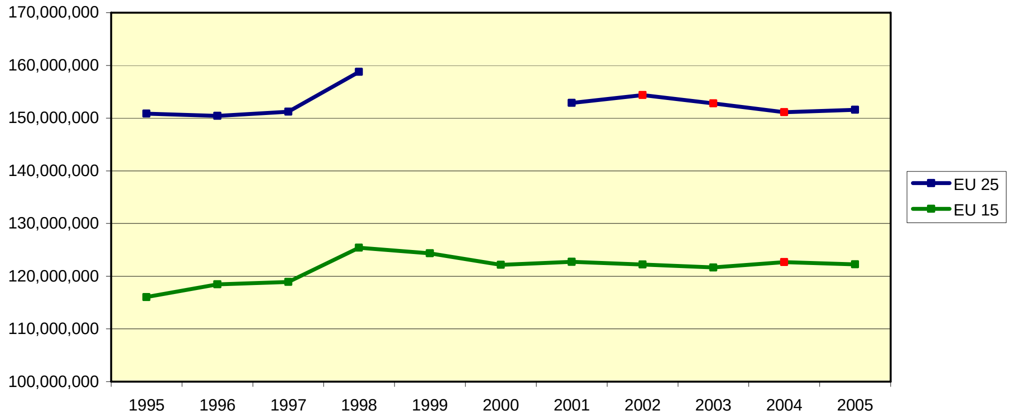


**Figure 1.** The number of pigs, whose meat is certified for human consumption, from 1995 to 2005 (in red, the provisional value) in the European Union (Source: Eurostat, 2007).

Germany, Spain, France, Denmark and the Netherlands have been confirmed as the major producers at EU level; with the enlargement in 2004, also Poland has been considered as one of the greater producers, with nearly 19 million of pigs in 2006 (Table 1).

**Table 1.** The number of pigs, whose meat is certified for human consumption, from 2004 to 2006 in the European Countries (Source: Eurostat, 2007).

| | 2004 | 2005 | 2006 |
|---|---|---|---|
| Austria | 3,125,204 | 3,169,541 | 3,139,438 |
| Belgium | 6,318,734 | 6,252,988 | n.a. |
| Bulgaria* | 942,992 | 932,699 | 1,010,789 |
| Cyprus | 470,504 | 429,719 | 452,644 |
| Czech Republic | 2,915,000 | 2,719,000 | 2,741,300 |
| Denmark | 13,407,000 | 12,604,000 | 13,613,000 |
| Estonia | 353,700 | 351,600 | 341,200 |
| Finland | 1,435,000 | 14,40,000 | 1,435,400 |
| France | 15,150,000 | 15,123,000 | 15,009,000 |
| Germany | 26,334,800 | 26,989,054 | 26,602,000 |
| Greece | 994,000 | 1,042,000 | n.a. |
| Hungary | 4,059,000 | 3,853,000 | 3,987,000 |
| Ireland | 1,757,600 | 1,678,000 | n.a. |
| Italy | 8,971,762 | 9,200,000 | 9,281,083 |
| Latvia | 435,700 | 427,900 | 416,750 |
| Lithuania | 1,073,300 | 1,114,700 | 1,127,100 |
| Luxembourg | 77,133 | 84,547 | 86,954 |
| Malta | 76,853 | 73,025 | 73,683 |
| Netherlands | 11,140,000 | 11,000,000 | 11,220,000 |
| Poland | 17,395,570 | 18,711,290 | 18,812,975 |
| Portugal | 2,347,852 | 2,344,064 | 2,295,451 |
| Romania[a] | 6,494,700 | 6,603,800 | 6,905,000 |
| Slovakia | 1,149,282 | 1,108,265 | 1,104,829 |
| Slovenia | 533,998 | 547,432 | 575,116 |
| Spain | 24,894,960 | 24,888,882 | n.a. |
| Sweden | 1,920,420 | 1,797,400 | 1,661,520 |
| United Kingdom | 4,787,379 | 4,726,207 | 4,691,245 |

[a] Joined the EU in 2007; n.a.: data not available

Productive levels in the EU were almost stable during the last 2 years. The self-sufficiency is stable too and the per capita consumption of pig meat meat was 42.9 Kg in 2006 (Table 2).

**Table 2.** Consumption of pork and self-sufficiency for the pig meat in the European Union in the last four years (Source: http://europa.eu/pol/agr/index_en.htm; modified, 2007).

| Consumption (kg/per capita) | |
|---|---|
| 2006 | 42.9 |
| 2005 | 42.7 |
| 2004 | 43.2 |
| 2003 | 43.8 (EU 15) |
| Self- sufficiency (%) | |
| 2006 | 108.1 |
| 2005 | 107.6 |
| 2004 | 107.0 |
| 2003 | 106.7 (EU 15) |

### 2.2. Current systems

The remainder of this chapter is taken from the Scientific Report on the impact on pig welfare of different space allowances and flooring types (EFSA, 2005) with some small additions.

The 25 EU countries have approximately 152 million pigs (Eurostat, 2007). Weights at slaughter differ markedly according to countries. Italy has a tradition of high carcass weights (up to 170 kg live weight), in connection with the production of dry meat products. On the contrary, UK, Ireland, Denmark, Greece and Portugal slaughter much lighter pigs. In the remaining countries, including most of the new EU member countries, carcass weights are in the range of 80-90 kg, corresponding to a live weight of 105-115 kg.

Over the last 15 years, there has been a general tendency for increasing carcass weights in most countries, including those slaughtering light pigs. This elevation in slaughter weight is likely to result in increased incidence of boar taint in entire males (EFSA, 2004a). Slaughter weights in the new member countries tend to converge towards the average slaughter weight in the 15 EU countries.

Although some pigs are reared in extensive outdoor facilities, most pigs in the EU are raised indoors under intensive farming conditions, which itself have implications for the local environment of intensive pig farms and also raise concerns for control of diseases. In intensive systems, three separate phases of production (farrowing, birth and neonatal period; weaning; and, growing and finishing) are recognised, and in many instances necessitate different feeding and housing conditions. The gestation length of the sow is approximately 112 to 115 days. The average litter size in the EU is 11. After birth, piglets are nursed by their dams for approximately 21 to 28 (in some member states up to 35) days. During this phase of production in most Member States, male piglets that will not be used for breeding are surgically castrated. In some countries this phase of life is spent outdoors. After weaning, piglets are generally moved to - and mixed with - members of other litters in specially designed housing systems for weaners. This phase presents the greatest management challenge as dietetic changes (from milk to solid foods at this early age) are frequently associated with disease outbreaks.

After about 5 weeks, when the piglets reach approximately 30 kg live weight the weaned pigs are moved on to further accommodation to finish their growth prior to slaughter. It is now rare that the weaning and fattening phases of a pig's life take place in outdoor facilities in the EU. As selection of individuals to fill pens in the fattening sheds is based on live weight, members of different litters may become penmates in the fattening pens. This mixing will provoke the establishment of new social hierarchies resulting in dominating and submissive behaviour. If entire (not castrated) males are becoming sexually mature at this stage, aggressive behaviour may be prolonged. There are a few incidences where pigs are housed together during the entire rearing period from weaning to slaughter. Ekkel et al. (1996) reported that health, production and welfare in general of pigs are improved when kept in these housing systems without being mixed or transported. However, due to economic reasons, different management and environmental requirements during the production phases, these systems are mostly found in some, mainly straw-based, housing systems in Scandinavia (Martinsson and Olsson, 1994).

Housing system designs are affected by a number of factors including, climate, legislation, economics, farm structure and ownership, research and traditions.

Recent EU legislation, combined with certain socio-economic issues, has had a great impact on pig housing systems in Member States. For example Council Directive 91/630 as amended by Council Directives 2001/88/EC (EC, 2001a) and 2001/93/EC (EC, 2001b) dealing with animal welfare and Council Directives 1996/61/EC (EC, 1996) and 2003/87/EC (EC, 2003) covering environmental concerns. And, added to the legislation, changes have also come about because of retailing standards applied in certain Member States that have had a major effect on the production methods used by some producers. Weaned pigs and fattening pigs are typically housed indoors, although there are housing systems that provide indoor housing with access to an outside area, although in some few cases, these pigs are also kept outdoors during the whole rearing period. Following group-farrowing, weaned pigs may remain in stable groups. Different climatic conditions and the availability of bedding material in various European regions also greatly influence the type of housing chosen. Deep-litter housing systems using straw or peat in buildings often kept at cooler temperatures are found more in Northern Europe, but are rare.

The length of time that pigs spend in the fattening sheds will be determined by their growth rate as in most systems live weight determines time of slaughter. The weight of carcasses will depend on the demand for meat cuts.

Indoor systems can be divided into 3 categories based on the manure-handling system adopted: deep-litter systems, scraped systems or slatted systems. Some of these systems provide different climatic zones where the pig can choose its microclimate for various activities (i.e. for resting in kennels or under thermo-boards). The latter systems may provide supplemented heating only in the lying area which reduces the overall energy input for the building.

In deep litter systems, the total area occupied by the animal has to be maintained in a clean and dry condition through regular provision and removal of absorbent bedding material. In such systems the animals will often subdivide the pen area into separate lying and dunging area, choosing to lie in the most thermally comfortable and undisturbed areas and excreting in areas of the pen which are cold, wet or draughty. Space requirements are therefore greater in these systems compared with fully or partly-slatted pens.

In scraped systems, the lying and dunging areas are made structurally distinct and the manure is removed at frequent intervals from the dunging area, often daily. Such systems require little or no bedding and make a lower space allowance for the animal.

There have been no very recent studies of the distribution of housing systems for weaners and for growers and finishers but Tables 3 and 4 show data from a 1999 publication. Housing systems with slatted floors are the most widely used throughout the EU. In these systems hygiene is maintained, usually in the absence of any bedding, by installation of slatted floors through which the excreta can fall and be stored in a physically separate place from that occupied by the animals. Floors may be fully-slatted over the entire pen area, or have a solid floored lying area combined with a slatted dunging area. Pens with partly-slatted floors may require more space allowance than fully-slatted floors. Partly-slatted floor systems need to provide enough space for pigs to be able to maintain separate and distinct lying and dunging areas, so that the solid portion of the floor and the pigs can be kept clean. Some pens are therefore equipped with two floor types that differ in the degree of perforation (i.e. 40% vs. 10 %; the area with lower perforation intended for lying) in order to reduce the risk for reduced cleanliness. More recently, slatted systems designed especially to reduce ammonia emissions have been developed.

**Table 3.** Distribution of housing systems for weaned pigs (weaning to 25-30 kg) in European countries (pigs x 1000; after Hendriks and Van de Weerdhof., 1999, on the basis of data from a questionnaire collected between 1996 and 1998, EAAP working group "Future Housing and Management for Pigs"). NB. The remaining 5% of piglets remain in lactation pen.

| | Without/restricted straw | | | | | | With straw | | |
|---|---|---|---|---|---|---|---|---|---|
| | Partly-slatted | | | Fully-slatted | | | Fully solid concrete | | |
| **Countries** | piglets | % | tr.[a] | piglets | % | tr.[a] | piglets | % | tr.[a] |
| **Belgium** | 405 | 18 | ↑ | 1689 | 75 | ↓ | 45 | 2 | → |
| **Denmark** | 1098 | 30 | ↑ | 2196 | 60 | ↓ | 366 | 10 | → |
| **France** | 696 | 16 | → | 3045 | 70 | ↑ | 522 | 12 | ↓ |
| **Germany** | 780 | 10 | ↓ | 5694 | 73 | ↑ | 702 | 9 | → |
| **Greece** | 105 | 25 | ↓ | 273 | 65 | ↑ | | | |
| **Hungary** | 21 | 5 | ↓ | 357 | 85 | ↑ | | | |
| **Ireland** | 855 | 15 | ↓ | 4788 | 84 | ↑ | | | |
| **Italy** | 124 | 6 | ↓ | 1656 | 80 | ↑ | 83 | 4 | ↓ |
| **Netherlands** | 1261 | 29 | ↑ | 2480 | 57 | ↓ | | | |
| **Portugal** | 180 | 18 | ↑ | 750 | 75 | ↑ | 20 | 2 | ↑ |
| **Spain** | 988 | 60 | → | 494 | 30 | ↑ | 82 | 5 | → |
| **UK** | 679 | 25 | ↑ | 950 | 35 | → | 1086 | 40 | → |
| **Total** | 7912 | 20 | → | 24372 | 67 | ↑ | 2906 | **8** | → |
| | | | | 32284 | **87** | ↑ | | | |

[a] tr.: trend in 1999

| | | | | | |
|---|---|---|---|---|---|
| ↑ | Increasing | → | Steady | ↓ | Decreasing |

**Table 4.** Distribution of housing systems for growers and finishers in European countries (pigs x 1000; after Hendriks and Van de Weerdhof., 1999, on the basis of data from a questionnaire collected between 1996 and 1998, EAAP working group “Future Housing and Management for Pigs”).

| | **Without/restricted straw** | | | | | | | | | **With straw** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Partly-slatted | | | Fully-slatted | | | Solid concrete | | | Solid concrete | | | Deep litter | | |
| **Countries** | finishers | % | tr.[a] | finishers | % | tr. | finishers | % | tr. | finishers | % | tr. | finishers | % | tr. |
| **Belgium** | 1092 | 31 | ↑ | 2291 | 65 | ↓ | | | | 71 | 2 | → | 71 | 2 | → |
| **Denmark** | 2185 | 35 | ↑ | 3558 | 57 | ↓ | | | | 312 | 5 | → | 187 | 3 | → |
| **Finland** | | ? | | | ? | ↓ | | | | | ? | ↑ | | | |
| **France** | 1099 | 11 | → | 7994 | 80 | ↑ | 599 | 6 | → | | | | 300 | 3 | ↓ |
| **Germany** | 9385 | 60 | ↓ | 4693 | 30 | ↑ | | | | 1251 | 8 | ↑ | 313 | 2 | → |
| **Greece** | 289 | 60 | ↓ | 193 | 40 | ↑ | | | | | | | | | |
| **Hungary** | 420 | 60 | ↓ | 280 | 40 | ↑ | | | | | | | | | |
| **Ireland** | 359 | 35 | ↓ | 615 | 60 | ↑ | | | | 51 | 5 | → | | | |
| **Italy** | 3558 | 60 | → | 1482 | 25 | ↑ | 890 | 15 | ↓ | | | | | | |
| **Netherlands** | 5997 | 83 | ↑ | 1084 | 15 | ↓ | | | | 145 | 2 | ↑ | | | |
| **Portugal** | 764 | 55 | → | 417 | 30 | → | 208 | 15 | → | | | | | | |
| **Spain** | 5818 | 50 | → | 5818 | 50 | ↑ | | | | | | | | | |
| **Switzerland** | 135 | 20 | ↑ | 405 | 60 | ↓ | | | | 135 | 20 | ↑ | | | |
| **UK** | 1756 | 37 | ↑ | 1803 | 38 | ↑ | | | | 712 | 15 | ↓ | 475 | 10 | → |
| **Total** | 32857 | 47 | ↓↑ | 30633 | 44 | ↓↑ | 1697 | 3 | ↓ | 2677 | 4 | ↑ | 1346 | 2 | ↓ |
| | Systems without/restricted straw | | | | | | 65187 | **94** | → | Systems with straw | | | 4023 | **6** | → |

[a] tr.: trend in 1999

| | | | | | |
|---|---|---|---|---|---|
| ↑ | Increasing | → | Steady | ↓ | Decreasing |

The following sections briefly review the design of typical commercial pig housing systems in the European Union with emphasis on floor design and space allowance.

## 2.3. Weaners

After weaning, the sow is returned to service accommodation and the piglets are either left in the farrowing pen (not very common) or more commonly, moved immediately to the weaner accommodation. The technology of segregated early weaning has been established primarily in large pig farm enterprises across North America. Segregated early weaning is characterised by weaning piglets at days 7-21 of age (mostly between days 12-16) and isolated housing in nurseries and growing / finishing units (multi-site production with all-in all-out pig flow). The goal of this technology is to break the infection chain by utilising acquired maternal (passive) immunity from the dam before piglets develop their own active immunity in response to pathogens (von Borell, 2000).

A variety of housing systems is used for weaned piglets. Piglets are typically housed in highly controlled environments with supplementary heating in partly or fully-slatted pens, or raised in flat decks, in groups of varying sizes (10-40). They may be moved from the first stage weaner accommodation to larger, second stage accommodation after 2-4 weeks or remain in the same pen until the age of 10 weeks (30-40 kg) or, in a few instances, until slaughter. The pen area per pig varies from 0.2 (< 20 kg) to 0.3 m2 per pig (< 30 kg). Weaner pigs are typically fed ad libitum (dry) or restricted (liquid) with an animal: feeder space ratio of 1: 1 to 12:1, depending on the feeding system.

Within nursery accommodation, the ambient temperature recommended by, e.g. Close and Le Dividich (1984) and Madec et al. (2003) and generally used (non bedded, perforated floors) is in the range 26-30 C e.g. a temperature of 28 C for piglets weaned at 26-28 days of age.

The following figures 3 to 8 are selected examples of housing systems taken from the IPPC-BAT Reference Document on the Intensive Rearing of Poultry and Pigs dated October 2000 (IPPC, 2000; 2003).

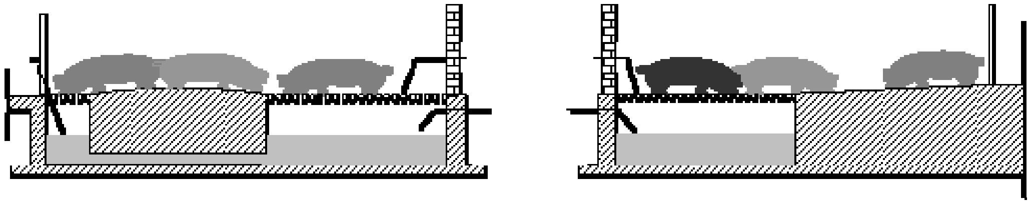

**Figure 2.** Partly-slatted and convex floor with iron or plastic slats (Hendriks and Van de Weerdhof, 1999).

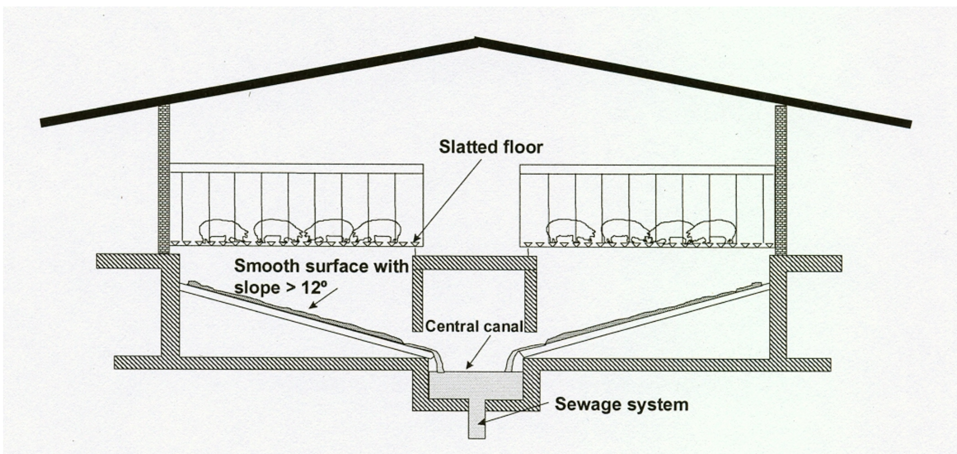


**Figure 3.** Example of flat decks with fully-slatted plastic flooring and sloped concrete floor underneath to separate faeces and urine (CRPA, 2003).

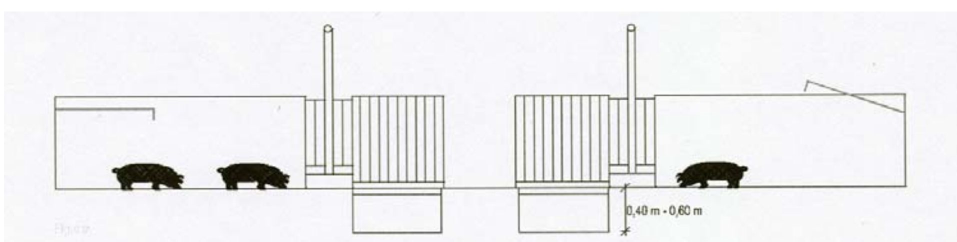


**Figure 4.** Rearing unit with partly-slatted floor and two-climate zones (IPPC, 2000).

## 2.4. Grower/ Finisher pigs

Accommodation for fattening pigs may be fully-slatted, partly-slatted, minimally bedded with scraped dunging area or deep bedded with straw or strawdust. Although there are national differences, housing with fully or partly-slatted flooring (typically on concrete slats with 17-20 mm slot spacing) with a pen floor area of 0.7 m2 at the end of the finishing period predominates within the EU. The recommended common range of temperature for buildings with non-bedded perforated floors is at 20-26C (Mc Farlane and Cunningham, 1993).

Feed might be provided either wet or dry. Feed is increasingly distributed automatically to sensor controlled liquid feeders or slop feeders (semi-liquid) with an animal feeding place ratio of max. 12:1. Dry feed is often given *ad libitum* from one or more hoppers, although feed may be restricted in the later stages to prevent excessive fatness of unimproved genotypes or with very heavy slaughter weights (>120 kg). Liquid feed is also restricted in Italian heavy pig production for animals weighing more than 60-70 kg. In controlled environment housing, it is common to use two or three housing stages with larger pens at each stage in the growing/finishing period, to make most efficient use of space (single-phase from 25-29 kg to 110-120 kg, two-phase with a grower period from 25-29 kg to 40-50 kg and a finisher period from 40-50 kg to 110-120 kg; Italy: 150-170 kg). Slaughter weights may be much lower (i.e. in the UK: 90 kg) in countries where male pigs are not castrated after birth. Feeding may be adjusted to the respective growing phase of the pigs. Traditionally, fattening pigs are housed in groups of 10-15, but recently the number of fattening units with large group sizes (24 pigs up to 40 and more) on perforated floors is increasing. Large group sizes are also typical for deep litter systems.

Kennels, intended to provide a separate resting area, can be included in all housing conditions. They are typically used in cold non-insulated buildings or outdoors. Combinations of kennels with the following floor types may require additional space per pig depending on the specific pen design features.

## 2.5. Fully-slatted floor

Slatted housing systems are widely used throughout the EU and in all other significant pig producing countries in the industrialised world. In these systems, slats cover the entire pen area, usually to maintain hygiene. Foraging material, if used (rarely), is small in quantity. From a technical point of view, flooring in unbedded systems should have sufficient perforation or slot-width to keep the pen clean from manure and urine. Studies have been carried out as laboratory tests as well as case studies (Seufert et al., 1980; Svennerststedt and Praks, 1997; Rantzer and Svendsen, 2001). The importance of designing slatted floors for avoiding emissions has been emphasised (Brok and Voerman, 1995).

The construction and design requirements for concrete slats are that of highest exposure class. Recommendations about design are to be found mainly for concrete and metal slatted floor constructions with less information for other (mainly plastic compound) constructions. The use of polymer and composite materials is increasing.

One vital component for the successful use of slatted flooring is the proportions of the floor solid and slot dimensions in relation to the dimensions of the feet of the pig at any given age. However, even the construction profile is critical: sharp edges may cause cut injuries as well as a compressive stress when the loading force will exceed the strength of the digits (Webb and Nilsson, 1983; Webb, 1984; Udesen, 1997). The lack of elasticity, besides softness, of hard flooring material such as metal constructions, is another critical characteristic and may explain the increased level of lesions (Fritschen, 1979).

Slatted flooring can contribute substantially to the cleanliness and health of an animal by allowing for the speedy removal of faecal and urinary products from the immediate environment of the animal, and thus assisting the provision of a dry lying area. Slatted systems generally give lower airborne endotoxin concentrations than litter based systems, due to bacterial contamination of straw and other litter materials (Seedorf and Hartung, 2002). The possible use of straw is strictly limited with fully-slatted floors.

<u>Usual characteristics</u>:

Pen floor area per pig: 0.4 $m^2$ (growing), 0.65-0.8 $m^2$ (finishing)
Concrete slats with 17 mm slot spacing

Pig: feeder place ratio 1:1 up to 12:1 depending on the feeding system

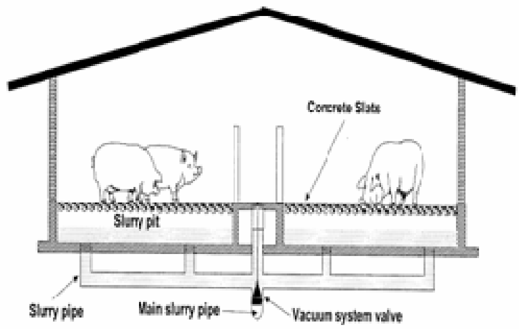


**Figure 5.** Example of growing-finishing unit with a fully-slatted floor (CRPA 2003).

## 2.6. Partly-slatted floor

Partly-slatted flooring may reduce emission of ammonia and other gases released from the excreta, and if correctly designed and well-drained, can lower emissions considerably. Partly-slatted floor systems, preferably with a raised level of the slatted part, allow for a fairly good supply of straw.

Usual characteristics:

Pen floor area per pig: 0.4 $m^2$ (growing), 0.65-0.8 $m^2$ (finishing)
Concrete slats with 17 mm slot spacing
Pig: feeder place ratio 1:1 up to 12:1 depending on the feeding system

a) b)

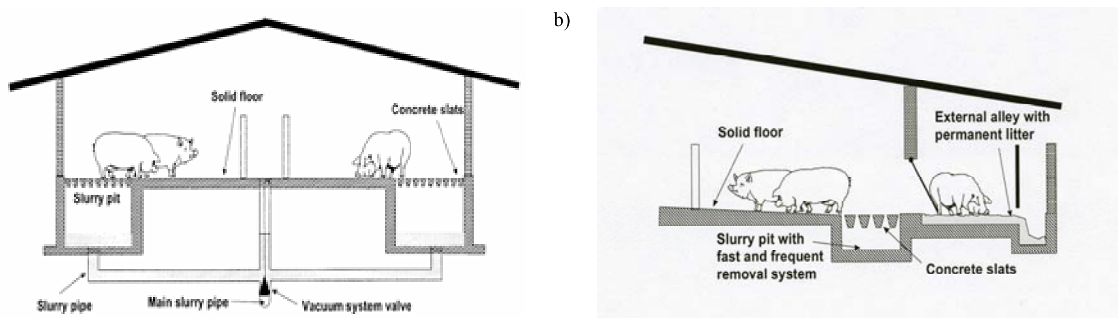


**Figure 6.** Example of: a) Partly-slatted floor with deep slurry pit; b) Partly-slatted floor with fast removal of slurry and littered external alley (CRPA, 2003).

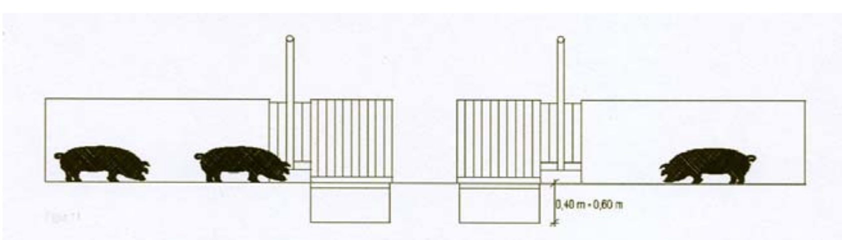


**Figure 7**. Growing-finishing unit with a partly-slatted floor (IPPC, 2000).

## 2.7. Solid floor, no bedding

Solid floors (concrete constructions) are used with all pigs from weaning to slaughter as the only floor type, or in combination with other constructions, where the resting area is of solid construction. The solid floor is characterised by a non-perforated surface where properties may differ according to the choice of surface treatment and materials in the concrete. The construction and design requirements for concrete are that it be of the highest exposure class to resist feed residues, faeces, urine, chemicals and high pressure cleaning (Nilsson, 1988; Jacobsen and Nielsen, 2001; Olsson et al., 1993).

Traditionally, solid concrete floors are used for both the resting and defecating areas. The manure is scraped, manually or by mechanical scrapers at frequent intervals and the urine usually drained separately. The slope towards the dunging area is about 3 % (Jacobsen and Nielsen, 2001).

A dry concrete floor can easily be warmed and it will retain heat quite well, but it will worsen the harmful effects of low temperatures if floors or bedding are cold or damp. Therefore, solid floors are found to need either insulation, or support from a floor heating system (warm water pipes or electric cables), whether used with or without small amounts of bedding materials (Nilsson, 1988).

Usual characteristics:

Solid pen floor area per pig: 0.5 $m^2$ (growing), 0.9-1.0 $m^2$ (finishing)
Flat or sloped (with 3 % gradient) solid floor, typically combined with an internal or external alley with a scraped manure canal
Pig: feeder place ratio 1:1 up to 12:1 depending on the feeding system.

## 2.8. Solid floor, some bedding (sloped-floor/straw-flow system)

The straw-flow system is used for growing pigs from 10 weeks (20–30 kg) to slaughter (90–150 kg). The straw-flow pen system is characterised by sloping concrete floors, where the laying area has a curved surface, gradually increased sloping, or an equal slope of about 5-7% towards the dunging area. The resting area is sometimes levelled about 5 cm above the manure area, which has a slope for allowing the manure to flow down into a manure channel or pit. The total depth of the straw-flow pen has to be limited to about 6 m. Contrary to deep-straw systems, the group-size in straw-flow systems will be about the size of a litter and is not recommended for more than 30 individuals (Brogaard-Petersen and Jensen, 1996; Jackisch et al., 1996; Andersson et al., 1998). For the flow function of the pen, the amount of 50 grams of straw per pig / day is satisfactory; the amount may not exceed 100 grams for avoiding clogging or a flow malfunction. Uninsulated floors, however, need a bedding depth of at least about 75 mm for the weaned pig to achieve a thermal resistance to the floor above about 0.5 (Bruce, 1990; Kelly, 1996; Brogaard-Petersen and Jensen, 1996).

Usual characteristics:

Pen floor area per pig: 0.5 $m^2$ (growing), 0.9-1.0 $m^2$ (finishing)
Sloped solid floor with 8-10 % gradient with some bedding (straw from rack)
Pig: feeder place ratio 1:1 up to 12:1 depending on the feeding system

## 2.9. Deep litter system

Deep bedding (> 10 - 15 cm bedding) with bedding materials such as straw, saw dust, wood chips, peat etc. usually have a solid concrete floor underneath, although even a slatted floor may be used for drainage purposes of the litter bedding. The use of a deep bedding system demands good facilities for removing the bedding and cleaning/disinfecting in a strict batch system. Provision of straw, especially straw of poor quality, and the use of wood chips and saw dust, will increase the production of airborne particles such as dust, moulds and fungi associated with respiratory disturbances in pigs and humans (Boon and Wrey, 1989; Jensen, 2003).

The deep litter system has disadvantages in increased emissions of, among other things, ammonia, nitrous oxide ($N_2O$), nitrogen and methane (Groenestein and Van Faassen, 1996). The amount of nitrogen excreted by the pigs will emit to the atmosphere up to 90 - 95 % depending upon type of bedding, temperature and other storage conditions (Jeppsson, 1998; Nicks et al., 2004).

In insulated buildings (and during summer periods in uninsulated ones) the UCT (upper critical temperature) of the deep bedding systems, especially when the bedding is "fermenting" and producing a large amount of heat, may be critical in creating thermoregulatory problems, resulting in heat stress and decreased performance; the heat production will also lead to an increased evaporation of water (Van den Weghe et al., 1999).

Deep straw bedding for pigs from weaning to 10 weeks (20-30 kg) and from 10 weeks (20–30 kg) to slaughter (90–150 kg) may take place with a wide variation of pen designs, feeding and management systems. The group size is usually more than 30 pigs with an area of at least 0.5 m2 and 1.0 m2 per weaner and grower, respectively. The use of straw is approximately 1 kg per kg live weight gain (Jensen and Nielsen, 2004; Brogaard-Petersen and Jensen, 2003 and 2004).

Usual characteristics:

Pen floor area per pig: 0.5 $m^2$ (growing), 1.0-1.2 $m^2$ (finishing)
Straw bedded deep litter pen with elevated feeding area
Pig: feeder place ratio 1:1 up to 12:1 depending on the feeding system

## 2.10. Outdoor / semi-outdoor rearing on earth or concrete

### 2.10.1. Mediterranean silvopastoral systems

This traditional Mediterranean system involves indigenous breeds that are extensively pastured in natural forests for the production of high-value dry-cured hams (Dobao et al., 1988). Typically, all phases of production take place outdoors, sometimes in extreme conditions in mountain zones. The finishing takes place during autumn in forests of oak or chestnut.

### 2.10.2. Pigs reared to organic standards

Whilst accounting for a small minority of pigs in the EU, this category includes most outdoor growing pigs since it is a requirement of the European Community standards for organic livestock and livestock products (Directive EEC 2092/91 as amended by Council Regulation EC 1804/1999) that organic pigs be maintained with outdoor access for the majority of their life. In some certification schemes (e.g. the UK Soil Association) it is also a requirement that finishing pigs be kept at pasture, although this is not universal and in many countries growing and finishing pigs are housed with an outdoor run area which may be of concrete (Olsen, 2001; Kelly et al., 2007). Minimum space allowances are specified by the Directive for both indoor and outdoor areas, and are greater than those required for other commercial pigs (see Table 5).

**Table 5.** Minimum space requirements for organic pigs (Council Regulation EC 1804/99)

| | | Indoor area ($m^2$/head) | Outdoor exercise area ($m^2$/head) |
|---|---|---|---|
| Piglets | Up to 30 kg | 0.6 | 0.4 |
| Fattening pigs | Up to 50 kg | 0.8 | 0.6 |
| | Up to 85 kg | 1.1 | 0.8 |
| | Up to 110 kg | 1.3 | 1.0 |

### 2.10.3. Field rearing

Outdoor rearing in fields can be divided into two types. In the first, free-range pigs are provided with a large paddock and simple shelter, whilst in the second they are confined within an outdoor hut-and-run system.

### 2.10.4. Paddock systems (free-range production)

In true paddock systems, pigs have the free run of a fenced paddock area. The stocking rate suggested has been approximately 4,000 kg/ha (Brownlow et al., 1995), giving 40-50 finishing pigs/ha, although this will depend on soil type and climatic conditions. Housing for free-range pigs depends on climate and group size and typically comprises corrugated iron arcs or wooden sheds, although tents have more recently been adopted on a few farms. Housing is generally moveable, so that each new batch of pigs can begin in a clean paddock with a newly resited house.

### 2.10.5. Tents and deep-litter paddocks

This system has been developed in Denmark (Jensen, 1994) and is not seen widely in the EU. The objective has been to provide outdoor housing on a semi-permanent site whilst controlling pollution risk. The tents have roofs of 16-guage double skin transparent polyethylene film supported by a 10 m central pole and shorter poles around the circumference. The walls are made of 2 layers of straw bales, protected by wire mesh. The inside area of 40 $m^2$ houses 100 pigs from weaning to slaughter. The outdoor area provides 1.8 $m^2$ per pig and is bounded by an electric fence. To prevent leaching of nitrate, the topsoil is removed from this area and banked around it. A 1mm density polyethylene membrane is placed at the bottom, with 10 cm layers of sand on both sides. An 80 cm drainage layer of crushed shells is then covered by a top layer of 10 kg straw per $m^2$.

### 2.10.6. Hut-and-run systems

In these systems, the pigs are provided with a hut and small outdoor run area bounded by solid fencing and bedded with straw to maintain hygiene. One common type features a wooden hut of 2.4 x 6.1 m with an insulated steel roof, and an outdoor run of ~33 $m^2$ to house 25 pigs from 30 to 90 kg (Figure 8). The hut has an adjustable ventilator and contains and integral feed hopper with large capacity and water tank holding a one day reserve supply. It is moved to fresh ground for each new batch of pigs.

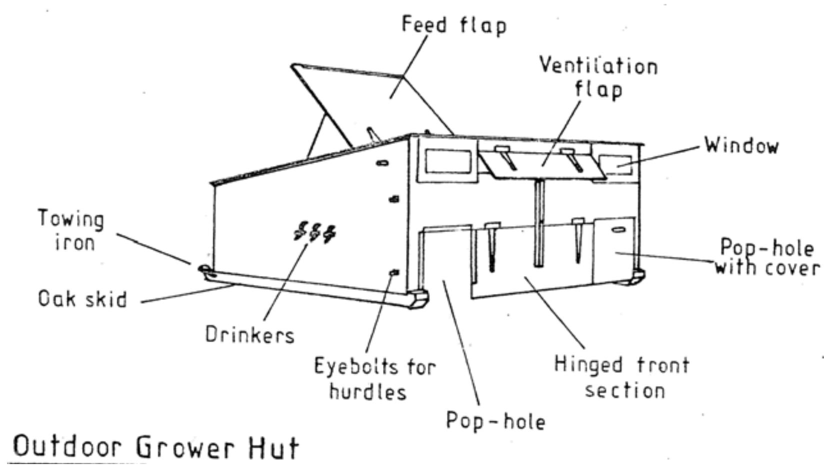


**Figure 8.** Outdoor growing hut for fattening pigs (drawing E. von Borrell )

## 3. Introduction to Tail Biting issues

Tail biting and tail docking are major welfare concerns for pigs, especially those kept in barren intensive husbandry systems (e.g. Fraser and Broom, 1997; Anonymous, 2001). Most piglets born in such intensive systems have their tails docked (i.e. cut off without anaesthetics) at an early age in order to prevent problems with tail biting later in life.

Tail biting, i.e. one pig biting the tail of another pig, indicates that welfare is poor not only in the victim whose tail is injured, but also in the biter (SVC, 1997). A tail biting victim will suffer pain and fear, because in a tail biting outbreak biting pigs will often attack victims with increasing persistency and perseverance. In small pens victims are unable to escape from the attacks and biters become excited mainly because of the taste of blood and other stimulation (e.g. increased activity) in the otherwise barren environment. In the absence of stockman interference this may lead to an escalation of tail biting behaviour and the problem may involve more pigs in the pen being involved in the biting and being bitten.

Even though the origin of tail biting behaviour is not fully understood, tail biting is considered to be an abnormal, pathological behaviour as it occurs mainly (though not exclusively) in pigs kept in barren environments. In such environments pigs have an increased motivation to bite and chew the tails of other pigs presumably because they are frustrated, especially in their need to perform exploration, play and foraging behaviours, including the rooting and chewing of objects (see chapter 8.5).

This report updates an earlier report (SVC, 1997), which suggested that solutions exist that do not require tail docking. It concluded its short section on tail docking as follows: ‘When pigs with intact tails are fed an adequate diet, provided with sufficient water, provided with straw or other manipulable materials, or earth for rooting, and kept at a stocking density which is not too high, tail-biting is seldom serious (Van Putten, 1980; Feddes and Fraser, 1993; Fraser, 1987a, b; Fraser and Broom, 1990). Tail-biting is an indication of an inadequate environment and indicates that welfare is poor in the animal carrying out the biting’ (SVC, 1997). This statement indicates that tail biting is a multifactorial problem. When studies on tail biting are reviewed several points may be noted. Firstly, most observations on tail biting refer to clinical observations of tail wounds. In some cases behavioural observations have been made of tail-in-mouth behaviour (often seen as a precursor of tail biting). Direct observations of tail biting behaviour actually leading to tail wounds are limited in number and mainly involve casual observations.

A second point is that different kinds of studies are included in the present review. Experimental studies directly focussing on tail biting are rare and those studies that exist have often been conducted on problem farms, which may not be representative of the population of farms in the EU reviewed here for the purpose of Risk Assessment. Experimental studies are best suited to assess causal relationships, which are formally required for hazard characterisation. Other studies on tail biting may have been conducted at the farm or at the slaughterhouse. Information from the farm was collected by scientists using questionnaires (surveys) and by direct observations of live animals by scientists or practitioners, while information from the slaughterhouse was collected, usually from inspection of carcases, by scientists and by meat inspectors. As a consequence of these differences studies may differ considerably with respect to reliability and validity for assessing tail biting. They provide correlational evidence which cannot establish causal relationships on its own.

A third point is that most available information concerns docked pigs. In this report it will be specified whether pigs were docked or not when tail status was known. In addition, where possible in the following sections, the type of behaviour studied is described either as 'tail-in-mouth' / tail-chewing behaviour or as (clinical) tail-biting implying that clear evidence of damage to the tails has been observed. However, it should be noted that some studies do not make this distinction.

## 3.1. Tail biting process

Two stages may be distinguished in the development of tail biting (Fraser, 1987b; Schrøder-Petersen and Simonsen, 2001): The pre-injury stage, before any visual wound on the tail is present, and the injury stage, where the tail is wounded and bleeding.

Tail-biting outbreaks are usually preceded by a period of tail-chewing or tail-in-mouth (TIM) behaviour, i.e. soft, nibbling manipulation of the tail of another pig. This does not cause obvious macroscopic damage to the tail, but histological examination may reveal inflammation suggesting that damage has been done (Simonsen et al., 1991). TIM behaviour is often performed when both biter and victim are lying down (Van Putten, 1980) and may result in the loss of hair of the (tip of the) tail, a sore skin and minute skin lesions (bite marks) that may be visible on close inspection of the tail (Buré, pers. comm.). Substantial hair loss was found in tails swollen due to tail biting compared with normal tails (Treuthardt, 2001; 0.93 and 1.80 hairs/mm$^2$ respectively). Although the pre-injury stage may include a period of increased restlessness, this period is mostly passed unnoticed by the farmer (Schrøder-Petersen and Simonsen, 2001).

The first stage may, more or less rapidly, result in a clear wound to the tail with associated bleeding. This is the injury-stage, the 'tail-biting outbreak', as in this stage restlessness dramatically increases as other individuals become attracted to the blood and to the ongoing tail biting activity in the pen.

Some information is known about the time of day tail biting is likely to occur. For example, Haske et al. (1979) suggested tail- and ear-biting was more frequent before midday. Pigs are normally more active during daylight hours (Fraser and Broom, 1990). Therefore it seems reasonable to assume that tail biting mainly occurs during that time (Schrøder-Petersen and Simonsen, 2001). Contrary to the suggestion made by Haske et al. (1979), chewing (on a chewing sensor) showed daily peaks at mid-day and late afternoon, corresponding to the animals' diurnal pattern of general activity but not corresponding to feeding behaviour (Feddes et al., 1993). Since nibbling behaviour directed towards the ears and tail is often performed by an active pig towards a motionless pen-mate (Van Putten, 1980; Arey, 1991), transition to the resting phase may be a critical period. This suggestion is in accordance with the finding from Petersen et al. (1995) that manipulation of littermates was related to lying inactive in the barren pens at all ages (4, 7, 18 weeks) and in the enriched pens at 4 weeks of age.

In this report a number of factors increasing the risk for tail biting, called hazards, will be discussed. Though much is known about a wide range of hazards, the exact triggering mechanisms remain elusive. Tail biting is considered an unpredictable event on farms that may have a multi-factorial origin (Moinard et al., 2003; Bracke et al., 2004a, b), and several authors have reported failed attempts to induce tail biting experimentally (Van Putten, 1969; Ewbank, 1973).

Hazards reviewed in this report include animal characteristics (such as breed, gender and age), the rearing environment, the social environment, substrate, floors and space, diet and feeding, health, climate, tail docking and tail injuries. The identified hazards can be related to this primary chain of events within the context of the conceptual framework for welfare assessment (Wiepkema, 1987; Anonimus, 2001; Bracke and Hopster 2006; Bracke, 2007b). In this framework causal factors are welfare 'design criteria'. The design criteria represent the properties of the animal's (physical and social; present and past) environment. The past environments co-determine the animal's norms/biological needs through e.g. natural selection and conditioning. Within this biological framework the modern pig is still motivated to perform behaviours, such as exploring, foraging, rooting, biting and chewing, that were functional for its survival in its environment of evolutionary adaptation (Jensen 1980, Stolba and Wood-Gush 1989, Wood-Gush et al. 1990). These behaviours have been selected during evolution (and domestication) as parts of animals' cognitive-emotional systems (Wiepkema, 1987) that specify the animals' motivational systems or welfare needs (Bracke et al., 1999; Wiepkema and Koolhaas, 1993).

Feedback loops may act at different stages of the animal's engagement with its environment. For example, pigs will naturally gnaw novel objects (Fraser, 1984). When a suitable material is unavailable, pigs may show appetitive search behaviour directed towards other pigs, floors and components of the pen, which is generally accepted as reflecting reduced welfare (Van Putten and Dammers, 1976, Fraser, 1978, McKinnon et al., 1989). Since this exploration does not give proper feedback, the pigs will tend to investigate the body parts of conspecifics, which are more interesting to the pigs because they are more soft, pliable, responsive and destructible (Feddes and Fraser, 1994; Sambrook and Buchanan-Smith, 1997). Pigs may take the tail in the mouth and chew on it (Van Putten, 1968). This behaviour is not only directed to the tails, but also to the ears of pen mates. The ears are very sensitive and ear biting may be perceived as agonistic behaviour. By contrast, manipulation of the tail elicits much less aversive responses. In addition, the size and shape of the tail may be more convenient for manipulation (Feddes and Fraser, 1994) and, when the tail has become slightly damaged, the manipulation of the (itchy) tail may even be perceived as pleasant (Van Putten, 1968). Therefore, when pigs fail to find a suitable substrate, secondary strategies will develop such as tail biting (Van Putten, 1969; Apple and Craig, 1992) or related problems such as ear and flank biting (Fjetland and Kjaestad, 2002). The non-destructive, harmless chewing by pigs on their pen-mates and surroundings can thus be considered to be a likely behavioural pre-cursor of tail biting outbreaks (Feddes et al., 1993; Feddes and Fraser, 1994).

Tail biting may, therefore, be related to the pigs' motivation to explore novelty, to search for food and general occupation. In addition, tail biting has also been related to instabilities in the social hierarchy (Hansen and Hagelsø, 1980). Especially, attacks of pigs unable to reach the feeder may result in tail biting (Hansen et al., 1982). This has been related to a natural tendency of male pigs to fight for food (Wallgren and Lindahl, 1996).

A tail wound causes pain and escape behaviour in the bitten pig. Blood (and other tissue) is attractive to many pigs (Fraser, 1987a), often leading to rapid escalation of the problem. Other pigs may become involved in the process, both as victims and as biters. Pigs in neighbouring pens may also be induced to start tail biting (Blackshaw, 1981). Escape behaviour may include running away and hiding the tail from further assault, e.g. by hiding the tail between the legs or in a corner of the pen. Changes in tail postures may also affect the tail biting process in that an exposed tail tip (tail held straight) is likely to attract more biting than a tail held in a loop/curl (Feddes and Fraser, 1994). Pigs with open tail wounds will often be reluctant to eat, as standing at the feeder exposes the tail to further attacks. Severe tail wounds may lead to loss of blood, weakness and lack of appetite (Schrøder-Petersen and Simonsen, 2001).

Continued tail biting may lead to increasingly extensive tail wounds (large parts of the tail being wounded or bitten off). The tail is pulled hard to effectively tear off pieces of tissue. This may result in fraying of the sinuous tissues of the tail. Victims try to escape, but are repeatedly attacked. Lesions may escalate to large wounds around the base of the tail and eventually death (Van Putten, 1968, 1969; Fritschen and Hogg, 1983; Schrøder-Petersen and Simonsen, 2001). Usually a single victim is attacked in a pen. The other animals may hunt the victim as a group.

## 4. Current situation on tail biting

### 4.1. Recorded Prevalence in EU

The incidence of tail biting in European countries has been estimated by different methods. The most common is by monitoring of tail damage on carcasses at the abattoir. This offers the advantage of simple and rapid monitoring of animals from many farms, but will underestimate the real prevalence of tail biting, since some pigs will die or be euthanized on the farm if tail damage is severe or results in generalised infection. Other pigs with mild tail damage may heal before slaughter and be undetected amongst other tail-docked pigs. Data collected as part of routine national meat hygiene monitoring schemes suggest lower prevalence than recorded in specific experimental investigations. For example, in a Swedish study, Keeling and Larsen (2004) recorded prevalence of 6.2 and 7.2%, whilst slaughterhouse records showed only 1.9%. Thus it is likely that abattoir records often note only severe cases associated with infection and condemnation.

A summary of published information (Table 6), suggests that in docked pigs the prevalence of pigs with any signs of tail lesion at the abattoir is ~3%, with 0.5-1% fresh injury and infection. In undocked pigs the prevalence of lesions is higher at 6-10%, with up to 30% damaged tails reported in a Finnish study (Valros et al., 2004), with 2-3% severe damage and infection.

There is only limited information on the relationship between abattoir prevalence and on-farm prevalence of damaged tails. A Danish study involving 111 herds showed that herd prevalence estimated by clinical examination on farm was twice that detected by carcass inspection at the abattoir (Busch et al., 2004).

Estimates of the prevalence of farms experiencing tail biting, and the prevalence of lesioned pigs on farm, are less frequent. They often rely on farmer reports and do not precisely quantify the magnitude of problems. A summary of published information (Table 7), suggests that 30-70% of farms have some degree of problem, with estimates of the prevalence of lesioned tails on farm varying widely but of the order of 1-5%.

**Table 6.** Summary of results of abattoir monitoring of tail biting.

| Country | Date | Docked?* | No examined | Prevalence | Reference |
|---|---|---|---|---|---|
| **1. Specific studies** | | | | | |
| Finland | 2000 | no | 10852 pigs<br>479 farms | 34.5%<br>- healed 22.8%<br>- fresh 11.7% | Valros et al., 2004 |
| England | | yes | 1 abattoir,<br>12 months<br>11,811 pigs | 0.07% | Penny and Hill, 1974 |
| England | | no | As above | 11.6% | Penny and Hill, 1974 |
| UK | | yes | 5 abattoirs<br>45,788 pigs | 3.3% | Guise and Penny, 1998 |
| UK | | no | As above | 9.4% | Guise and Penny, 1998 |
| UK | 1997 | yes | 6 abattoirs,<br>1 week each<br>62,971 pigs | 3.1%<br>-healed 2.4%<br>-fresh 0.7% | Hunter et al., 1999 |
| UK | | no | As above | 9.2%<br>- healed 6.9%<br>- fresh 2.3% | Hunter et al., 1999 |
| UK (Northern Ireland) | | ?yes | 75,000 pigs | 0.73% | Huey, 1996 |
| Sweden | | ?no | | 6.2% & 7.2% | Keeling and Larsen, 2004 |
| Norway | | ?no° | 85,000 pigs | 2.3% tail inflammation | Flesjå and Ulvesæter, 1979 |
| Norway | 1975-77 | | 9,800 pigs | 3.0% tail inflammation | Flesjå et al.,1984 |
| Norway | 1995-2002 | ?no° | | 4% lesions | Fjetland and Kjeastad, 2002 |
| **2. Data from meat inspection records** | | | | | |
| Denmark | 1994 | ?yes | 20 million pigs | 0.22% | Schroeder-Petersen and Simonsen, 2001 |
| Denmark | 1998 | ?yes | 20 million pigs | 0.62% | Schroeder-Petersen and Simonsen, 2001 |
| Denmark | | ?yes | national | 3-4% tail bitten<br>0.14% abscesses | Treuthardt, 2001 |
| Denmark | 1999-2001 | ?yes | 111 herds<br>for 12 weeks | 0.62 | Busch et al., 2004 |
| Sweden | 1996 | no | 318 units | 2.7% | Holmgren and Lundeheim, 2004 |
| Sweden | 1995-96 | | | 3.4% | Holmgren and Lundeheim, 1997 |
| Netherlands | 1987-89 | yes | 550,000 | 0.05-0.49 | Elbers et al., 1992 |
| Netherlands | 1965 | ?yes | 300,000 pigs | 0.5% infected tails | De Bruin, 1967 |
| Netherlands | 1972, 1974 | ?yes | | 0.18, 0.33% infected | Meijer et al., 1976 |
| Netherlands | 1979 | ?yes | 1 million pigs | 0.5% tail infections | Van den Berg, 1982 |
| Netherlands | 1983 | ?yes | | 1.5% tail infections | De Kruijf and Welling, 1988 |
| Netherlands | 1987-88 | ?yes | | 0.6% | Huiskes et al.,1991 |
| Netherlands | 2001 | ?yes | 1 abattoir<br>137,260 pigs | 0.19% condemned | Brinkhuis, 2001 (cited in Zonderland and Spoolder, 2001) |
| Netherlands | 2001 | ?yes | | 0.14-0.24% condemned | Noort, 2001 (cited in Zonderland and Spoolder, 2001) |
| UK | 2005-06 | Mostly yes | National abattoir monitoring | 0.7% tail damage | BPHS, 2006 |

* ?yes or ?no means although the paper did not give information on docking status, it can be assumed from commercial practices in that country. ° Data very likely refer to undocked pigs since tail docking is not practiced in Norway.

**Table 7.** Summary of results of on-farm surveys of tail biting.

| Country | No of farms | Docked | Measure | % of farms | % pigs/farm | Reference |
|---|---|---|---|---|---|---|
| **1. Postal survey or farmer report** | | | | | | |
| Finland | ? | No | Treatment for tail biting | 69% | 3% | Heinonen et al., 2001 |
| UK | 46 | | Tail biting in the last year | 66% | | Chambers et al., 1995 |
| Netherlands 1973 | national | ?yes | Occurrence of tail biting | 30% | 0.4% mild<br>0.4% severe | Hoornweg, 1973 |
| UK | 415 herds | mixed | Tail damage prevalence estimated by vet | | 0.9% | NADIS, 2006 |
| **2. Assessment during specialist visit** | | | | | | |
| Denmark 1999-2001 | 111 herds 151,000 pigs | ?yes | Pigs with tail lesions | | 1.2 | Busch et al., 2004 |
| Finland | 16,000 pigs | | Tail bitten pigs ~25 kg | | 8% | Tiilikainen, 2000 |
| Belgium 2003-4 | 60 herds | yes | | | 1.3% mild<br>0.9% severe | Smulders et al., 2007 |

Because of the lack of comprehensive recent information, the Working Group made a survey of the current tail docking and tail biting situation within the EU member states. A summary of the collected information arising from the survey is given in Annex 2. This indicated that the percentage of undocked pigs in the survey countries varied widely from <1% to 100%, with an EU mean of 5-10%, and the prevalence of tail bitten pigs also varied widely and was often unknown.

## 5. Welfare and health aspects of tail biting

### 5.1. Behaviour (frustration, biters/bites/victims)

The behavioural and putative ‘psychological’ state of tail-biting pigs has been discussed by some authors. Van Putten (1969) suggested that pigs with no straw to root in become restless and redirect their rooting and chewing behaviour to the tails and ears of pen mates (see also Wood-Gush and Vestergaard 1989). Thwarting access to a preferred substrate may result in a state of frustration that motivates the redirected behaviour (van Putten 1969; Schrøder-Petersen and Simonsen 2001). Thwarting of feeding motivation has also been proposed as a cause of stereotypic behaviour in sows (Rushen 1985; Lawrence and Terlouw 1993), though tail-biting is not usually considered to be a true stereotypy. More generally, many authors suggest that ‘stress’ may underlie the development of tail-biting behaviour, partly based on observations that tail-biting appears to occur under conditions that seem likely to be stressful (e.g. over-crowding, poor air quality, barren environments, (Schrøder-Petersen and Simonsen 2001; Moinard et al. 2003; see later), and also that animals experiencing an outbreak, and perhaps prior to the outbreak sometimes appear ‘restless,’ active and agitated (Svendsen et al., 2006). Stress is usually not clearly defined, but the implication is that poor welfare or a negative (affective) state may accompany and perhaps underlie the expression of tail-biting and other forms of abnormal behaviour. Independent measures of the physiological stress state of tail-biting pigs (e.g. activity of the hypothalamic-pituitary-adrenal (HPA) and sympathetic-adernomedullary (SAM) axes) might provide support for this hypothesis, although studies by Jankevicius and Widowski (2004) indicate that injection of ACTH does not enhance chewing at a tail-like object as might be anticipated if HPA activation was directly linked to the expression of tail-chewing / biting behaviour. McIntyre and Edwards (2002c) reported that tail biting pigs tended to have higher neutrophil:lymphocyte ratios than control penmates, possibly indicative of a physiological stress state. Some authors consider tail-biting to be related to dominance status (Blackshaw, 1981), or an abnormal expression of aggression (Hansen and Hagelsø, 1980). In general, however, the context in which it is shown and its motor form are different to those typical of competitive aggressive encounters (Rushen and Pajor, 1987), and it seems unlikely that it shares the same motivational basis. It has also been suggested (M. Gunn, pers. com.) that pain and irritation due to eruption of new teeth might stimulate chewing behaviour.

In contrast to the above suggestions that tail-biters may be experiencing some negative state or poor welfare, some researchers have emphasised the 'calm' and 'quiet' nature of tail-in-mouth behaviour that occurs in the absence of obvious clinical damage to the tail (e.g. Van Putten, 1980). Schrøder-Petersen et al. (2004) suggested that this form of behaviour may be linked to general exploration of the environment, and particularly social exploration – for example, they found that ano-genital nosing was closely linked in time to performance of tail-in-mouth behaviour. Sambraus (1985) also suggested a link between anal massage behaviour and tail-biting. Manipulation of the tail might therefore also occur in a relatively non-aroused state (in contrast to a state of 'frustration' which is typically considered to be linked to enhanced activity; e.g. Roper, 1984), including in more extensive environments where foraging substrate is available (e.g. Newberry and Wood-Gush, 1988) as well as in more barren environments where there is little stimulation (Petersen, 1994).

It therefore seems likely that the behaviour and psychological state of tail-chewing or tail-biting pigs may vary according to situation. Low level and non-damaging chewing behaviour may be performed by pigs that are relatively calm, but also by those that are experiencing some level of stress or frustration. When tails are damaged and blood is present, motivation to investigate tails may increase amongst previously uninterested pigs and lead to intense and focused biting behaviour perhaps driven by an attraction to blood (Fraser, 1987b); but see Jankevicius and Widowski, 2003, 2004). Specific attempts to measure correlates of affective state in tail-biting pigs (see Paul et al., 2005) would provide more information on this issue and build on what are, in general, inferences made from behavioural observations.

The behaviour and psychological state of bitten pigs has received even less direct attention in the scientific literature. A general observation is that pigs whose tails are being gently chewed by others appear to tolerate this and often do not move from a lying position (Van Putten, 1980; Fraser, 1987b). For these animals, there may be little effect of the chewing behaviour, at least in the short-term. However, chewing or biting that leads to damage to the tail such as breaking of the skin, may result in irritation or pain, an increase in tail movement and avoidance behaviour (Van Putten, 1969; Schrøder-Petersen and Simonsen, 2001). Vigorous biting or pulling at the tail may be accompanied by vocalization and rapid evasive action by the bitten pig (Poppy Statham, personal communication). Pigs with open tail wounds may be reluctant to eat, as standing at the feeder exposes the tail to further attacks. Severe tail wounds may lead to loss of blood, weakness and lack of appetite. In these cases, the animals are likely to be in a state of pain or distress (for more information on pain, see next section). Sambraus (1985) suggests that pigs that have been repeatedly and severely tail-bitten may give up avoiding others and lie down, a state that could be linked to the phenomenon of learned helplessness which has been used as a model of depression (Maier and Seligman, 1976). Whether pigs in a pen with a tail-biting outbreak, who themselves have not yet been bitten, experience states such as fear or anxiety is possible, but at present unknown.

Overall, tail-biters may be experiencing poor welfare due to frustration of specific needs. Pigs that have had their tails gently chewed appear not to be affected by this, but those whose tails have been bitten and injured are likely to experience pain (described in the next section) and distress. There are limited scientific observations to allow a clear view of the affective experiences of pigs that are in a pen where tail-biting is occurring but who have not yet been bitten.

### 5.1.1. Injuries, infections and pain

Tail biting is the most common cause of secondary bacterial spread in pigs and subsequently increases the risk of carcases being discarded due to abscessation (Huey, 1996). Infectious thrombi from an infected tail may travel through lymphatic vessels to lumbar or thoracic vertebrae where osteomyelitis is most commonly seen (Hagen and Skulberg, 1960; Huey, 1996). Huey (1996) records that tail biting was the cause of infections in 61.7% of all the carcasses with lesions at more than one site and that abscesses were found at one site only in 2.87% of carcasses examined and in 0.26% of carcasses having lesions in more than one site. Besides causing spinal abscesses, infection may reach the lungs, less commonly the kidneys and other parts of the body, as a result of pyaemia (Hagen and Skulberg, 1960; Fraser and Broom, 1990).

The major clinical consequence of a spinal abscess is posterior paralysis. As it is illegal to transport a paralysed pig to a slaughterhouse, information from slaughterhouses probably under-estimates the prevalence of the problem. However, paralysed pigs have to be considered as a total loss for the producer. Often the pathogenic bacteria found in the lungs belonged to the genus *Arcanobacterium* (*A. pyogenes* http://www.bacterio.cict.fr/bacdico/nomstaxons.html) (Hagen and Skulberg, 1960) Data from slaughterhouses probably also underestimate the incidence of tail biting as even in tails that appear normal there may be minor inflammatory reactions, presumably caused by the chewing activities of pen-mates (Simonsen et al., 1991). Even mild tail damage, restricted to puncture wounds can quite readily set up pyaemia (Smith and Penny, 1998). Tail biting was associated with the main cause of carcases condemnations due to pyaemia - 94.4% (Lee *et al*., 1993). Pigs that had their tails bitten had more damage to other parts of their carcass, including significantly more ear damage (12.5 v 5.5%), than did un-bitten pigs (Hunter *et al*., 1999). Kritas and Morrison (2007) report on two studies. In one study they found a significant association between the severity of tail biting and prevalence of external carcase abscesses and carcase trimming. In a second study they found a significant association between the severity of biting and the prevalence of lungs with abscesses or pleuritic lesions.

An important and severe consequence of tails being bitten is reduced weight gain. Wallgren and Lindahl (1996) found a significant decrease in weight gain in severely tail-bitten pigs, as did England and Spurr (1967). As treatment with antibiotics generally takes place during an outbreak of tail biting, it is possible that data on average daily gain (ADG) may be also underestimated. In a study by Wallgren and Lindhal (1996) comparing 7 tail bitten and 11 non-bitten barrows, ADG was significantly reduced in the bitten pigs during the period of biting, - by 11% during fattening and by 5% during the entire lifetime (Wallgren and Lindahl, 1996). They concluded that tail biting affects the growth rate of barrows throughout their lifetime despite antibiotic (penicillin) treatment.

Tail biting may also be a means of transmission of *Trichinella* (Visnjakow and Greorgieu., 1972). However in the EU (EFSA, 2004) the number of reported cases of *Trichinella* is very small (69 cases) and the risk of the exposure to parasites is far greater in outdoor pigs where tail biting is rare.

In summary, tail biting is associated with a range of pathological effects from injury to spinal abscesses and pyaemia in different parts of the body. Such effects may be associated with reduced growth rate or in more severe cases, total carcass condemnation.

# 6. Current situation on tail docking

## 6.1. Legislation

Current EU legislation (Commission Directive EC 2001/93, article 8 of the annex) authorizes pig producers to perform tail docking but with some limitation that theoretically leads to ban docking on a routine basis:

*"All procedures intended as an intervention carried out for other than therapeutic or diagnostic purposes or for the identification of the pigs in accordance with relevant legislation and resulting in damage to or the loss of a sensitive part of the body or the alteration of bone structure shall be prohibited with the following exceptions:*

- *a uniform reduction of corner teeth […]*
- *docking of a part of the tail,*
- *castration […],*
- *nose ringing […].*

*Neither tail docking nor reduction of corner teeth must be carried out routinely but only where there is evidence that injuries to sow's teats or to other pigs' ears or tails have occurred. Before carrying out these procedures, other measures shall be taken to prevent tail biting and other vices taking into account environment and stocking densities. For this reason, inadequate environmental conditions or management systems must be changed.*

*Any of the procedures described above shall be carried out by a veterinarian or a person trained as provided in Article 5 of this Directive experienced in performing the applied techniques with appropriate means and under hygienic conditions. If castration or docking of tails is practised after seventh day of life, it shall be performed under anaesthetic and additional prolonged analgesia by a veterinarian."*

In short, tail docking should not be performed on a routine basis in EU countries. In Denmark, Sweden, Finland and Lithuania, there is specific legislation further limiting tail docking. In Denmark, suckling piglets can be tail docked between days 2 and 4 of life when it can be documented in the herd that damage to tails due to tail biting occurs when tail docking is not performed. The tail should be docked as little as possible and it is not allowed to dock more than ½ of the tail. If tail docking is performed after the $4^{th}$ day of life, the piglets should be given long-lasting analgesia. In Sweden, docking is not allowed (i.e. it does not appear on the list of surgical interventions allowed for medical reasons; law SFS 1988:534 §§ 2, 4, 10). Similarly, in Finland, docking the tail of an animal is forbidden as an act causing needless pain to the animal (law 2002:0910). Finally, in Lithuania, tail docking is totally banned.

In Switzerland and in Norway, tail docking is also strictly regulated. In the actual Swiss regulation (Animal Protection Ordinance, Switzerland, 2001) tail docking of piglets has been removed from the list of mutilations that can be performed without anaesthesia. In Norway, amputation of tails for medical reasons can only be performed by veterinarians using anaesthesia and prolonged analgesia (Regulation for Housing of Swine from 2003, § 10). Since nobody will use anaesthesia to dock the tail of a pig, tail-docking is not carried out any more.

## 6.2. Current practices

The practice of tail docking on farms has increased as a result of increased tail biting problems following intensification of pig production and the adoption/generalization of slatted floor. For instance, abattoir surveys in the UK showed an increase of tail docking from 25% in 1972 (Penny et al., 1974), to 34 % in 1974 (Penny et al., 1974) and 81% in 1999 (Hunter et al., 1999). Nowadays, the percentage of piglets that are docked varies probably with the housing system and the legislation. In countries where tail docking is permitted, it may be nearly 100%

when pigs are raised (at some stage of their later life) on slatted floors but less when pigs are raised on litter or reared outdoors. In countries where tail docking is banned, it is probably close to 0%. A questionnaire has been sent to an expert in each EU country plus Norway and Switzerland in the framework of the present report (Annex 1). From this survey, it seems that more than 90% of the pigs are docked.

Tail docking is usually performed by the farmer or his employees within a few days after birth together with other routine practises such as iron injection, tooth resection and sometimes also castration. It is carried out with scalpels, scissors/wire cutters or by cautery with a hot iron. As a general rule, no anaesthetic or analgesic treatments are performed to reduce the pain. When scissors or wire cutters are used, they are usually dipped in an antiseptic for disinfection but usually no antiseptic is applied on the tail before or after docking.

Length of the intact tail varies between 28 and 41 mm in one-day old piglets (Done et al., 2003). The length of the tail that is removed by docking is variable: from only the tip of the tail to up to ¾ of the tail, or more. The proportion of the tail that is docked may depend on the sex and purpose of the animals (the tail stump is normally longer in females that are raised for reproduction) and on the prevalence of tail biting in the farm (when tail biting is frequent, farmers tend to dock tails more severely). In practice, the length of the remaining tail is often less than 20 mm (Chermat, 2006).

## 7. Welfare and health consequences of tail docking

Docking itself is likely to be a source of pain since the tail is innervated already in neonatal pigs: histological observations from Simonsen et al. (1991) have demonstrated the existence of peripheral nerves to the tip of tails in one-day old piglets. Behavioural data from Noonan et al. (1994) and from Prunier et al. (2001) confirmed that docking the tail probably induces pain. Indeed, animals “struggled” and screamed during tail docking; they wagged (flicking the tail from side to side or up and down) or jammed (clamping of the tail between the hind limbs) the tail in the first minutes following docking. However, time to first suckling and main time-budget (resting, suckling or standing) during the 12 hours following docking were similar in docked (hot iron cautery) and control (sham-iron docking) piglets (Prunier et al., 2001).

Acute pain is usually associated with an activation of the adrenal axis (Molony and Kent, 1997). However, Prunier et al. (2005) did not observe any clear changes in plasma profiles of cortisol and ACTH during the first 3 hours following docking in one-day old piglets. This suggests that painful stimuli due to tail docking are not sufficient to elicit a physiological stress response. Alternatively, this lack of ACTH and cortisol response can be explained by a lack of responsiveness of the pituitary-adrenocortical axis that is known to be down-regulated in neonates. However, this latter explanation is less likely, because data in pigs have shown that cortisol increment after exogenous ACTH stimulation was similar at 3, 7, 21 and 35 days of age despite differences in pre-treatment cortisol concentrations (Otten et al., 2001).

Similarly, Klemcke and Pond (1991) did not find differences in the cortisol response of piglets subjected to maternal deprivation at 3, 10, 17 or 24 days of age. It may be that one-day old piglets differ from three day old piglets in their cortisol responsiveness. Finally, it was observed in sheep, as species more highly developed at birth than pigs, that cortisol increment after restraint or ACTH injection was similar in the first day of life and during the following weeks (Moberg et al., 1980). It therefore seems likely that tail-docking of day-old piglets does not induce a major physiological stress response, although these animals may be capable of showing such a response.

In addition to acute pain, docked pigs may suffer from long-term pain as described in humans after amputation. Two types of long-term pain can be distinguished in human amputees (Jensen and Rasmussen, 1997) and could exist in docked pigs: (a) phantom limb pain that is any painful sensations referred to the absent limb, (b) stump pain that is localized to the stump (also known as ‘residual limb pain’). Data regarding the frequency of such pain have been reported mainly by people that have had amputations for medical reasons. In this situation, pre-amputation pain in the limb is a risk factor for the development of phantom pain (Woodhoose, 2005) and hence the percentage of people with chronic pain may be very high. In a cohort of upper limb amputees from Sierra Leone, Lacoux et al. (2002) were able to determine the incidence of long-term (10 to 49 months after amputation) pain in people having healthy limbs prior to amputation. Stump pain was present in nearly all cases, being intermittent in most cases and continuous in a minority of cases. Phantom pain was described in about 20% of the cases and was always intermittent. In docked pigs, during and after the process of repair, Simonsen et al (1991) and Done et al (2003) observed the presence of neuromas (random proliferation of axons and glial support cells) that are known to be very sensitive in other species and have been associated with stump pain in humans with amputated limbs. Therefore, the tail stump of docked pigs might be sensitive to touching. This hypothesis was tested by observing the behavioural reactions (try to jerk the tail away or loud vocalization) of piglets when the tail was squeezed by calibrated pressure callipers (McIntyre, 2003). Data obtained failed to show any difference between control and docked (either 1/3 or 2/3 of the tail being removed) pigs from 2 to 10 weeks of age. Moreover, tail sensitivity to cold or heat stress was investigated in docked heifers at about 20 months after tail amputation done by banding (Eicher et al., 2006). Results indicate some differences between docked and intact heifers in the behavioural response to the thermal tests.

The tissue lesion due to tail docking may constitute a route for bacterial entry and hence favour local or systemic infection. Experimental evidence regarding this possible consequence is scarce. Data from Riising et al. (1976) have shown that tail docking and tooth clipping increase the incidence of fatal streptococcal infections. More recently Strom (1996) suggested that surgery procedures like tail docking, tooth clipping and castration increase the risk of arthritis in piglets.

## 8. Hazard Identification for Tail Biting

Where possible in the following sections, the type of behaviour studied is described either as ‘tail-in-mouth’ / tail-chewing behaviour or as (clinical) tail-biting implying that clear evidence of damage to the tails has been observed. However, it should be noted that some studies do not make this distinction.

### 8.1. Animal Characteristics

These factors can be considered as ‘internal’ properties of the animal that may affect its general predisposition to tail-bite or be bitten, and may also mediate the extent to which ‘external’ factors impact upon it and lead to tail-biting behaviour.

#### 8.1.1. Breed and Genetics

Various authors have commented on the putative effect of genetics on the occurrence of tail-biting (see Schrøder-Petersen and Simonsen, 2001). For example, Sambraus (1985) suggested that the replacement of old style ‘lard hogs’ with more reactive ‘bacon pigs’ resulted in the appearance of tail-biting as a problem. Similarly, van Putten (1970) speculated that ‘heritable nervousness’ may predispose a pig to be more likely to tail-bite under unfavourable environmental conditions. Gadd (1967; see Fraser and Broom 1990) mentioned anecdotally in the agricultural press that Landrace pigs may be more prone to tail-biting than other breeds, and Penny and Hill (1974) observed that lop-eared pigs, such as the Landrace, were more frequently bitten than animals with pricked ears, though they noted that genotype might be confounded with husbandry system in their study. Aside from these observations and speculations, there is limited and contradictory evidence in terms of detailed data on breed differences. Lund and Simonsen (2000) found no significant differences between Danish Landrace and Duroc pigs in the amount of tail-biting observed, possibly because tail-biting levels were generally very low in this study which also had a very small sample size (20 of each breed). It was also unclear whether tail-docking was carried out. Guy et al. (2002) also failed to detect any differences in tail-biting (holding the tail in the mouth and biting it) between classic indoor cross-breeds (Large White x Landrace) and outdoor cross-breeds (part-Meishan cross or part-Duroc cross), though again tail-biting levels were low, and the outdoor breeds included Large White and Landrace genetic contributions. However, in a recent Swedish study, Keeling and colleagues (personal communication) observed higher levels of tail-biting behaviour in Landrace (1.7% of 1151 pigs) relative to Yorkshire pigs (0.64% of 1101), with the reverse being the case for those animals that were bitten (Landrace: 1.8%; Yorkshire: 3.5%). Interestingly, Hampshire pigs showed the lowest levels of both tail-biting (0.13% of 797 pigs) and being bitten (0.5%).

Recent studies by Breuer et al. (2003, 2005) present the most detailed analyses of genetic effects on tail-biting behaviour. Breuer et al. (2003) studied tail-biting (manipulating, sucking, or chewing) behaviour in pure-bred Landrace, Large-White and Duroc pigs (100 per breed), housed in mixed-breed single-sex groups of about 10 pigs per group following weaning. They found that Duroc pigs showed a greater propensity to chew at a simulated pig tail (a rope) during a pre-weaning ‘tail-chew’ test than Large-White or Landrace pigs. However, there were no clear post-weaning breed differences in actual tail-biting / manipulating behaviour (the pigs were tail docked, S. Edwards, personal communication), although Landrace pigs performed less ear-biting and total-pig-directed biting behaviour than did Durocs, with Large-Whites being intermediate. This latter result, assuming some relationship between ear-biting and tail-biting, is somewhat contradictory to previous observations and speculations that Landrace pigs are more predisposed to tail-bite. However, it is important to note that mixed-breed groups were studied here and this might affect the expression of breed differences observed in single-breed groupings or studies. Also, ‘tail-biting’ included non-damaging behaviours which may not have actually given rise to tail damage.

Breuer et al. (2005) subsequently studied the heritability of tail-biting in a sample of over 3,000 Large White and nearly 6,000 Landrace pigs all of which had the distal 10% of tail docked soon after birth. Clinical tail-biters were those pigs observed to be responsible for over 50% of chasing and chewing the tails of others during a 10 min observation of a pen where a tail-biting outbreak had been detected. 2.8% of Large White and 3.5% of Landrace pigs were categorised as clinical tail-biters and this difference was nearly significant. Tail-biting was not heritable in the Large-Whites, but its estimated heritability of the predisposition to tail bite in the Landrace pigs was 0.27. There was a significant positive genetic correlation between tail biting predisposition and lean tissue growth rate and a significant negative genetic correlation between tail biting predisposition and back fat thickness. The reason for a breed difference in heritability scores is not clear. In a large-scale epidemiological study on UK farms, Moinard et al. (2003) also observed that the risk of tail-biting decreased by 1.5 fold when P2 back fat level increased by 1mm.

To summarise, genetic factors appear to have some influence on tail-biting behaviour, although the effects are not clear cut, may be swamped by environmental factors, and their mechanisms are unknown. A candidate mechanism may involve feeding motivation and nutrient intake processes, in that there is some evidence that leaner animals are more predisposed to tail-bite. Given that feeding patterns and intake show some heritability in pigs (Labroue et al., 1994, 1997; Von Felde et al., 1996), it is conceivable that heritability of tail-biting is related to heritability of these motivational and physiological processes. If so, selection for fatter animals – in contrast to the direction of selection over the last decades – might help to reduce the tail-biting problem. However, more work is required to establish the strength of this hypothesis.

### 8.1.2. Gender

A ubiquitous genetically determined risk factor not considered in the previous section is gender. A number of abattoir-based studies have examined the incidence of tail damage in slaughter pigs and related this to pig gender. Results from these are summarised in the Table below.

**Table 8.** Incidence of tail damage in slaughter pigs related to pig gender.

| Country | Date | Sample size | % Docked? | Gender-related risk | Reference |
|---|---|---|---|---|---|
| England | 1972 | 988 ♂ (likely all castrated), 1063 ♀ from 1 abattoir | 24.3% ♂ and 25.2% ♀ docked | 14.4% ♂ and 7.1% ♀ with bitten tails 8.4% ♂ and 8.1% ♀ with necrotic tail tip | Penny et al., 1972 |
| England | Mar 1972 -Feb 1973 | 11811 pigs (5690 castrated ♂, 6121 ♀) from 1 abattoir | 34.8% ♂ and 34.4% ♀ docked | 15.7% undocked ♂ and 7.7% undocked ♀ with bitten tails 11.5% undocked ♂ and 11.6% undocked ♀ had necrotic tail tip of tail-bitten pigs, 34.8% ♂ and 25.7% ♀ had severe lesions (> half tail lost) | Penny & Hill, 1974 |
| England | 1980 | 422 intact ♂, 458 ♀ from 1 outbreak on 1 farm single sex groups | no | 11.8% ♂ and 2.6% ♀ tail-bitten 8% ♂and 0% ♀ had severe tail biting lesions (tail bitten to rump) | Penny et al. 1981 |
| | | 10111 carcasses (♀ and castrated ♂) | | castrated ♂ more likely to be bitten and had more severe wounds | Lee et el 1993 |
| Denmark | | 20 million | | 0.22% diagnosed with 'tailbite/ abscess' at slaughter of which 72% were castrated ♂, and 28% were ♀ | Mousing 1995 |
| | | | | castrated ♂ tail-bitten more than ♀ | Wallgren & Lindahl 1996 |
| England | 1997 | 62971 pigs at 6 abattoirs (♂ likely not castrated) | 80.9% docked | 4.58% ♂ and 3.37% ♀ tail-bitten odds of a ♂ not being bitten 0.7 worse than the odds of a ♀ not being bitten | Hunter et al. 1999 |
| Finland | 2000 | 10852 pigs (5542 castrated ♂, 5310 ♀) from 479 farms | no | Castrated ♂ had 30% higher risk of being tail-bitten, 40% higher risk of fresh tail damage, 60% higher risk of severe damage than ♀ | Valros et al., 2004 |
| USA | 2007 | 128 tail-bitten and 128 matched control carcasses studied | yes | Of pigs with mild, healed or chewing / puncture lesions, 60.4% were castrated males and 39.6% were females. Of pigs with swelling / partial loss of the tail, 65% were castrated males and 35% were females. | Kritas & Morrison 2007 |

The findings in the above table suggest that male pigs (both castrated and intact) are at a considerably greater risk of receiving tail bites than female pigs. However, it is important to note that abattoir studies of this sort can only detect those pigs that are tail-bitten as opposed to those that perform it, may be unable to detect pigs with previous tail damage that has healed by the time of slaughter, and do not include those animals that have been culled on farm due to tail-biting. Therefore, they may not provide a truly representative picture. Observational studies can add further information on tail-biting vulnerability and also on performance of tail-biting behaviour. In one such study of pigs from barns which had experienced a high incidence of tail-biting, Kritas and Morrison (2004) also observed that castrated males were more likely to be bitten than females. Furthermore, a recent study of outdoor growing-finishing pigs in winter (likely to be undocked, but docking status not reported) provided the first formal report of tail-biting in this 'extensive' environment , and found again that barrows were more likely to be tail-bitten than gilts (Walker and Bilkei, 2006). The authors also observed that the prevalence of bitten males was positively correlated with the proportion of females in the group (see also Kritas and Morrison, 2004). Schrøder-Petersen et al. (2003) provided further observations on a possible link between group sex composition and tail-biting in their study of 96 tail-docked and castrated weaners (5 weeks old and onwards). They showed that 'tail-in-mouth' (TIM) behaviour (one pig orally manipulating the tail of another), which may be a precursor of tail-biting behaviour, occurred more in mixed-sex groups than in single-sex groups and that, in the mixed-sex groups, pigs tended to direct TIM to members of the opposite sex, with females tending to do more TIM than males. In a follow-up study on older pigs (40-50 kg), they found that the lowest level of TIM behaviour was observed in all-male groups, while all-female and mixed-sex groups showed higher amounts (Schrøder-Petersen et al. 2004). However in this study, which had half the sample size of the former experiment, there was no evidence that females performed more TIM in mixed-sex groups than did males.

One hypothesis arising from these findings is that females have a greater propensity to direct tail-related behaviour to males than vice versa, and the consequence is that males are more at risk of being bitten. Indeed, Sambraus (1985), Simonsen (1995) and Schrøder-Petersen and Simonsen (2001) have speculated that as females start to become sexually mature they become more active and also more interested in ano-genital investigation and anal massage, particularly directed at male pigs, than do castrated males. The relevance of this hypothesis obviously depends on females reaching maturation before slaughter and at a point when tail-biting outbreaks occur. The hypothesis may also not extend to intact males, as indicated by the findings of Penny et al. (1981) that intact males in single-sex groups showed higher levels of tail-biting than that observed in all-female groups. Furthermore, Blackshaw (1981) observed that within post-weaning mixed groups of tail-docked (castration status not reported) pigs, there were no sex differences in the performance or receipt of tail-biting, and that sex composition of the groups appeared to have little effect on the occurrence of tail-biting. Breuer et al. (2003) also observed no differences between intact males and females in their performance of tail-biting behaviour four weeks after weaning. Van de Weerd et al. (2005) also observed no sex differences in the performance of tail-biting, though they did find that males were more likely to be 'fanatical tail-biters' (animals that were highly active during tail-biting outbreaks and moved purposefully from tail to tail) than females, and that males were more likely to be bitten. Hunter et al. (2001) found lower levels of tail-damage at slaughter in animals that had been housed in mixed-sex as opposed to single-sex groups, both before and after adjusting data for docking procedure, and with a stronger effect for long-tailed pigs. Moinard et al. (2003) found no association between sex composition of the group and tail-biting in an epidemiological case-control study of tail-biting on commercial farms. The latter three studies are likely to have focused primarily on intact males, as males were unlikely to have been castrated on farms participating at the time in these UK studies.

Studies carried out by Zonderland et al. (2003a) have also failed to find strong effects of group sex composition on tail-biting. In a study of 96 pens of 10 undocked and uncastrated pigs, there were non-significant suggestions that the risk of mild tail damage was higher when the groups contained either less than 30% or more than 79% females (in these cases, nearly 80% of pigs were at risk of mild damage) than when the sex ratio was unity (here only 50% showed mild damage). But these suggestions were only partially confirmed in a follow-up study (Zonderland et al., 2007).

Overall, there is a consistent suggestion from a range of abattoir-based studies that males may be more at risk of incurring tail-biting damage than females. While some of these studies include intact males, the majority appears to be studies of castrated males, and it appears that these animals are particularly susceptible to being tail bitten. The reason for this is unclear, although it may be the case that putative lower levels of activity make them more attractive targets for tail investigation behavior by others, perhaps especially females. One might then predict higher levels of tail-biting behaviour in mixed sex groups where females are attracted to investigating these (castrated) males. However, most studies reporting effects of group sex composition on tail-biting or related behaviours do not show the predicted effect, albeit that these studies have involved intact (rather than castrated) males.

### 8.1.3. Weight or age

Tail chewing or TIM behaviour is evident from early life and certainly soon after weaning. In general, TIM is seen early in life, soon after weaning, and appears to decline as pigs grow older, while tail-biting usually starts to occur later. It is possible that these behaviours are not directly related, or may even be inversely related as evidenced by their different time courses and the suggestion from one or two studies that TIM may be lower in pens where there is tail-biting, and vice versa. Despite these changes with pig age, it is difficult to disentangle maturational effects, due to biological and behavioural development, from environmental effects, such as alterations to husbandry and housing that are associated with different stages of the pig rearing cycle. For example, Schrøder-Petersen et al. (2003) recorded this behaviour during the first week after weaning and observed that it became more frequent during the following four weeks (see also Simonsen 1995), despite no actual tail-biting or associated tail damage being observed. They suggested that the rate at which TIM behaviour increases across time may be affected by internal (e.g. age) and external environmental factors (e.g. being moved to a new pen, (Schrøder-Petersen et al. 2004)), and influence the likelihood that tail-biting occurs, though Ruiterkamp (1985) observed that TIM behaviour was sometimes higher in those pens that did not have tail-biting outbreaks relative to those that did (see also Van de Weerd et al., 2005). That TIM behaviour is evident early in life is supported by other studies recording this type of behaviour soon after weaning, and even before weaning (e.g. Cox and Cooper, 2001; Petersen et al., 1995).

Blackshaw (1981) studied 147 tail-docked pigs weaned at 26-32 days into groups of 6-12 animals and recorded a combined measure of tail and ear biting events. The mean age when biting was first observed was 40.7 (+/- s.d. 15.5) days indicating that in some groups it occurred very close to the time of weaning. The mean age at which it ceased to be observed was 90 (+/- s.d. 28.4) days, despite observations continuing weekly until marketing at 170-210 days. However, the severity or intensity of this biting was not reported so it is not entirely clear whether this was TIM behaviour or damaging tail-biting. Simonsen (1995) distinguished between ‘nibbling’ (TIM) and ‘tail-biting’ behaviour and found that the former decreased across the fattening period, while the latter increased. Day et al. (2002) observed ‘tail-biting’ behaviour (biting or chewing) at low levels throughout the period from around 10-20 weeks of age, and Van de Weerd et al. (2005, 2006) observed pig manipulation behaviour (including tail nosing, chewing or biting) at a low but fairly stable level in growing/fattening pigs (>30 kg), with some indication of a decrease in frequency with increasing age (Van de Weerd et al., 2005). Weaned pigs on a problem farm started tail biting as of day 5 after weaning, i.e. at an age of 33 days, but problems had mostly disappeared (spontaneously) after these animals were moved to the (partly slatted) fattening unit (Zonderland et al., 2007).

Given the occurrence of TIM behaviour from early life onwards, perhaps with a tendency to decrease in prevalence during the fattening period, the critical issue is when damaging tail-biting behaviour emerges. In the above studies, it is not entirely clear whether any of the events described involve damaging tail biting, and detailed information on the time course of tail-biting outbreaks is surprisingly difficult to find. Schrøder-Petersen and Simonsen (2001) cite comments and reports from authors indicating that tail-biting outbreaks tend to occur in older, fattening pigs (e.g. onset at. 90-150 days of age: Sambraus (1985); Haske et al., 1979; Aalund, 1978; Olsson and Hederstrøm, 1989). Van de Weerd et al. (2006) observed tail-biting in undocked pigs aged 10-20 weeks. In another study they also observed tail-biting outbreaks in 57% of pens of undocked fattening pigs (>55 kg; Van de Weerd et al., 2006). Schmolke et al. (2003) recorded tail-damage due to biting in pigs to increase from around 23kg (c. 8 weeks) to 90kg (12 weeks later). Barnikol (1978) also mentions tail-biting occurring in sows and boars of breeding age. Other studies report outbreaks in much younger animals. For example, Penny et al. (1981) recorded tail-biting occurring around 42-49 days of age, and Breuer et al. (2005) observed most tail-biting outbreaks between 28-90 days, with few occurrences after this time. In the epidemiological study of Moinard et al. (2003), the general pattern of farmer reported outbreaks (where at least one pig showed signs of tail-biting damage – a bleeding or wounded tail) was sporadic occurring from soon after weaning, until around 140 days of age.

## 8.2. Rearing

Interest in this area is driven by the possibility that early experience may affect subsequent stress responsiveness and abilities to deal with challenge and may thus influence vulnerability to developing tail-biting (Schouten, 1991; De Jonge et al., 1996; Sneddon et al., 2000; Cox and Cooper, 2001).

### 8.2.1. Early housing conditions

In their epidemiological study, Moinard et al. (2003) observed that tail-biting was less likely on farms where straw was provided in the farrowing pen once or more per day. In another epidemiological study, Smulders et al. (2007) found that the greater the percentage of floor covered with slats in the farrowing unit of a farm, the higher the number of pens containing at least one animal with a tail or ear-biting lesion on that farm. They also observed that a higher temperature and a lower number of feeding places in the nursery pens (from 6-20 kg) was associated with a higher number of pens containing at least one pig with a tail or ear-biting lesion. These findings suggest that early experience may have effects on subsequent tail (and ear) biting levels. However, it is not usually possible to determine causal relationships from epidemiological studies of this sort (e.g. in Moinard et al., 2003, farms providing straw in farrowing pens may also have provided it later in life, hence confounding a potential early experience effect with effects of the current environment). Experimental studies are thus necessary to tease these possibilities apart, and some have been conducted. In the rest of this section, we specifically focus on studies in which early experience has been manipulated to investigate its effects on the occurrence of tail-biting in later life under standardised housing conditions. Studies investigating long-term effects of enrichment, substrate provision, or other manipulations in which current conditions (at the time of tail-biting) and early conditions are confounded (e.g. remain the same throughout) are considered elsewhere.

Schouten (1991) reared 4 litters of 8 pigs in each of strawed or crated pens and observed more manipulation of pen-mates by crated piglets (massaging, rooting and biting – tail-related behaviour not specifically identified) during the pre-weaning period. This continued after weaning (at week 6 of age) until week 8 during which time piglets continued to be housed as before weaning. Crated piglets also showed increased avoidance and restlessness relative to those housed on straw, and this persisted later in life when all animals were housed on slats. However, at this stage manipulation of other pigs was not affected by early experience, indicating over-riding effects of the current environment.

Simonsen (1995) also studied pigs from two different farrowing systems (tethered / confined sows, no straw, weaning at 4 weeks *vs* loose housed sows, straw, weaning at 5-6 weeks) when they were housed in enriched pens from 33 kg (c. 10-12 weeks) onwards and found that pigs from the more intensive farrowing system showed more nibbling behaviour at pen-mates, but that there was no difference in tail-biting. In a similar study, Bøe (1993) observed litters weaned at 4 or 6 weeks and either kept in their farrowing pens or housed in flat decks until 9 weeks at which time all pigs were moved to bedded pens. Prior to movement, piglets in flat-decks showed more tail-biting behaviour than those in the farrowing pens, but this difference disappeared at 12 weeks following transfer to the bedded pens, though piglets from the flat decks had higher levels of (historical) belly and tail lesions. Cox and Cooper (2001) also found no effect of previous experience in either indoor or outdoor farrowing systems on TIM behaviour in the 2 days following weaning and transfer to a bedded pen at 6 weeks. Beattie et al. (1996) studied the effects of the mother's (gilts) prior rearing conditions (barren or enriched) on her piglets subsequently reared under barren or enriched conditions, and found effects on some forms of behaviour but not on the category of 'social behaviour' which included tail-chewing and biting.

Day et al. (2002) studied the behaviour of pigs that either had continual access to straw from birth to c.10 weeks of life or no access during this time, and were then housed for 10 weeks with minimal, substantial, deep or no straw. For 3 weeks following the move to new housing, pigs without prior experience of straw exhibited higher levels of tail biting / chewing behaviour than did pigs that had had prior experience of straw. Day et al. (2002) suggested that this might reflect a prior propensity to tail-bite that gradually disappeared with exposure to a straw foraging substrate. Interestingly, when diet was changed 6 weeks after transfer to new housing, there was an indication that pigs reared without straw showed a stronger increase in tail biting / chewing in response to this change. This study also found that pigs previously housed on straw showed higher levels of aggressive biting towards other animals when moved to a no-straw environment although a similar effect on tail-biting was not found. Chaloupková et al. (2006) found that piglets reared with straw and more space prior to weaning were less aggressive in food competition tests later in life than those reared in conventional crates, although it was not clear what type of environment all pigs lived in following weaning. Ruiterkamp (1985) observed that pigs reared on straw and then moved to slatted housing showed higher levels of nibbling at tails of pen-mates, while those reared on slats and then moved to straw-bedded housing showed lower levels of nibbling at tails of pen-mates and higher levels of straw-directed behaviour. Gonyou and Bench (2003) found that providing enrichment (peat, straw, shredded paper) during the post-weaning phase was more effective in reducing behaviour such as belly nosing than enrichment during the pre-weaning period.

In a recent study, Van de Weerd et al. (2006) examined the effects of 4 early enrichment treatments (substrate rooting box; liquid dispenser with chewable tubes; straw bedding; no enrichment) presented either during weeks 1-4 or 5-8 of life (weaning at 4 weeks), on behaviour in either partly slatted or straw-bedded systems from 10 weeks of age onwards. Groups in each system included animals from all 4 early enrichment treatments. Pig manipulation behaviour (nosing / chewing tails, ears, ano-genital area, hocks of other pigs) was higher in the part-slatted system in pigs that had experienced the liquid dispenser compared to those that had had no enrichment experience, and in those that had received any of the three enrichments post-weaning compared to those that had received them pre-weaning. However, there were no differences in the straw-bedded system. There were also no effects of early experience on the occurrence of tail-biting, although there were clear effects of the current environment, with tail-biting occurring more often in the part-slatted system. Although the current environment appeared to over-ride effects of early experience on tail-biting, it is worth noting that all groups consisted of animals from all early experience treatments, and as tail-biting outbreaks occur at a group level, individuals from different early experience treatments could have influenced the behaviour of their group-mates and hence obscured any early experience effects.

Overall, there is some indication that access to bedding early in life may decrease tail manipulation behaviours during that period, and also during the first couple of weeks following transfer to new housing, but that current conditions, in particular the presence of straw, soon over-ride these effects of early experience. Thus, provision of straw following early experience of a barren environment may help to alleviate a propensity to manipulate the tails of others. There may also be a small but specific risk for enhanced agonistic and tail-directed behaviour in animals that have previous experience of foraging substrate or enrichment and are then denied it. It is worth noting that most studies cannot demonstrate whether any such effects are on propensity to display tail-biting behaviour or on attractiveness as a target for being tail-bitten.

### 8.2.2. Weaning age

One other potentially important aspect of early experience is weaning time. Schrøder-Petersen and Simonsen (2001) suggest that removing piglets from the mother before their natural weaning age (c. 17 weeks; Jensen, 1988) may result in high motivation to suckle which cannot be expressed and hence may be redirected to other piglets in the form of chewing or sucking behaviour. Belly nosing behaviour is commonly observed following weaning of pigs, and there is evidence that it is more prevalent if pigs are weaned earlier (e.g. Fraser, 1978; Metz and Gonyou, 1990; Bøe, 1993; Gonyou et al., 1998; Weary et al., 1999; Worobec et al., 1999; Main et al., 2005) and therefore that it may indeed reflect some form of redirected suckling behaviour. It is less clear that tail-directed behaviour shares this motivational basis and hence whether it would be expected to occur more in early weaned pigs, but there have been a few studies that have examined this possibility. It is notable that these studies have generally not focused on tail-biting as main outcome measure and have often used fairly indirect measures of this behaviour.

Worobec et al. (1999) observed that piglets weaned at 14 days of age spent more time nosing / chewing at pen-mates on days 14-15 than did piglets weaned at 7 days, and on days 28-29 than did piglets weaned at both 7 and 28 days. It is not clear why piglets weaned at the intermediate age of 14 days should show the highest levels of this behaviour, and it is difficult to disentangle the effects of absolute weaning age *vs* time elapsed between weaning and data collection. Also, the behaviour recorded was not just restricted to TIM type behaviours, and could have included chewing behaviour directed at other parts of the body. Hohenshell et al. (2000) studied pigs weaned at 10 and 30 days into groups of 4 and observed their behaviour at regular intervals up to slaughter. They observed higher levels of pig manipulation behaviour (again, this included manipulation, but not belly nosing) in early weaned pigs at day 40 of age, but this difference was no longer evident from day 60 onwards. In a complex study investigating the effects of environmental enrichment, weaning age (3 and 5 weeks) and maternal predisposition to tail-chew, O'Connell et al. (2005) found no effect of weaning time or maternal predisposition on tail manipulation, sucking or chewing behaviour, although belly nosing was observed to occur more often in early weaned pigs. Mason et al. (2003) recorded the behaviour of pigs weaned at either 21 or 35 days during the 2 days following weaning and did not observe any differences in immediate post-weaning performance of nosing or chewing at litter-mates. In the last two studies, it was not clear whether pigs had their tails docked or not. Bøe (1993) failed to observe any long-term effects of weaning time on tail-biting behaviour.

Overall, the evidence indicates that weaning age may not have a strong effect on the propensity to show TIM type behaviours. However, studies in this area have tended not to examine tail-directed behaviour in any detail, focusing instead on belly nosing behaviour which clearly is influenced by weaning age. Therefore, it remains a possibility that there are longer-term effects of early weaning (i.e. 3 weeks or earlier) on TIM and tail-biting, perhaps especially for non-docked pigs as it is unclear whether any studies have focused on these animals.

## 8.3. Social environment

### 8.3.1. Group size, space allowance and stocking density

In this section, stocking density refers to 'individuals / unit space'. This can also be measured as individual space allowance ('floor space / individual') which is the inverse of stocking density. Measurements of both types are given here. Schrøder-Petersen and Simonsen (2001) list a number of studies (e.g. Jericho and Church, 1972; Krider et al., 1975; Haske et al., 1979; Fritschen and Hogg, 1983; Geers et al., 1985; Arey, 1991) which mention that an increased stocking density or 'over-crowding' is associated with an increased risk of tail-biting, and this may also be expected since higher stocking density and group size will increase the probability that a snout of a pig encounters the tail of another pig (hence contributing in theory to the start of a tail biting outbreak). Moinard et al. (2003) also found in their epidemiological study of UK farms that when stocking density during the growing and finishing period exceeded 110 kg/m$^2$, deemed acceptable by current UK regulations (DEFRA, 2003), the risk of tail-biting increased by 2.7. Lack of space per individual and elevated agonistic behaviour at higher stocking densities (e.g. Turner et al., 2000) might lead to a more stressful environment and a consequent lower threshold for displaying tail-biting behaviour, though some authors contest the link between increased stocking density and increased 'stress' (Kornegay et al., 1993). However, it is not always clear to what extent group size (which may be positively correlated with stocking density) is also contributing to the effects observed. For example, Dybkjaer (1992) observed that 4 week old newly weaned pigs allocated to groups of 8 with straw and housed at 0.3 m$^2$/pig manipulated other piglets less (including tail-chewing) than pigs mixed and then housed in groups of 16 without straw and at 0.15 m$^2$/pig. Many different factors, including both group size and stocking density, could have contributed to these findings. However, Penny et al. (1981) mention that tail-biting outbreaks tended to occur as groups of approximately 12 weaner pigs 'began to fill' their flat-deck pens around 6-7 weeks of age, indicating a crowding effect in groups of roughly constant size. Frequency of tail biting is often reported to increase as the pigs grow older and heavier, which might also reflect reducing free space (Schrøder-Petersen and Simonsen, 2001).

In contrast to the above general findings, Chambers et al. (1995) did not find any association between stocking density and tail biting in their postal survey of 104 farmers in South West England. Arey (1991) observed increased tail-biting when groups of pigs were split into two, effectively doubling their space allowance per individual, although disruption of the social group and movement to new environments may have played a role. Flesjå et al. (1982) suggested that a space allowance of between 0.47 m$^2$ and 0.6 m$^2$ per pig increased the risk of cannibalism and tail-biting in a study of 40 bacon herds (90-100 kg live weight), indicating a non-linear relationship between space allowance and tail-biting risk. The authors could not explain this effect and suggested that it might be a random quirk of the data.

It is difficult to identify precise causal relationships from field studies of the sort mentioned above. For example, farms which stock their pigs at high densities may also have environmental conditions that predispose tail-biting, and it is not possible to disentangle the relative importance of these factors. Controlled experimental studies which demonstrate a relationship between stocking density and tail biting risk are rare. In a study of growing/finishing pigs housed at 10 or 20 per pen (0.63 v 0.43 m$^2$/pig, equivalent to final "k" values of 0.029 and 0.020 in allometric expression of space as discussed in (EFSA, 2005) no significant tail biting was seen when pigs had docked tails (Krider et al., 1975). However, when pigs with intact tails were placed on the same treatments, tail biting did occur and was more serious at the higher stocking density where only 15% of pigs completed the finishing period with undamaged tails, compared with 49% in the lower density pens. Overall, 13/60 pigs (22%) in high density pens lost more than one-third of their tail, compared with 4/39 (10%) at the lower density.

A few studies which report on the incidence of TIM behaviour or tail-biting (usually as a side issue rather than as a central focus of the research) have attempted to separate the effects of group size and stocking density by holding one constant while manipulating the other. Beattie et al. (1996) studied pigs in groups of 6 housed at stocking densities of 0.5, 1.1, 1.7, or 2.3 $m^2$ / pig from 6-12 weeks of age. No differences in 'tail-biting' or 'tail-bitten' (both undefined) were observed. Schmolke et al. (2003) studied the effects of group sizes of 20, 40, 60 and 80 pigs / pen (holding stocking density constant at 0.76 $m^2$/pig in all groups at the start of the study), and found that similar proportions of pigs were removed from each group size due to severe tail-biting.

Spoolder et al. (1999) mention that little damaging tail-biting was observed in their study of groups of 20, 40 and 80 pigs housed at 0.55 $m^2$/pig, and no obvious differences between group sizes. Two internal Danish reports also indicate that pigs housed in different groups sizes showed no differences in the incidence of tail-damage (15, 30, 60, 120 - Nielsen, 1992 cited in Turner et al., 2003; and 16, 48 - Petersen, 1990 cited in Turner et al., 2003), though it is not entirely clear whether stocking density was kept constant. Randolph et al. (1981) studied the effects of different group sizes housed at different stocking densities in two 2x2 designs (experiment 1: 5 v 20 pigs at 1.64 $m^2$/pig vs 0.82 $m^2$/pig – mean start and end weights 21.6 – 89.5 kg; expt experiment 2: 5 v 10 pigs at 0.66 $m^2$/pig vs 0.33$m^2$/pig; mean start and end weights 15.9 – 41.5kg). Although other forms of behaviour were affected, there were no effects of treatment on tail-biting. Unfortunately, many other studies of this sort do not provide information on TIM or tail-biting behaviour (e.g. Moore et al. 1994; Turner et al. 2001; see Turner et al. 2003). It is worth noting that in most of these studies stocking density (individuals / unit space) is likely inversely related to, and confounded with, total space allowance per pen, preventing disentanglement of the effects of these two factors.

In some studies, stocking density and space allowance have been confounded with other key predisposing factors, since bedded pens are commonly stocked at lower density than slatted pens. For example, tail biting was reported to be lower in enriched pens (extra space, peat and straw in a rack), than in barren pens (Beattie et al., 1995). Similarly, piglets in wire floored cages at 0.3 $m^2$/pig, started tail biting as of 12 kg live weight (compared to pigs at 0.6 $m^2$/pig on unbedded solid floors or at 0.55 $m^2$/piglet with straw (Schneider and Bronsch, 1974). In such comparisons, floor type or presence of substrate may be the critical causal factor or may interact with space allowance, since both enrichment and space lead to reduced nosing and tail biting in growing pigs (Beattie et al., 1996). From an experimental attempt to identify which factor, enrichment or space allowance, had more influence on pig behaviour, it was concluded that enrichment of the environment, was not totally effective in reducing the frequency of these activities (Petersen et al., 1995).

Overall, older studies and field studies indicate that increased stocking density may lead to a greater risk of tail-biting. This agrees with anecdotal reports of the importance of stocking density, but the mechanisms of any such effect are unclear. Experimental studies of either stocking density or group size effects tend to focus on other aspects of pig behaviour and production (e.g. aggression, growth rates).Those that do measure tail-related behaviour do not report any clear effects of stocking density or group size on tail biting. Perhaps this is because tail-biting is so difficult to induce under controlled experimental conditions.

### 8.3.2. Other aspects of the social environment

The effects of the sex composition of groups of pigs on the occurrence of TIM and tail-biting behaviour have been discussed in section 14.1.2.

Schrøder-Petersen and Simonsen (2001) suggest that group instability, for example due to mixing of unfamiliar animals, may be a cause of tail-biting outbreaks (Hansen and Hagelsø, 1980). However, it is not always easy to disentangle any effects of mixing from those that may be occurring simultaneously (e.g. weaning and separation from the mother; transfer to a new pen; diet change). Ongoing work suggests that inadvertent mixing of pigs into adjacent pens in the absence of any diet change could be a cause of tail-biting outbreaks (Poppy Statham, personal communication). However, an on-farm comparison of 39 pens of pigs which had not been mixed post-weaning with 59 pens in which litters had been mixed revealed no significant differences in the levels of mild or severe tail damage (Zonderland et al., 2007). Also, in their epidemiological study, Smulders et al. (2007) did not find a correlation between the frequency of mixing and tail-biting previously reported by Arey (1991).

Dominance status may also influence the propensity to show tail-biting behaviour, and to be a target of tail biting. For example, Blackshaw (1981) observed that low ranking pigs showed least tail biting, while high ranking pigs bit middle and low ranking pigs more than expected. Middle ranking pigs tended to direct their biting behaviour to other middle rankers. In contrast, Schrøder-Petersen and Simonsen (2001) mention that Steiger (1975) reported middle ranking pigs to be the most active tail-biters, as did Hansen et al. (1979), who suggested that tail-biting might sometimes be an unusual form of aggressive behaviour that animals use while competing for a limited resource such as access to a feeder.

In general, the effects of social status and events such as mixing on tail-biting have received limited attention. Although no clear and consistent picture emerges from the research conducted so far, anecdotal evidence and industry opinion suggest that mixing may act to trigger tail-biting under commercial conditions.

## 8.4. Herd size

Survey results have indicated that there is an association between large herd size and the prevalence of tail biting. In a postal survey of 104 farmers in South West England, Chambers et al. (1995) reported that tail biting was more likely to occur as herd size increased. In a subsequent UK survey, Moinard et al. (2003) reported that farms which were part of larger pig enterprises (5 or more different units), had an increased risk of tail biting (OR=3.5). There are many possible reasons for an effect of herd size, since this is likely to be confounded with type of production system, degree of automation and other management variables shown to influence tail biting risk. However, the survey of Moinard et al. (2003) also highlighted the possibility that level of stockman input might be implicated, since as the number of pens per stockman increased by one, the risk of tail biting increased 1.06-fold.

A hazard for tail biting is therefore large herd size.

## 8.5. Flooring and substrates

Chewing of littermates has been reported to occur under semi-natural conditions only at very low frequency (Newberry and Wood-Gush, 1988) or not at all (Petersen, 1994). However, more recent data indicate that tail biting does also occur in pigs kept outdoors (Walker and Bilkei, 2006). From a large commercial abattoir database in the UK, the prevalence of tail damage from more than 62,000 undocked free-range pigs over a 12 month period was 0.23% (Edwards, unpublished data).

### 8.5.1. Floor type

In housing with slatted floors the losses due to tail biting are higher (Koomans, 1978). When considering only unbedded floors, the proportion of slatted floor is often reported as a risk factor for tail biting. Approximately twice as much tail biting has been reported to occur on fully slatted floors compared with half-slatted (Madsen, 1980). Hansen and Hagelso (1980) found that more tail biting occurred when there was a slatted floor in the feeding area.

Ruiterkamp (1985) reported that the frequency of tail biting behaviours was greater in fully slatted than in part slatted or straw bedded pens, and the number of animals lost during the finishing period as a result of cannibalism was correspondingly much higher (50, 8 and 1 animals respectively).

Other construction details of the pig pen - such as tubular pen walls, open connection to a manure pit, poorly insulated pen floors - also appear to increase the risk of cannibalism and tail biting (Kjell et al., 1982).

In housed conditions, it is widely reported that the occurrence of tail biting is reduced by the presence of straw bedding (Aalund, 1978; Van Putten, 1980; Hansen and Hagelso, 1980; Jacob, 1982; Bohmer and Hoy, 1993). Animals in open-fronted, deep-litter stalls showed fewer abnormalities such as tail biting than did animals in insulated housing with slatted floors (Etter Kjelsaas, 1986). In a Danish study Madsen (1980) found the prevalence of tail bitten pigs to be 29% when kept on fully slatted floors, 16% in part slatted floors and 2% on floors with bedding. It has also been reported that massaging and chewing of penmates by weaned piglets are more prevalent in flat decks than on straw (Buré, 1981; McKinnon et al., 1989).

Most surveys have reported that keeping pigs on unbedded, slatted floors increases the prevalence of tail biting. In a UK postal survey of 104 farms, tail biting was significantly increased when there was no bedding and slatted floors (Chambers et al., 1995). In a subsequent study, keeping grower pigs on partially or fully slatted floors versus solid floor increased risks of tail biting (with an odds ratio of 3.2) but it was not possible to determine whether it was the absence of bedding that led to this or if it was the slats *per se* causing the increased risk (Moinard et al., 2003). Hunter et al. (2001), following up an abattoir survey of tail biting prevalence amongst pigs from 450 UK farms, found that 78% of units docked the tails of pigs and 41% of units housed pigs without straw during the finishing period. There was a significant association between straw use and natural ventilation, giving a potential confounding factor. For both docked and long-tailed pigs there was a higher probability of tail biting in systems without straw provision, and this effect was greater in long-tailed pigs.

There have been several recent studies where buildings, or pens within buildings, with and without straw provision have been subject to contemporary comparison on the same farm. Tail and ear-biting were more frequent on floors without straw than on floors with straw, when 5 types of housing were compared in 84 pigs from 35 to 55 kg, (Haske et al., 1979). In four separate trials over a 3 year period, removals of pigs as a consequence of tail biting were higher from a fully-slatted than from a straw based system in newly-built matched housing (BPEX 2004a, b; 2005a, b), although relatively little tail biting occurred in the third experiment and all pigs had docked tails. In a more confounded comparison, with both floor type and ventilation system differing, Van de Weerd et al. (2005) found that pens of pigs with undocked tails showed 100% prevalence of tail biting in a part-slatted, unbedded system with fan ventilation, compared with 8% in a straw bedded system with natural ventilation. In a subsequent study carried out within the high-risk, fan-ventilated building, 1/6 pens given deep straw bedding showed tail biting, compared with 3/6 pens given straw in a rack and 5/6 in an unbedded, part slatted pen (Van de Weerd et al. 2006). Despite the limited sample size, this difference between the straw bedded and unbedded pen was statistically significant ($P<0.05$).

### 8.5.2. Enrichment

#### 8.5.2.1. Straw

The role of straw in reducing risk of tail biting can be considered in more detail, since this is one of the most widely cited factors. Straw has often been present as one of many components in comparisons of “enriched” pens which show reduced tail biting risk. For example, tail biting has been reported to be absent in enriched pens in the studies of Beattie et al. (1995) (enriched = extra space, peat and straw in a rack), and of Simonsen (1990) (enriched = extra space, straw and logs), and reduced in the study of Petersen et al., (1995) (enriched = straw, logs and branches). However, the precise role of each individual factor in such multi-component studies is difficult to determine.

As discussed in the previous section, tail biting is more frequent in strawless pens than in pens with straw (Haske et al., 1979; Troxler and Steiger, 1982). The straw need not be present as permanent deep bedding, but can be given in smaller daily amounts to achieve the same beneficial effects on tail biting (Zonderland et al., 2007). Many studies have demonstrated that a daily ration of fresh straw can reduce the risk of tail biting considerably (Ernst, 1995; Zonderland et al., 2007), even when ventilation is not optimal (Van Putten, 1969, 1980). For example in one study, “a handful” of straw per pig per day reduced cannibalism to 1/6 of its previous frequency (Ekesbo, 1973). In a survey involving 1000 pigs the incidence of tail biting in animals with access to 0.1 kg straw was 1.6%, but rose to 7.8% when straw was completely lacking (Eksbo, 1973). The provision of limited straw was also shown to reduce tail biting by 50% on farms where tail-biting was a problem (Bure and Koomans, 1981; Buré et al., 1983).

Day et al. (2002) compared groups of finishing pigs in solid-floor housing provided with different amounts of straw daily (0.09 kg, 1.1 kg or 2.2 kg/pig/day). They found that an increased provision of straw increased the total frequency of straw-directed behaviours and the proportional frequency of rooting and ploughing behaviour. A decrease in pig-directed behaviours, including aggression, belly nosing, tail biting, ear chewing and licking, biting and nosing other pigs, was recorded when comparing the no-straw treatment with any level of straw provision. However, there were no significant differences between the different levels of straw provision. In this factorially designed study, results were also influenced by whether pigs had previous experience of straw (see also section 10.2.1).

In contrast, it has also been noted that pens with relatively high straw use can show similar levels of pen-directed behaviour and sometimes even higher levels of tail biting (Krötzl *et al.*, 1993) although in this study chopped rather than long straw was provided.

Because of the logistical problems associated with the provision of long straw, and its risk of blocking liquid manure handling systems, there are practical reasons to prefer the use of chopped straw, particularly in buildings with slatted floors. The importance of the form of straw which is provided has been evaluated in relatively few studies. Day et al. (2007) compared long straw with straw of different chop lengths, when provided at 400 g/pig/day. Length of straw affected both the quantity and quality of straw-directed behaviours. Whilst the provision of straw of any length reduced the occurrence of pig-directed behaviours in comparison with absence of straw, levels of tail biting behaviours were higher in groups provided with short chopped straw (19% of particles >40 mm length) than with long straw (96% of particles > 40 mm length) or partially chopped straw (52% of particles >40 mm length). It was suggested that chopped straw may increase the level of exploratory or foraging motivation and, consequently, the pigs' propensity to express nosing, rooting and chewing type behaviours, but then not easily accommodate chewing behaviours, which are redirected towards penmates as adverse behaviours (Day et al., 2001).

In slatted systems, where straw cannot readily be supplied on the ground, the use of straw racks has been investigated. When fresh straw is presented in this way, it becomes a major focus for chewing and rooting, and these activities are directed less at penmates (Fraser et al., 1991b). In a number of studies, provision of straw from a rack has been reported to reduce tail biting (Krötzl et al., 1993; Stubbe et al., 1999). Recent Dutch work by Zonderland et al. (2007) compared the behaviour of weaner pigs housed on part slatted floors on a farm with known tail biting problems. Groups offered a straw rack (5g straw/pig/day) did not differ from pens with either a suspended metal chain or a rubber toy (hose cross), whereas pens provided with some straw (20 g/pig/day) twice daily showed a significant reduction in bite marks on the tail. When (more serious) tail wounds were compared, these authors found the lowest lesion levels with twice daily straw provision. This level differed significantly from the chain and toy, but not the straw rack treatment. The straw rack gave significantly lower serious lesion levels than the chain treatment. The straw rack was thus less effective than straw on the floor (especially in reducing bite marks), which might be attributable to either quantity of straw or mode of presentation. Similarly, in a study by Van de Weerd et al. (2006), provision of long straw in a rack reduced the number of pens affected by tail biting in comparison with a suspended plastic or rubber chewable device, but was less effective than full straw bedding.

As a similar alternative to racks, metal baskets with long straw hanging in the pen also allow moving of the basket. Tail biting was reduced from 4.74 to 2.03% on one farm and from 4.54 to 2.44% on another by supplying between 350 and 880 g straw per pig/fattening period in baskets (Buré and Koomans, 1981). Thus, whilst straw in a metal basket cannot completely prevent tail biting, it can significantly reduce it (Buré et al., 1983).

#### 8.5.2.2. Rooting material – earth, peat, compost

It has been suggested that pigs have a behavioural need to root (Van Putten, 1997, 1981; Horell, 1992) and will root unyielding surfaces and penmates in the absence of more suitable rooting substrates, with a possible risk of triggering tail biting. Rooting materials other than straw are less widely used in commercial practice, but may also be efficacious in reducing tail biting risk. Beattie et al. (1993) showed that growers housed indoors and given a rooting substrate, such as peat, increased exploration and decreased inactivity and pen-mate directed behaviours such as ear- and tail chewing. In many of the experiments from this centre, provision of straw and peat or compost was confounded as part of complex enrichment strategies (e.g. Beattie et al., 1996). However, these studies showed that access to rooting substrate was significantly more effective in preventing tail biting than increased space allowance. In later work, the use of mushroom compost on racks in fully slatted housing significantly reduced the level of pig directed behaviour and gave a large decrease in the prevalence of tail bitten animals (Beattie *et al*., 2001). Preference testing studies suggested that pigs prefer peat, mushroom compost or sawdust as a medium to root in rather than straw (Beattie *et al*., 1998).

Similarly, in Dutch work, providing compost twice daily on a rooting board ('vlonder') reduced abnormal behaviours (such as rooting and biting directed at penmates, and tail biting). This considerably reduced the risk of cannibalism, without leading to slurry blockage problems (as straw does) (Buré et al., 1983). Garden mould provided from an automat had some positive effect on reducing tail biting, but had less clear effects than straw in a metal basket or the twice daily provision of compost on a rooting board (Buré et al., 1983).

In an experiment comparing the use of sugar-beet pulp shreds in a hopper as a rooting material with, a hanging plastic toy, Scott et al. (2006) showed that the rooting material provided greater occupation for pigs in fully slatted pens, but that in both cases this was far below the level of occupation provided by straw. Pig-directed behaviours and tail biting showed no significant difference. The use of other roughage feeds such as silage and root crops as rooting substrates for pigs has been suggested (Olsen et al., 2000). However, no information has been found on their efficacy in preventing tail biting under different conditions.

#### 8.5.2.3. Hanging toys, footballs, etc.

Because of the difficulties associated with providing particulate substrates in fully slatted housing, with liquid manure handling facilities, there have been many attempts to devise toys which might be equally efficacious as environmental enrichment (for an overview see e.g. Bracke et al., 2006; 2007a, b). It is suggested that objects suitable for chewing and rooting provide stimulation or outlet for exploration and manipulation with the snout and mouth, and reduce adverse behaviours (Van de Weerd et al., 2003). In a large study of different environment enrichment materials, Van de Weerd et al. (2003) identified the key characteristics of objects which provided sustained occupation for growing pigs as ingestible, odorous, chewable, deformable and destructible. Surprisingly, rootability was negatively associated with occupation value in this study, largely as a result of a number of suspended devices which proved to be highly engaging (particularly when edible, such as carrots and coconut halves). Similarly, in a more limited comparison of objects, Zonderland et al. (2003b) identified flexibility and destructibility as important characteristics.

Suspended metal chains have been very widely used in commercial intensive production, and appear to provide significant occupation under some circumstances (e.g. Stubbe, 2000). However, since they do not provide an opportunity for destructible chewing which is preferred by pigs (Feddes and Fraser, 1994; Bracke, 2007a), they can be habituated to and provide a relatively poor source of enrichment (Day et al., 2002; Bracke, 2006; Bracke and Spoolder, 2007). Tail biting levels were higher in pens with chains than with a straw dispenser (Stubbe et al., 1999).

Suspended plastic objects might be more chewable than metal ones, and a number of home made devices (such as alkathene pipe helicopter toys; Scott et al., 2006) or commercial equivalents (e.g. the Bite Rite toy; Scott et al., 2006; Van de Weerd et al., 2006) are in common commercial use. However, these appear to be relatively ineffective at preventing tail biting, as has been shown in high risk conditions with undocked pigs (van de Weerd et al., 2005, 2006; Zonderland et al., 2007).

The provision of wooden logs or branches is another commonly used practical enrichment strategy. Provision of branches can reduce pig directed behaviour (Petersen et al., 1995), and in one study tail biting was significantly reduced in pens with nibbling beams (Krötzl et al., 1993).

Other widely used commercial enrichment objects are tyres, balls and ropes, but there is little objective information on the extent to which these influence tail biting risk (Bracke et al., 2006). In Danish studies on problem commercial farms, hanging ropes in the pen has reduced prevalence of damaged tails (T. Jensen, personal communication).

It has been suggested that a chewable object, carrying a flavour that competes well with blood for the pig's attention, might be a useful device to help prevent or control tail-biting problems (Fraser, 1987a, 1987b). Van de Weerd et al. (2006) assessed two enrichment devices designed to provide novel flavours. A device presenting flavoured feed appeared relatively successful in minimising tail biting risk under challenging conditions, even though the normal commercial diet was also available *ad libitum*. In contrast, all pens containing a device designed to supply flavoured liquids showed tail biting, but this was attributed to practical problems with the device itself which did not fulfil its design objectives. In an earlier experiment, provision of a flavoured chewing bar as environmental enrichment did not reduce pig directed behaviour (Day et al., 2002).

## 8.6. Diet and feeding

### 8.6.1. Restricted level of feeding and high feeding competition

Restricted feed intake and increased competition for feed, because of limited access, are generally confounded under group-housing conditions. Both may affect metabolic state, through reduced nutrient intake, and frustration resulting from thwarted feeding motivation. There have been no experimental comparisons of tail biting in pigs subject to different levels of feed restriction. In an experimental model system using artificial tails with or without blood impregnation, reduction in daily energy or protein intake failed to show large effects on chewing behaviour or attraction to blood (McIntyre and Edwards, 2002a). However, a UK survey found higher levels of tail biting in farms with restricted rather than ad lib fed pigs, associated with higher levels in trough and floor fed pigs compared to those fed via single or double space feeders (Guise and Penny, 1998). Penmate manipulation in general is increased with restricted feeding (Robert et al., 1991). In contrast, a subsequent UK survey found no difference in tail biting prevalence between pigs from farms feeding restricted, to appetite or ad libitum (Hunter et al., 2001).

In general, reports on tail biting highlight circumstances which might lead to intake variability within the group arising from competition for access to feed. For example, Geers et al. (1985) claimed that the easier the access to the food, the higher the feed intake, and the lower the incidence of tail biting. It has been observed that in competitive situations pigs are likely to be attacked from the rear while feeding, leading to tail biting (Sambraus and Kuchenhoff, 1992; Hansen and Hagelso, 1980). In a Swedish survey, restricted feeding in troughs providing <30 cm per pig increased tail biting (Holmgren and Lundeheim, 2004). A high ratio of pigs to feeding places in *ad libitum* feeding systems has also been shown to increase tail biting. In an experimental comparison, tail biting and ear biting was significantly less in pigs with several self-feeders per pen as compared to only one self-feeder (Hansen et al., 1979). In survey data, using a feeding system with five or more grower pigs per feed space increased risks of tail biting (Moinard et al., 2003), and the probability of long-tailed pigs being tail-bitten was reduced with use of double or multi-space feeders (Hunter et al., 2001). With high feed competition, in groups of 20 pigs, feeders fitted with stalls for protection during feeding had reduced enforced withdrawals and queuing, and reduced occurrence of tail biting (Morrow and Walker, 1994). In an epidemiological study of 60 Belgian farms, Smulders et al. (2007) showed a significant effect of the number of feeding places per animal (range 0.1-0.8) in the nursery on subsequent prevalence of tail lesions in finishing pigs. It was suggested that frustration of feeding due to restricted access may have had long term adverse effects on behaviour. No effect of number of feeding places in the finishing accommodation was demonstrated, although variation in this parameter was not reported.

Another two UK surveys noted that tail biting was less likely with manual feeding rather than automatic feeding (Chambers et al., 1995; Moinard et al. 2003). The reason for this is not immediately apparent, although there have been many anecdotal reports of tail biting being triggered by breakdowns in mechanical delivery which have allowed feed provision to be interrupted. A recent producer survey implicated "problems with the feeding and drinking system" as triggering tail biting outbreaks (Paul et al., 2007).

### 8.6.2. Form of feed

There have been suggestions that the form in which feed is provided might be a risk factor for tail biting, but published results are contradictory. One report mentioned dry meal feeding as a possible cause of tail biting but failed to demonstrate this experimentally (Van Putten, 1969), whereas survey data have shown higher levels of tail biting in pigs on liquid feed than on pellets or meal (Guise and Penny, 1998), in pigs given pelleted rather than liquid or meal feed (Hunter et al., 2001; Moinard et al., 2003), and in pigs given dry feed rather than wet feed (Smulders et al., 2007). It has been suggested that the need to explore remains chronically unsatisfied due to liquid feeding in a barren pen (no straw or other occupation) leading to tail biting (Stubbe, 2000). In a factorial experimental comparison of feeding and housing systems, the number of veterinary treatments for tail biting was highest with the combination of slatted housing and liquid feeding (as opposed to straw bedded housing and pellet feeding) (BPEX, 2004a). Interpretation of survey findings requires caution, since feed form is often confounded with delivery method and housing system, as well as ingredient composition of the diet.

### 8.6.3. Minerals

Mineral deficiencies or imbalances have frequently been anecdotally associated with tail biting outbreaks, and provision of supra-nutritional levels of sodium is a common remedial approach when an outbreak occurs (e.g. Smith and Penny, 1986). Although pigs require only about 0.2% salt in the diet for maximum weight gain, salt is often provided at 0.5% of the diet for growing pigs, and it is sometimes suggested that an increase to 0.75 or 1% can reduce the incidence of tail biting (Gadd, 1967; Fritschen and Hogg, 1983). In 6 farms with tail biting problems, addition of animal protein (higher in minerals than vegetable protein sources) and minerals to the feed led to marked improvement within a few days (Barnikol, 1978).

In an experimental model system using artificial tails with or without blood impregnation, it was demonstrated that after 4 weeks of a mineral deficient diet (lacking iodized salt, dicalcium phosphate, limestone, iron, zinc, manganese, copper, and selenium) a pronounced increase in chewing the blood-covered model occurred (Fraser, 1987a). A heightened response to blood-covered tail-models (cotton cord) was produced by omitting only iodized salt from the diet, whereas omission of all other mineral supplements (dicalcium phosphate, limestone, iron, zinc, manganese, copper, and selenium) except salt led to a much smaller and non-significant change. Four weeks of recovery on the control diet reduced, but did not completely eliminate, the enhanced attraction to blood (due to the previous mineral deficient diet) (Fraser, 1987a). It was therefore suggested that during a tail biting outbreak, a lack of salt in the diet can increase the pigs' attraction to blood, and escalate the problem. In rodents, stress has been shown to increase sodium clearance and it was suggested that this might be a common causal mechanism for stress-induced tail biting (Fraser, 1987a). However, more recent work surprisingly failed to demonstrate that pigs fed salt deficient diets increased their attraction to salt-soaked tail models (Beattie et al., 2001), or that pigs showed increased salt appetite in response to exogenous ACTH treatment (Jankevicius and Widowski, 2003, 2004).

Blood samples from tail biting pigs in one study suggested a disturbed Ca:P ratio (with elevated P values) (Barnikol, 1978), but no other experimental data specifically implicating these two major dietary minerals has been reported. However, addition of calcified seaweed (a high calcium buffer product) has controlled tail biting outbreaks on some problem units (R. Bull, personal communication).

Pigs in tail biting pens have been shown to have lower serum magnesium than those in control pens (Holmgren et al., 2004). However this may represent a shift in Mg from extracellular to cellular fluid, rather than an absolute deficiency, since Mg content in red blood cells was increased. Such a response has been seen in humans during physical stress. Krider et al. (1975) found that the addition of magnesium to the diet did not have any effect on the tail biting behaviour of pigs.

### 8.6.4. Protein and amino acids

The other major dietary component most frequently linked anecdotally with tail biting outbreaks has been protein. Tail biting pigs have been reported to have lower levels of serum protein than non biting contemporaries (Barnikol, 1978; Holmgren et al., 2004).

Low protein diets have been suggested to cause tail biting (Jericho and Church, 1972), whilst in 6 farms with tail biting problems, addition of animal protein and minerals to the feed led to marked improvement within a few days (Barnikol, 1978). Even when supplemented with the major limiting essential amino acids (lysine, methionine, threonine, tryptophan) in a controlled study, a low protein diet increased tail biting in slatted, but not straw bedded accommodation (BPEX, 2005b). Since growth rate of pigs was reduced on this diet, it can be concluded that dietary protein was still inadequate for optimal growth and that other amino acids must have been limiting. Phase feeding, i.e. changing the protein to energy ratio according to body weight to giving diets more closely suited to the protein needs of the animal at any given time, has reduced the prevalence of tail biting in both survey (Holmgren and Lundeheim, 2004) and controlled experimental comparison (BPEX, 2004b).

In an experimental model system using artificial tails with or without blood impregnation, omission of the soyabean meal from the diet for four weeks led to a large increase in attraction to blood and a significant reduction in body weight gain (Fraser et al., 1991a). Supplementation of a diet without soyabean meal with synthetic lysine or synthetic lysine and other amino acids led to weight gains that were intermediate between control and soyabean meal free diets. Attraction to blood was also intermediate on average, although not significantly lower than on soyabean meal free diet (Fraser et al., 1991a). A subsequent study with older pigs failed to demonstrate such clear effects of dietary protein deficiency on attraction to blood (McIntyre and Edwards, 2002a). However, in a similar model system, reduced dietary tryptophan has been shown to increase attraction to blood, and to increase exploratory behaviour under home pen conditions (McIntyre and Edwards, 2002b). A possible link between dietary amino acid levels and brain neurotransmitters involved in aggressive and exploratory behaviour has been suggested as contributing to tail biting risk (Edwards, 2006).

### 8.6.5. Fibre

Levels of dietary fibre have been anecdotally linked to tail biting outbreaks, although no controlled studies which demonstrate this have been reported. It has been suggested that when fed a low-fibre diet, pigs may remain hungry after a meal, and that this can cause restlessness and irritability eventually resulting in tail biting (Colyer, 1970). The beneficial effects of straw in reducing tail biting may involve some contribution through provision of additional ingestible fibre, although this is less likely to be the case when pigs are fed *ad libitum*. Conversely, others have suggested that both a low and a high level of fibre might contribute to the escalation of tail biting (Gadd, 1967).

### 8.6.6. Specific raw materials

A Swedish survey of 233 fattening barns with liquid feeding found significant increases in prevalence of tail biting of inclusion in the diet of distillers waste, triticale or high levels of barley (>50% of grain mixture) (Holmgren and Lundeheim, 2004). Inclusion of whey, a material with high sodium content, significantly decreased the prevalence of tail biting in the same survey. A diet with reduced palatability as a consequence of inclusion of rapeseed meal, which also has lower amino acid availability than soya, was reported to cause tail biting in conditions where growth performance was non-significantly lower on that diet (Salo, 1982).

### 8.6.7. Feed additives

It has been anecdotally reported that feed additives which control subclinical intestinal disease can reduce the prevalence of tail and ear biting. Conversely, Kavanagh (1992) found that when pigs were fed a diet containing 100 mg/kg of Carbadox, which was twice the normal recommended level, growth rate and feed intake were reduced and this was accompanied by an outbreak of tail biting.

### 8.6.8. Sudden changes in feed

Tail biting outbreaks, or an increase in tail chewing behaviour, have been anecdotally linked to sudden changes in diet (e.g. Day et al., 2002). Since a least cost diet specification is usually designed to give optimal economic return when fed over a period of many weeks, during which the pigs' exact nutrient requirements are progressively changing, it will generally undersupply nutrients initially, and then oversupply nutrients in the later stages when live weight and voluntary food intake are higher. Thus, dietary deficiencies leading to tail biting behaviour may be more likely immediately after a diet change to reduced nutrient density.

### 8.6.9. Water provision

The quality of the feed and the drinking water has been suggested as a possible cause of tail biting (Groskreuz, 1990), as has a cut in water supply in summer (Radnai, 1977). Although there is anecdotal evidence of commercial tail biting problems being solved by correcting a restriction in water supply, no experimental studies on such factors have been found.

## 8.7. Health/disease (as 'causal' factor)

### 8.7.1. Growth retardation

It has often been suggested that it is the small pigs which start an outbreak of tail biting (Schrøder-Petersen and Simonsen, 2001; Sambraus, 1985). However neither Breuer et al. (2005) nor Zonderland et al. (2007) found that identified tail biting pigs were smaller than their contemporaries. Van de Weerd et al. (2005) reported that, whilst body weight of all identified tail biting pigs did not differ significantly from the other pigs, animals identified as "fanatical" (extreme) biters were significantly lighter at mixing and predominantly ranked in the lower weight range within their group. Post hoc investigation revealed that this difference in body weight did not exist at birth or weaning, indicating that these animals had experienced a subsequent growth retardation. Beattie et al. (2005) also reported that animals in the upper quartile for expression of tail chewing behaviour in the 7 weeks after weaning were lighter at weaning, but not at birth, indicating reduced growth during the suckling period.

A greater predisposition to tail biting behaviour in growth retarded pigs might reflect a health condition (metabolic deficiency) with a direct effect of tail biting predisposition or an indirect effect on reduced competitiveness and therefore frustration of motivation to access resources such as feed. Evidence for both possibilities exists. Tail chewing behaviour of blood soaked artificial tail models in experimental tests has been shown to be higher in animals with nutritionally induced growth reduction (Fraser et al 1991a; McIntyre and Edwards, 2002a), suggesting a direct effect. Equally, the explanation may be associated with frustration amongst small pigs since they are often driven away from the trough or from their resting-place by larger pen-mates (Schrøder-Petersen and Simonsen, 2001, Larsen, 1983; Groskreutz, 1986). More precisely, Wallgren and Lindahl (1996) suggested that small pigs are less likely to win a fight by normal agonistic behaviour (Fraser and Broom, 1990) and this is the reason why they will attack their bigger pen mates from behind (Schrøder-Petersen and Simonsen, 2001). In a principal components analysis (PCA) to investigate individual pig characteristics associated with performance of adverse social behaviours, poorer growth after weaning and poor competitiveness in a food competition test both had high weightings in the first component (O'Connell et al., 2007), supporting both relationships.

#### 8.7.2. Disease

Although many factors may predispose to ill-health (i.e. poor management, housing, etc.), a strong link between herd health and tail biting was reported by Moinard et al (2003) who found that there was a 3.9 fold increase in the risk of tail biting when post-weaning mortality was above 2.5%; while the presence of respiratory diseases was associated with a 1.6-fold increase in the risk of tail biting. An association between respiratory problems and ear and tail biting in weaned piglets was also reported in a Dutch survey conducted on 438 farrow-to-finish farms (Elst et al., 1998). Many other anecdotal and published reports have linked poor herd health status to tail biting outbreaks (e.g. Walker and Bilkei, 2006), and there are reports where improving health status has reduced tail biting prevalence (e.g. by vaccination against Lawsonia; Almond and Bilkei, 2006).

#### 8.7.3. Parasitism

The presence of external parasites, such as mange mites, has been suggested as a cause of tail biting (Colyer, 1970; Fritchen and Hogg, 1983) and improvement has been sometimes achieved after deworming (Barnikol, 1978).

### 8.8. Climate and ventilation

Whilst the climatic environment of pigs is recognised as being of major importance in determining risk of tail biting outbreaks, the effects of climate on tail biting are complex, with many different factors often being confounded in studies on the subject.

#### 8.8.1. Time of year

Tail biting is often reported as showing seasonal differences, but these are not always consistent between different studies. Between 1993 and 1997 there were more 'tail bites/ abscesses' diagnosed at the Danish abattoirs during the winter months (Schrøder-Petersen and Simonsen, 2001). A survey of intensive pig farms in Poland revealed tail biting in 70-80% of the pigs in the autumn-winter period, whilst in spring and summer the tail-biting decreased or even completely disappeared (Visnjakow and Georgieu, 1972). Blackshaw (1981) also found that ear and tail biting occurred more frequently in colder months. In contrast, in a British study, the April to June quarter had the highest prevalence and October to December the lowest (Penny and Hill, 1974). However, in more recent UK data from a national abattoir health recording scheme (BPHS, 2006), prevalence of tail damage was highest in the autumn quarter (October to December, 0.8%) and lowest in the summer (April to June, 0.57%), with other quarters being intermediate. Time of year effects may be attributable to many factors including temperature, and associated changes in building ventilation rates, or photoperiod and associated changes in pig endocrine state.

#### 8.8.2. Heat stress

Heat stress has been reported as a triggering factor for tail biting on many occasions (e.g. Penny et al., 1981). Tail and ear-biting were more frequent in warmer, south-facing houses than in north-facing ones, and more common when the temperature was more than 20C (Haske et al., 1979). Lohse (1977) compared behaviour in pigs at 25C and 35C and found an increase in aggression and ear and tail biting at the higher temperature. During summer, a low air velocity combined with high inside temperatures caused little body contact, more lying in the dunging area, bad pen hygiene, lower growth rates and a tendency to increased tail biting (Sallvik and Walberg, 1984). However, Van Putten (1968) was unable to provoke tail biting by increasing temperatures to 28C. In an epidemiological study of 60 Belgian farms, Smulders et al. (2007) showed a significant effect of the temperature in the nursery accommodation (range 23-29C) on subsequent prevalence of tail lesions in finishing pigs. It was suggested that high temperature caused increased restlessness and aggression which persisted into the finishing period.

### 8.8.3. Cold and draughts

Many anecdotal reports link tail biting outbreaks with cold, or heating breakdowns in winter (Radnai, 1977; Schrøder-Petersen and Simonsen, 2001), and tail biting was induced experimentally in one study by lowering room temperature to 23 C (Van Putten, 1968). In a study of fattening pigs in 12 houses, tail biting was stated to be minimized by a temperature range of 20-22 C, and was highly correlated with the occurrence of temperatures of <16C in pigs of 40-50 kg live weight (Geers et al., 1989). These temperatures were calculated to be below the LCT of pigs in this study. However, relationships between temperature and tail biting in other weight ranges were less clear, and overall conclusions are difficult.

However, a more potent stimulus to tail biting than cold per se appears to be high airspeed (draughts). This has been both reported anecdotally (Colyer, 1970), and demonstrated experimentally (Sallvik and Walberg, 1984). The latter authors suggested that for preventing biting in small groups the optimum values of the chill factor is proposed to be 70-90 $W/m^2$, and for larger groups 50-60 $W/m^2$. The extent to which the effect of draughts is through changing the animals' perception of temperature, or through other behavioural disturbance, in undetermined.

### 8.8.4. Air quality

It is suggested that one of the reasons for increased tail biting in winter months is the reduction in ventilation rate in buildings to assist in the maintenance of temperature, leading to deterioration in air quality. It has been reported from practical experience that tail biting may begin in pens where isolated pockets of stale, humid air are allowed to accumulate (Colyer, 1970). However, experimental studies have found it difficult to provoke tail biting by poor air quality. No tail biting was observed when groups of pigs were inadvertently exposed to 80 mg/litre NH3 and 0.13% CO2 (Ewbank, 1973), or where levels of dust and ammonia were experimentally increased in flat deck housing (Wathes et al., 2002).

### 8.8.5. Ventilation type

In epidemiological studies, risk of tail biting has, on several occasions, been linked to ventilation type. In UK surveys, the risk of tail biting has been reported to be higher with artificial ventilation than with natural ventilation or artificially controlled natural ventilation (Guise and Penny, 1998; Hunter et al., 2001), although the postal survey of Chambers et al. (1995) failed to find any association with ventilation type. It is important to bear in mind the potential confounding factors, since use of straw is much more commonly associated with natural ventilation systems.

#### 8.8.6. Light

Historically, the use of dim light, or even darkness, was often practised to reduce the prevalence of tail damage. Van Putten and Elshof (1984) reported more clinical tail wounds at 25 lux than at lower light levels. However, this experimental study showed that in the dark (0 lux except during feeding) the pigs lay down more, showed less social behaviour, less exploratory behaviour and more tail biting behaviour (than in 1 lux or 25 lux) (van Putten and Elshof, 1984).

There has been little study of effects of photoperiod or spectral effects. However, Moinard et al (2003) found that higher levels of tail biting occurred on farms which used artificial lighting as opposed to a mixture of artificial and natural or just natural lighting. Once again, there is the possibility of confounding in such surveys, since use of straw is much more commonly associated with natural lighting. Chambers (1999) stated that tail biting is associated with neon (strip) lighting, and that replacing this kind of lighting with tungsten lights has been reported to solve the problem.

### 8.9. Tail docking as a control measure

Tail docking may prevent tail biting by reducing the attractiveness of (what is left of) the tail (e.g. because the tail is shorter and without long hair at the tip). This hypothesis is very common but experimental studies to test it are scarce. Data from Haske et al. (1979) and Simonsen (1995) do not support this hypothesis since the frequency of "tail in mouth" or of animals engaged in tail biting is similar in docked and intact groups of pigs during the fattening period. However, in the second study, only 1/3 of the tail was removed whereas in commercial piggeries docking is often more severe. More recently, McIntyre (2003) compared the behaviour of intact, one-third and two-third docked pigs. Animals of the different tail-groups were kept together whereas in the older studies, intact and docked pigs were separated. McIntyre (2003) observed that the pigs with their tail intact were the recipients of more tail-directed behaviours.

Another common hypothesis is that docking induces hyperalgesia and allodynia and, as a consequence, piglets will react more readily to pen mates assaults to their tail.

Simonsen et al. (1991) and Done et al. (2003) showed the presence of neuromas (random proliferation of axons and of the glial support cells) that are known to be very sensitive in other species and this would support the first part of the hypothesis (increased sensitivity). However, data obtained in one experiment with docked pigs failed. The second part of the hypothesis (increased responsiveness) has been very poorly investigated. In a pilot experiment, Chermat (2006) has observed the reaction of docked piglets (mild to severe docking) to tail assaults (tail in mouth) of other piglets: less than 5% had a reaction (aggression or more often avoidance) when there was no lesion on the tail whereas about 70% showed a reaction when the tail presented a lesion. In comparison, more than 50% of the animals reacted (mostly with avoidance behaviour) to attempt to bite the ears (without sign of lesion) in the mouth. Therefore, even when the tail is docked, most pigs do not seem to react actively unless a lesion is present.

**Table 9.** Effects of tail docking on tail biting occurrence.

| Type of survey | Reference | Docked pigs Short | Docked pigs Long | Undocked pigs | Statist. Signif.[5] |
|---|---|---|---|---|---|
| **Abattoir recording:** | | | | | |
| 11811 pigs | Penny & Hill, 1974 | 0.1[2] | | 11.6[2] | *** |
| 62971 pigs | Hunter et al., 1999 | 3.1[2] | | 9.2[2,3] | *** |
| 2855 pigs | Hunter et al., 2001 | 1.2[2] | | 4.3[2,3] | *** |
| **Farm:** | | | | | |
| 40 farms (postal questionnaire) | Chambers et al., 1995 | 79[1] | | 25[1] | *** |
| 101 farms (on-farm recording) | Moinard et al., 2003 | 87[1] | 53[1] | 37.5[1] | ** |
| **Experimental trial:** | | | | | |
| 200 pigs | Krider et al., 1975 | 2.0[2] | | 72.0[2] | *** |
| 60 pigs | McGlone et al., 1992 | 1.0[4] | | 1.5[4] | * |

[1] Percentage of farms with tail damage; [2] Percentage of pigs with tail damage; [3] Some of these pigs (about 15%) had the tail tip removed; [4] Tail score (1.0 = no wound, 3.0 = severe wound, 0.5 unit score); [5] *** P < 0.001, ** P <0.01, * P =0.05

Most arguments supporting a reduction of tail biting in tail-docked piglets come from anecdotal observations in commercial farms showing that tail biting was solved, at least in part, by tail docking. There are also (partly conflicting) arguments from data collected in commercial abattoirs (Penny and Hill, 1974; Hunter et al., 1999, 2001) or from farm surveys aiming at identifying risk factors for tail biting (Chambers et al., 1995; Moinard et al., 2003). Such studies may be criticized: abattoir studies probably underestimate the occurrence of tail biting since animals with severe biting may have died before they are slaughtered; farm surveys identify associations rather than cause and effect relationships. Overall, most of these studies indicate a lower incidence of tail biting when piglets are docked leading to the conclusion that tail docking reduces tail biting (Table 9). However, two UK studies showed the inverse (Chambers et al., 1995; Moinard et al., 2003). The most likely explanation for this finding is that tail docking is widely performed by farmers in response to tail biting problems (in fact according to UK regulations tail docking is permissible only when a farm's veterinary surgeon gives his agreement to the procedure because tail biting is likely to occur if it is not performed). Tail docking, however, does not completely remedy the problem, probably because underlying causes for the tail biting problem remain unresolved. As a consequence, pigs with intact tails are mainly found on farms with 'good' conditions (as regards tail biting problems), whereas docking is performed on more problematic farms.

To our knowledge, there are only two experimental published studies that have measured the effects of tail docking on tail biting (Krider et al., 1975; McGlone et al., 1992). They confirmed that tail docking reduces the risk of tail biting in confined animals (Table 9). However, when animals were housed outdoors, tail biting did not occur in either group, intact or docked pigs (McGlone et al., 1992). In a current UK study comparing contemporary pigs with intact or docked tails, reared under equivalent husbandry conditions chosen to minimize tail biting (straw-bedded housing and carefully monitored nutrition), the initial replicates (720 pigs monitored in 28 pens per treatment) have shown that tail biting was more prevalent when tails were left intact (S. A. Edwards, personal communication). Whilst tail biting did not occur amongst docked pigs, 18% of undocked pigs required veterinary treatment on farm for tail biting, and 16.5% had signs of tail biting recorded at the abattoir.

### 8.10. Presence of pig(s) with tail injury

Observations in groups of pigs undergoing tail biting have suggested that tail lesions themselves stimulate tail biting leading to the "explosion" of tail biting. Numerous hypotheses have been elaborated to explain these vicious circles.

One of them is related to blood attractiveness: once the tail has been injured, bleeding may stimulate further tail biting. Indeed, experiments using a tail model (a rope having a length and diameter similar to a pig's tail) have shown that pigs perform more chewing when the model is impregnated with blood than with a control solution (Fraser, 1987b; Fraser et al., 1991a; McIntyre and Edwards, 2002c; Jankevicius and Widowski, 2004). It is likely that pigs use olfactory or taste cues to discriminate among the different tail models (Jankevicius and Widowski, 2003). This attraction to blood could be increased in pigs that are fed a mineral-deficient diet (Fraser, 1987b) or a diet containing inadequate protein content (Fraser et al, 1991). However, the influence of low protein content was not observed in a more recent experiment (McIntyre and Edwards, 2002c).

Some other hypotheses come from occasional observations but experimental evidence is scarce. For instance, it has been suggested that irritation of the wounded tail may stimulate tail movements in the bitten animals rendering its tail more attractive to the biter pigs (Van Putten, 1979). This irritation may also increase behavioural activities of the bitten animals which will disturb their pen mates and hence their biting activity (Colyer, 1970). Finally, in severe cases, wounded animals may become apathetic and their lack of reaction, when they are bitten, may favour new biting (Sambraus, 1985).

On the other hand, arguments also exist to demonstrate that the presence of tail lesions may have an inhibitory influence on subsequent tail biting. For instance, McGlone et al. (1992) showed that posture of the tail of undocked pigs changes in case of tail biting: 100% of pigs reared outside without cannibalism maintained the tail up and curled compared to 30% of the pigs reared in confinement during the episode of cannibalism; other pigs had the tail down ducked under the hind legs (24%) or in an intermediate position (46%). Maintaining the tail down clearly decreases its exposure to other pigs' assaults and can be interpreted as an attempt to avoid further biting. In addition, Chermat (2006) observed that the proportion of tail-docked pigs that reacted, mostly with avoidance, when their tail was touched/chewed by another pig was higher when there was a lesion on the tail.

## 9. Risk Assessment approach

### 9.1.1. Introduction

Animal welfare problems are generally the consequence of negative animal-environment interactions, resulting from animal management factors or housing factors, so called "design criteria" (Anonymous, 2001). Presently there are not any standards for animal welfare risk assessment, but previous studies exist where risk assessment for animal welfare and tail biting has been explored (Anonymous, 2001; Bracke et al., 2004a, b; EFSA 2006; Bracke et al., 2007c; Cagienard et al., 2005).

Risk assessment is a systematic, scientific-based process to estimate the likelihood and severity of a hazard impact and include 4 steps: hazard identification; hazard characterisation; exposure assessment and risk characterisation.

In food risk assessment terminology (Codex Alimentarius), a hazard is a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect. The risk is a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard(s) in food.

Making a parallel to the Codex Alimentarius risk assessment methodology, a hazard in animal welfare risk assessment is a design criterion (usually an environment-based factor) with a potential to cause negative animal welfare effect (adverse effect as measured by one or more welfare performance criteria).

A risk in animal welfare is a function of the probability of a negative animal welfare effect and the severity of that effect, consequential to the exposure to a hazard(s).

Risk has two components: the probability or likelihood of the adverse effect at population level and the magnitude of that effect at an individual level on the same population.

While hazards and risks usually relate to negative welfare impacts, the risk assessment approach can also be extended to include positive welfare consequences (resulting in risk-benefit analysis). Hazard characterisation includes identification of factors whose absence increases animal's chances of well-being.

The degree of confidence in the final estimation of risk depends on the variability, uncertainty, and assumptions identified and integrated in the different risk assessment steps.

Uncertainty arises in the evaluation and extrapolation of information obtained from epidemiological, experimental, and laboratory animal studies and whenever attempts are made to extrapolate (i.e. to use data concerning the occurrence of certain phenomena obtained under one set of conditions to make estimations or predictions about phenomena likely to occur under other sets of conditions for which data are not available).

Uncertainty analysis describes the fact that we have incomplete knowledge. Uncertainty could be treated formally in conducting more studies or quasi-formally in using expert opinions or informally by making judgment.

Variability is a biological phenomenon (inherent dispersion) and is not reducible. Reduction in variability is not an improvement in knowledge, but instead would reflect a loss of information.

For the two steps of the process; Hazard Characterisation and Exposure Assessment, the experts were asked to individually fill the tables for each population (i.e. docked and undocked weaned, growing and fattening pigs in Europe), based on their scientific knowledge and data described in hazard identification section. These values were compared and discussed to reach a consensus Table (see Appendix 3).

### 9.1.2. Steps of Risk Assessment

*1) Definition of the target populations*

The first step on the development of the RA was to identify the target populations to be considered, depending on the animal categories (and life stages) and the different husbandry systems. The target populations considered for the RA were the following:

| | |
|---|---|
| a) Sows and Boars: | Dry Sows - from weaning to 4 weeks of service |
| | Pregnant Sows (from 4 weeks after service) |
| | Farrowing Sows |
| | Boars |
| | Piglets (up to weaning) |
| b) Fattening: | Weaning (up to 10 weeks) indoor |
| | Weaning (up to 10 weeks) outdoor |
| | Growing (from 10 weeks onwards) indoor |
| | Growing (from 10 weeks onwards) outdoor |
| | Fattening pigs (over 110 kg) |
| c) Tail biting: | Docked pigs |
| | Undocked pigs |

*2) Hazard identification*

The aim of this step is to identify hazards, i.e. causes or factors that affect the animal's welfare needs (negatively as well as positively).

In this step, the scientific evidence of association between the exposure to a given production factor (hazard) and the consequent impact on animal welfare are reviewed.

Once the target populations were defined, a list of hazards with their adverse effects affecting each of the populations was agreed. Some general examples are shown in Table 10 (Candiani et al., 2007).

**Table 10.** Examples of hazards related to animal needs with related adverse effects.

| Need | Hazards | Adverse effect |
|---|---|---|
| **Nutrition:**<br>to drink, to thermoregulate,… | Difficult access to water<br>Insufficient feed<br>Too low milk T°,… | Thirst<br>Hunger<br>Stress, anxiety,… |
| **Housing:**<br>to rest, to exercise,… | Sliding floors<br>Inappropriate ventilation,… | Lameness<br>Pain, malaise,… |
| **Management:**<br>To avoid fear, to have proper social interactions,… | Staff without experience<br>Mixing of unfamiliar animals,… | Stereotypes<br>Fear<br>Stress,… |

For each population, a Microsoft Excel® Table was made listing all identified hazards with their adverse effects. If for the same hazard different adverse effects occur, a line for each considered adverse effect was listed (see example Table 13).

For the two following steps, Hazard Characterisation and Exposure Assessment the WG experts were asked to individually fill the tables for each population (i.e. docked and undocked weaned, growing and fattening pigs), based on their scientific knowledge and data described in the hazard identification section of the scientific report.

*3) Hazard Characterization (HC)*

The objectives of this step are:

- to review and describe the consequences of an exposure to one or several hazards in terms of magnitude of adverse effect;
- to assess the relationship between the level of the hazard in terms of intensity, and duration and the likelihood and magnitude of the adverse effect.

The Severity of the adverse effects was scored subjectively by the members of the Working Group based on scientific information about the level of physiological and behavioural responses. Severity scores ranged on a 5 points scale from Negligible (score 0) to Critical (score 4). See Table 11 for the hazard characterisation scores.

**Table 11.** Severity scores of the adverse effects.

| Severity of the adverse effect | Descriptive definition | Scores |
|---|---|---|
| Critical | Fatal, death occurs either immediately or after some time | 4 |
| Severe | Involving explicit pain, malaise, frustration, fear or anxiety<br>Strong stress reaction, dramatic change in motor behaviour, vocalization may occur | 3 |
| Moderate | Some pain, malaise, frustration, fear or anxiety<br>Stress reaction, some change in motor behaviour, occasional vocalization may occur | 2 |
| Limited | Minor pain, malaise, frustration, fear or anxiety<br>Physiological effects may be recorded as well as moderate behavioural changes | 1 |
| Negligible | No pain, malaise, frustration, fear or anxiety | 0 |

The Duration of the effect was expressed as the number of days where a pig was believed/expected to be experiencing the adverse effect, once it would be exposed to the hazard. The life time in days for each target population was agreed by the WG; therefore the numbers of days was converted to a % of the life time. Both values were showed in the Tables except in the case of the tail biting hazard characterisation.

The experts were asked to score the Quantitative Assessment of Likelihood that an adverse effect can occur for a given exposure to a hazard (defined in terms of intensity and duration). The experts opinion were modelled using a Beta-Pert distribution that requires three parameters, namely minimum, most likely and maximum. The three parameters range from 0 100% (see example in Table 13).

The Qualitative Assessment of Uncertainty for each assessment according with the availability of any scientific evidence was also scored (see Table 12). The scored values were compared and discussed to reach a consensus Table (see Appendix 3).

**Table 12.** Qualitative uncertainty scores for the likelihood and exposure.

| | |
|---|---|
| **Low** | Solid and complete data available;<br>strong evidence provided in multiple refs; authors report similar conclusions |
| **Medium** | Some but no complete data available; evidence provided in small number of refs; authors' conclusions vary from one to other.<br>Solid and complete data available from other species which can be extrapolated to the species considered |
| **High** | Scarce or no data available; rather evidence provided in unpublished reports, based on observations or personal communications; authors' conclusions vary considerably between them |

Once all the scores were agreed and the consensus tables completed, from the severity and duration of an adverse effect, the Magnitude of an adverse effect was calculated as follows (values not shown in the Appendix, but used for Risk estimation):

**Magnitude = (Severity score/4) * Duration of the effect (number of days)**

*4) Exposure assessment (EA)*

EA is the quantitative assessment of the probability of the specific scenario of exposure. The different exposure scenarios were defined by the experts. The scenario takes into account the Intensity and Duration of an exposure to one or several hazards during the considered period of the animal's life within the considered population (i.e. 170 days and European populations of docked and undocked pigs, respectively). The considered life time for each target population was also agreed by the WG in order to get a consensus on the scored %.

The Intensity of exposure to a hazard is measured either as full exposure/no exposure or exposure to a given range of intensity of the hazard (ammonia concentration example). If there are different levels of exposure, one line was created for each level (see Table 13). This is relevant when data on the frequencies of the different level of exposures and data on the relationship between the level of exposure and the severity and likelihood of the consequences (adverse effect) are available.

The probability of each exposure scenario (Quantitative Assessment of Probability of Exposure) for a defined target population was assessed by the experts and modelled using a Beta-Pert distribution (as before three parameters minimum, most likely and maximum, ranging from 0 to 100% are required). The Uncertainty score (see Table 12) for each assessment, was estimated as in the HC.

**Table 13.** Table for scoring the hazards: example of a consensus.

| **Target population: Dry Sows** [a] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hazard description** | **Hazard characterisation** | | | | | | | **Exposure assessment** | | | | | |
| | **Adverse effect** [b] | **Magnitude** | | **Quantitative assessment of likelihood** [e] **(%)** | | | **Qualitative assessment of the uncertainty** [f] | **Duration** [g] **%** | **Intensity** [h] | **Quantitative assessment of P. of Exposure**[i] **(%)** | | | **Qualitative assessment of the uncertainty**[j] |
| | | **Severity** [c] | **Duration** [d] **%** | **min** | **ml** | **max** | | | | **min** | **ml** | **max** | |
| High Conc. Ammonia (above 20-25 pm) | **Respiratory Disease** | **Limited-1** | **80**[3] | **5** | **30** | **50** | **Medium** | **70** | **25-49 ppm** | **90** | **95** | **99** | **High** |
| | **Respiratory Disease** | **Moderate-2** | **80** | | | **X** | | **70** | **50-99 ppm** | | | | |

**Table 13 Legend:**

a = Name of the **Target population**.

b = **Adverse effect** in relation to the needs and consequence of not fulfilling the needs.

c = **Severity** of the adverse effect. Classification based on the criteria in Table 11.

[3] The example shows a sow which is through her life as a sow, exposed to a levels of ammonia of 25-49 ppm during 70% of her lifetime, and which, as a consequence of this exposure, suffers from a respiratory disease of a limited severity during 80% of the sow's lifetime.

d = **Duration** of the adverse effect given the indicated exposure, during the life time: value from 0% to 100%. Also, when the adverse effect is fatal the duration is 100%.
e = **Quantitative Assessment of Likelihood**: minimum (**min**), most likely (**ml**) and maximum (**max**). This range of values describes the uncertainty and not the variability.
f = **Qualitative Assessment of the Uncertainty**, based on data available for the quantitative assessment (Table 12).
g = **Duration** of the exposure relative to the life time: value from 0% to 100%.
h = **Intensity** of exposure to a hazard, measured either as full exposure/no exposure or exposure to a given range of intensity of the hazard. If there are different levels of exposure, one line was created for each level.
I = **Quantitative assessment of Probability of Exposure**: minimum (**min**), most likely (**ml**) and maximum (**max**).
j = **Qualitative Assessment of the Uncertainty**, based on data available for the quantitative assessment (Table 12).

### *5) Risk characterization (RC)*

Risk characterisation uses HC and EA scores to calculate a RC score expressing the magnitude of risk of animals in the population exposed to a given hazard.

This step aims to estimate the likelihood of the occurrence of the adverse effect in a specific husbandry system in a specific period of the animal's life. It aims to give information to the risk manager to evaluate a specific situation regarding the fulfilling of animal needs and maximising good welfare.

This risk estimate was calculated for each hazard, and expresses its animal welfare burden in the considered population:

| | |
|---|---|
| **Risk =** | **(Magnitude of the effect) * (Likelihood of the effect given a scenario of exposure) * (Probability of the considered scenario of exposure)** |

This formula assumes the following:

- that there is linearity on the severity scores (e.g. 2 days suffering from an intensity score 2 is equivalent to 1 day suffering from an intensity score 4);
- that there is no interaction between hazards;
- that the hazards are mutually exclusive.

Because the previous assumptions are extremely tentative and could not be verified within the scope the WG's mandate, the risk calculation has to be interpreted with extreme caution. A simple interpretation is to consider the risk calculation as the number of days the animals are suffering from poor welfare induced by the exposure to the considered hazard.

To asses the effect of an exposure to several hazards, summation is avoided by precaution, as the different exposures are not mutually exclusive and it is needed to weight the different outcomes before summation.

The risk calculation mainly serves the purpose of ranking the importance of the different considered hazards within the examined populations.

Because the risk formula input, likelihood of the effect given a scenario of exposure and likelihood of the considered scenario of exposure, are both random variables the risk assessment output is a random variable. The risk formula was run for 10 000 iterations using Monte-Carlo sampling method with @Risk (Palisade, Ithaca, USA) add-in for Microsoft Excel®. The risk output distribution was described using its median, 5th and 95th percentiles.

The qualitative assessment of the uncertainty on the risk output was derived accordingly the classification matrix (Table 14).

**Table 14.** Classification matrix of the qualitative assessment of the uncertainty

| Likelihood uncertainty \ Exposure uncertainty | High | Medium | Low |
|---|---|---|---|
| High | High | High | High |
| Medium | High | Medium | Medium |
| Low | High | Medium | Low |

#### 9.1.3. Graphical presentation of the Risk Characterisation

The consensus Tables in the Appendix are divided in three sections: Hazard Characterisation (HC), Exposure Assessment (EA) and Risk Characterisation. HC and EA sections include all values agreed by the experts and used to calculate the Risk Characterisation for each hazard listed in the consensus Tables. The Risk estimate (CI 95%) values are reported by the median and the 5th and 95th percentiles. The qualitative uncertainty of the risk estimate is calculated from Table X6 (by multiplying EA and HC uncertainties).

In the Appendix 3, for each hazard within each population, values of the risk estimate (median, 5$^{th}$ and 95$^{th}$ percentiles) and magnitude of the hazard are presented as a histogram. Hazards have been ordered in each population by decreasing risk estimate value.

In the case of the Fattening and the Sows and Boars scientific opinions the results of the risk assessment process also allowed the confirmation of some conclusions obtained from the data presented in the scientific reports. Conclusions from the risk assessment process have been explicitly detailed in the tail biting scientific opinion as explained in the following subheadings.

#### 9.1.4. Definition of Exposure Scenarios and Hazard Characterisation

The hazards identified in this chapter were used for further risk assessment in two pre-defined populations of weaned, growing and finishing pigs, namely:

1. Docked pigs in Europe
2. Undocked pigs in Europe

These pigs are kept in a wide variety of husbandry systems. However, in practise the docked pigs are mainly kept in slatted systems without substrate, while undocked pigs tend to be either slaughtered at a younger age and/or kept under less intensive conditions. Nevertheless, for the purpose of risk characterisation, we assumed a life-span of 140 days (from weaning to slaughter) in both populations, and assumed that under good management the pig would normally be removed/treated within a short period but time for healing would then be needed. The total time for the pig being ‘seriously affected’ was estimated by experts as being on average around 20 days and that the adverse effect on welfare could be characterised.

We also concentrated on the adverse effect for the bitten pigs, i.e. on the fear and pain caused by being tail bitten. Adverse welfare aspects present in the biters, i.e. animals performing the tail biting, were not taken into account for the present Risk Characterisation (RC). The present RC focuses instead on assessing risk for the bites, i.e. on the presence of clinical tail biting (i.e. tail wounds). This was decided because data on the prevalence of tail biters is largely lacking in the literature (one cannot be sure from a prevalence of bitten pigs how many biters were responsible), making a proper risk assessment virtually impossible at the present time.

Nevertheless, the wider welfare aspects (e.g. for tail biters) have been described elsewhere in this report and will also be included in the risk assessment in the report on fattening pigs.

In formulating hazards for RC we started with what was scientifically known about these hazards (as described in chapter 8) and then took a prevalent situation as a starting point and related this to what was scientifically known about it; realising that there is some variability in hazard formulation.

In including/excluding hazards we also considered the possible manageability of the hazards in terms of decreasing the risks for tail biting.

For example, gender, weight/age and individual housing (versus being kept in group) were considered to be not realistic management options. By contrast, three substrate-related categories were identified addressing potentially feasible management options.

In formulating the hazard characterisation scores, the starting point was an estimate that the prevalence of tail biting in populations of docked pigs is approximately 3% and the prevalence in undocked pigs is 10%.

The following hazards were used for risk characterisation:

*Genetic selection for high lean tissue growth rate (low fatness)*
This hazard identifies the risk for tail biting due to a pig in the target population being the result of intensive selection for high lean tissue growth rate. The duration of this hazard was 100% of the pig's life.

*Lack of farrowing house bedding / enrichment*
This hazard indicates that a pig in our target population has been previously reared in a farrowing accommodation without bedding or enrichment. The duration of this hazard is, logically, 100% of the pig's life.

*Removal of bedding*
This hazard indicates that pigs previously housed on bedding may at some point in their life be exposed to a period where no bedding is suddenly provided. For risk characterisation, the duration of this period of transition was assumed to last for a period of 2 weeks in the pig's life.

*Fully slatted floor during suckling period*
This hazard refers to the situation in which a pig is kept on a fully slatted floor during suckling. The hazard was estimated to last for 84% of the pig's life.

*High Stocking density*
This hazard refers to the situation in which pigs are exposed to a stocking density of at least 110 kg/m2 and, since this esp. occurs at the end of the fattening period, this hazard was estimated to last for about 2 weeks (i.e. 8% in the pig's life).

*Mixing of animals excluding at weaning time*
This hazard indicates the situation in which pigs are mixed again after the usual post-weaning mixing, and that the impact of such an event with respect to tail biting risk lasts for about 2 weeks.

*Large Herd size*
This hazard refers to being kept on a farm with more than 5000 growing pigs.

*Lack of long straw*
This hazard refers to being kept in a system without long straw, regardless of floor type (i.e. including both slatted and solid) and regardless of whether or not other types of enrichment were provided.

*Lack of straw and 100 % slatted floor*

This hazard was formulated in addition to the previous hazard to indicate that scientific evidence exists that an increased proportion of slatted floors is a separate hazard for tail biting.

*Lack of straw and absence of adequate enrichment*

This hazard refers to the situation where pigs are subjected to deprivation of any type of adequate enrichment, specified as particulate, rooting substrate and/or destructible toy.

*High feeding competition*

This hazard was specified as more than 10% pigs waiting to get access to feed at any time and it was specified that this situation would occur for a total of about 4 weeks in the pig's life.

*Delay of feed supply*

This hazard indicates a period of more than 12h delay of feed supply when normally fed ad libitum, or less than 12 h in animals fed in meals. This was assumed to last for 1% of the pig's life.

*Abrupt change of feed composition*

This hazard indicates a pig being subjected to an abrupt change in feed. Its duration was set at 8%, i.e. 2 weeks (this also includes the situation where a pig is exposed to more than 1 feed change, but where the total impact on tail biting was considered to last for 2 weeks.

*Inadequate dietary  sodium*

This hazard indicates that less than 0.17% dietary sodium is present in the diet, with a hazard duration of 12% of the pig's life.

*Aminoacid deficiency*

Insufficient protein (aminoacids) intake, such that lean tissue growth is retarded, lasting for 16% of the animal´s life time.

*Poor herd health status*

Living in a herd with a poor health status, i.e. where an enzootic disease is present, for 100% of the animal´s life.

*Presence of clinical disease in the individual*

Being clinically ill, for 8% of the animal´s life.

*Being in a group with growth retarded pigs*

For 80% of the animal´s life being in a group with growth retarded pigs, defined as pigs with a body weight that is 25% less than the group average.

*Heat stress*

Being for 16% of the animal´s life at a temperature that is at least 3 degrees above the upper critical temperature.

*Cold stress*

Being for 4% of the animal´s life at a temperature that is at least 3 degrees below the lower critical temperature. (Note that cold stress due to draughts are not included here, but under ´high air speed´).

*High air speed (draughts)*

Being exposed to high air speed (i.e. above 0.5 m/s, i.e. draughts) for 16% of the life time (but note a difference with hazard ´cold stress´).

*Poor air quality (low ventilation)*

Being exposed to a poor air quality, e.g. due to low ventilation, with values above 25 ppm $NH_3$, for 12% of the pig´s life.

*Absence of natural light*

Absence of natural light for the full life time. (Insert footnote: Not all working group members agreed that there was sufficient scientific evidence to formulate this ´natural light` as a hazard for tail biting).

*Presence (no removal) of tail bitten and tail biting animals*

Biters and bitees are not removed from the pen, resulting in a total of 4 week exposure to pen mates that have wounds and/or are predisposed to perform tail biting behaviour.

*Lack of tail docking*

This hazard applies only to the population of undocked pigs. The duration of exposure to this hazard is logically 100% of the pig's life.

### 9.1.5. Discussion of Risk Characterisation table

The results of the risk assessment analysis are shown in Appendix 3.

Previously, a so-called semantic model has been constructed which was designed to assess the risk of tail biting in pigs (Bracke et al., 2004a; Bracke, 2007b). This model was based on information obtained from abstracts of scientific papers retrieved in a systematic literature search on the subject of tail biting, and validated using a meta-analysis (Bracke et al., 2004b). The results from the model can be compared with the results of the risk characterisation performed here (for a detailed discussion of similarities and differences between semantic modelling and risk assessment see Bracke et al., 2007c), despite the fact that the exercises were not independent (Bracke was a member of the EFSA working group and the statements collected in the RICHPIG database were used as a starting point for literature review by the EFSA working group). As a consequence it may not be surprising that there are considerable similarities with respect to the ranking of items/hazards. Most notably hazards like 'substrate' are important in both analyses and hazards like 'light' are less important. However, some notable differences are also present. First, RICHPIG identified '(not) tail docking' as the most important hazard for tail biting. The RICHPIG model contains several time-related hazards: time of day, time of year, age/weight of the pig. These variables/hazards were not as clearly identified in the present report, partly because there was a (small) difference in deciding when scientific evidence was sufficient to formulate an item as a hazard and partly perhaps because the risk assessment framework may not be ideally suited to represent processes in time (e.g. because in the EFSA working group the argument whether a hazard was 'manageable' was often considered relevant, whereas in the semantic modelling of RICHPIG such arguments were not considered relevant).

## 10. Management of Tail Biting Outbreaks

Halting an outbreak of tail biting may be difficult. Eliminating the predisposing factors may not solve the problem. For example, Zonderland et al. (2007) showed that providing some straw twice daily by hand was not as effective in reducing fresh tail wounds during tail biting outbreaks as it was in preventing the occurrence of tail biting. In addition to counteracting predisposing hazards a number of additional management measures have been suggested. These include alteration of the (social) environment (e.g. removing the victim or the biter, providing more space and enrichment materials), medical treatment (antibiotic injections, application of tar on the tail) and surgical intervention (amputation of the severely wounded tail and/or the teeth of biters; classification based on Schrøder-Petersen and Simonsen, 2001). When the tail biting outbreak is halted, a tail wound may heal but often the wound becomes infected (Sambraus 1985; Fraser and Broom, 1997) with an enhanced risk for spinal abcessation, severe lameness and even death as a secondary complication of tail biting.

While much is known about predisposing factors, relatively few studies have examined the effects of factors reducing tail biting during an outbreak.

Zonderland et al. (2007) compared two curative treatments that were applied following the onset of tail biting in a pen with weaned pigs on a farm with tail biting problems: (i) twice daily provision of straw and (ii) removal of the biter. No significant differences between the treatments effects were found. Although neither treatment could eliminate tail biting entirely, the number of piglets with red fresh blood on their tails was found to be reduced from day 1 to 9 following the onset of each treatment, compared to day 0. The authors concluded that providing straw and removing the biter appeared to be equally effective in stopping a tail biting outbreak.

Jensen et al., 2006 (unpublished data) reported that at herd level it was often possible to identify and correct disadvantageous environmental conditions, and thereby reduce tail biting. This, however, required extensive investigations into possible underlying causes, as each herd seemed to have its own tail biting aetiology. For this reason a detailed checklist (including climate, behavioural, health and management factors) or more sophisticated computer-based decision support system (such as a Bayesian network or relational database, see also Bracke et al., 2004a, b) should be developed further for use in control strategies.

Jensen et al., 2006 (unpublished data) reported beneficial effects of suspended ropes and providing straw twice daily in stabilizing outbreaks of tail biting. Ropes seemed more effective than straw in fully slatted pens. These authors also reported a stabilizing effect of increased attention by the farm in dealing with the tail biting problem, while an examination of the effects of feed composition with respect to protein and carbohydrate was not feasible under practical (non-experimental) conditions (due to relative large - 10% - variation in e.g. protein content accepted in Denmark).

In addition to a better understanding of the causal factors leading to tail biting and tools for detecting causal factors on farms, adequate management would also benefit from improved early detection of tail biting outbreaks. This is important because tail biting is known to be a self-reinforcing and damaging activity (Fraser, 1987a).

In order to effectively stop or even prevent an outbreak of tail biting, it seems necessary that it is diagnosed as early as possible, preferably in the pre-injury stage before an animal has been harmed. So far, however, attempts to find early behavioural indicators in the days preceding an outbreak have not been successful (e.g. Zonderland et al., 2007; Bracke, pers. comm.).

Causal factors (hazards) for tail biting described in this report included animal characteristics (such as breed, gender and age), the rearing environment, the social environment, substrate, floors and space, diet and feeding, health, climate, tail docking and tail injuries. Several of these hazards could be used as possible treatment-solutions during an outbreak. These include managing the social environment, providing substrate and other enrichment materials, increasing space allowances, optimising diet and feeding systems, alleviating health problems and improving climatic conditions. These treatment-solutions may be applied singly or sequentially as this may help identifying causal factors on a farm. They may also be applied in combination or to a sufficient extent to exert the maximum possible effect in counteracting the outbreak. For instance, Van Putten (1968) suggested providing plenty of straw, extra fresh air or an extra meal.

In addition to counteracting possible causal factors (identified hazards), a number of additional management factors have been suggested as "treatments" during an outbreak. These include (1) alteration of the (social) environment, (2) medical treatment and (3) surgical intervention (after Schrøder-Petersen and Simonsen, 2001).

(1) Alteration of the (social) environment may include removal of the tail biter(s) and/or the bitten pig(s) from the pen, moving pigs to another pen, applying repellent materials to the tails

(of affected and unaffected pigs) and keeping pigs in total darkness. Early isolation of the biter, provided such an individual can be identified, can be used effectively against an outbreak of tail biting (Ray, 1961; Colyer, 1970). The work by Zonderland et al. (2007) has shown, however, that identification of the biter(s) is not always possible. Early removal of the victims was suggested by Van den Berg (1982) and Arey (1991). In a later stage this measure, however, may not stop the biter(s) from making new victims. According to Dalrymple (1978) providing new toys or moving pigs to another pen in order to distract the pigs' attention may help. It is suggested that avoiding the mixing of animals of different sizes in the same pen is a common control measure. The ultimate 'removal' may be sacrificing tail-biters and tail-bitten pigs (Arey, 1991). Van den Berg (1982) recommended immediate slaughter of animals showing complications such as paralysis and growth checks.

Darkening the barn was recommended by Van Putten (1968) and by Van den Berg (1982). However, keeping pigs in total darkness is no longer considered acceptable (Arey, 1991) and may have limited effect. Van Putten and Elshof (1984) compared 0, 1 and 25 lux light levels (as preventive measures) and found most clinical tail wounds in the 25 lux treatment, but also more tail biting behaviour in the 0 lux treatment during night-time hours.

(2) Medical treatment includes treatment with antibiotics and immersion of the tail in a therapeutic solution. Wallgren and Lindahl (1996) treated severe cases of tail biting with procaine penicillin G at 30 mg/kg body weight daily for three consecutive days in order to prevent secondary infections. The tails were also dipped in tar. In mild cases, the tail was dipped in tar only. This treatment did not, however, prevent abscesses from being recorded more frequently in tail bitten pigs; nor did it prevent a negative effect on growth rate. Arey (1991) mentioned wood tar or tar oil to be used in an outbreak, because of their repellent smell and taste. Hemsworth (1992) suggests that once an outbreak has occurred, the most useful approach may include the application of various preparations such as Stockholm tar to tails and rumps and restricting light.

The use of antibiotics may not be effective (Paizs, 1972, cited in Van den Berg, 1982). Therapeutic solutions applied on the tail to limit infections include tincture of iodine and wound sprays containing antibiotics such as Terramycin (Arey, 1991). Moving wounded animals to a newly disinfected pen may help prevent infection of the tail wounds (Van den Berg, 1982). Decreasing restlessness using sedation has been described with variable success (Van den Berg, 1982).

(3) Surgical intervention includes amputation of the tails and removal of the incisor teeth.

Removal of the incisor teeth is a control measure in pigs, but according to Sambraus (1985) pinching off the incisors may not be effective as biting is done with the molars (cited in Arey, 1991). Tail amputation might be drastic, but necessary in severe and persistent outbreaks of tail biting (Schrøder-Petersen and Simonsen, 2001). Fritschen and Hogg (1983) suggested that a tool such as a side-cutter should be used and that the tail should be removed about 2.5 cm from the body. Pulling the skin slightly towards the body before removing the tail leaves more skin to cover the wound and this will promote healing.

A serious welfare hazard in this respect is that farmers faced with a tail biting outbreak may perform surgical interventions (removal of teeth and tails) without anaesthesia. This is illegal in the EU at present and the 'treatment of choice' should, besides being effective, always aim to be the least invasive, least painful and least welfare-reducing for the individual animal (Schrøder-Petersen and Simonsen, 2001).

## 11. Food Safety Considerations

Food safety aspects are considered in the Scientific Opinion of the Panel on Biological Hazards on a request from the European Commission on food safety aspects of different pig housing and husbandry systems. The EFSA Journal (2007) 613, 1-20, available at: <http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178675505797.htm>.

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## APPENDICES

### APPENDIX 1 - WELFARE AND ITS ASSESSMENT

The wording of the Treaty of Amsterdam (EU, 1997) reflects the concerns of the public about the welfare of the animals and hence there is a requirement that there be an evaluation of animal welfare with a scientific basis. Farmed animals are subject to human imposed constraints and for a very long time the choice of techniques was based primarily on the efficiency of production systems for the provision of food. However, it is important to protect these animals against mistreatment and poor welfare; therefore it is essential to know how their welfare is affected by the various methods for keeping and managing animals.

Broom (1986) defines animal welfare as follows: the welfare of an animal is its state as regards its attempts to cope with its environment. In this definition, welfare includes pleasurable mental states and unpleasant states such as pain, fear and frustration (Duncan, 1996; Fraser and Duncan, 1998) because feelings are a part of many mechanisms for attempting to cope with good and bad aspects of life and most feelings must have evolved because of their beneficial effects (Broom, 1998). Although feelings cannot be measured directly, their existence may be deduced from measures of physiology, behaviour, pathological conditions, etc.

The word "health", like "welfare", can be qualified by "good" or "poor" and varies over a range. According to Broom and Kirkden (2004) and Broom, (2006) health refers to the state of body systems, including those in the brain, that combat pathogens, tissue damage or physiological disorder and hence welfare is a broader term than health, covering all aspects of coping with the environment and taking account of a wider range of feelings and other coping mechanisms than those associated with physical or mental disorders.

Pathology is the detrimental derangement of molecules, cells and functions that occurs in living organisms in response to injurious agents or deprivations (Broom and Kirkden 2004, modified after Jones et al., 1997 who omit the word "detrimental") and the study of such conditions. Disease, implying that there is some pathology rather than just pathogen presence, may have has some adverse effect on welfare, the extent depending on the severity and type of the pathology (Broom and Corke, 2002). Sub-clinical disease processes, by definition, have no effect on the welfare of the individual.

The pain system and responses to pain are part of the repertoire used by animals to help them to cope with adversity during life. Pain is clearly an important part of poor welfare (Broom, 2001). However, prey species may show no behavioural response to a significant degree of injury (Broom and Johnson, 1993). In some situations responses to a wound may not occur because endogenous opioids that act as analgesics are released. However, there are many occasions in humans and other species when suppression of pain by endogenous opioids does not occur (Melzack et al., 1982).

Physiological measurements can be useful indicators of poor welfare. For instance, increased heart-rate, adrenal activity, or adrenal activity following ACTH challenge, or reduced heart-rate variability, or immunological response following a challenge, may all indicate that welfare is poorer than in individuals which do not show such changes. The impaired immune system function and some of the physiological changes can indicate the pre-pathological state (Moberg, 1985). In interpreting physiological measurements such as heart rate and adrenal activity it is important to take account of the environmental and metabolic context, including activity level. Glucocorticoids have various important functions in the body including facilitation of learning in pigs (Poletto et al., 2003) and are not produced in all potentially damaging situations. Some hormones, such as oxytocin, can be pleasure indicators (Panksepp, 1998; Carter, 2001). In this report, the term stress is defined as an environmental effect on an individual which over-taxes its control systems and reduces its fitness or appears likely to do so.

Behavioural measures are also of particular value in welfare assessment (Wiepkema, 1983). The fact that an animal avoids strongly an object or event, gives information about its feelings and hence about its welfare (Rushen, 1986). The stronger the avoidance the worse the welfare whilst the object is present or the event is occurring. An individual which is completely unable to adopt a preferred lying posture despite repeated attempts will be assessed as having poorer welfare than one which can adopt the preferred posture. Other abnormal behaviour, which includes excessively aggressive behaviour and stereotypies, such as bar-biting or sham-chewing in sows, indicates that the perpetrator's welfare is poor. Very often abnormal activities derive from activities that cannot be expressed but for which the animal is motivated. For example, pigs deprived of manipulable materials may be more likely to develop tail-biting. A single physiological, behavioural or other measure indicating that coping is difficult, or that the individual is not coping, can be sufficient evidence that welfare is poor.

Studies of the brain inform us about the cognitive ability of animals and they can also tell us how an individual is likely to be perceiving, attending to, evaluating, coping with, enjoying, or disturbed by its environment so can give direct information about welfare (Broom and Zanella, 2004). Pigs have complex brains so must have a great range of possibilities for good or poor welfare. In studies of welfare, we are especially interested in how an individual feels. As this depends upon high-level brain processing, we have to investigate brain function. Abnormal behaviour and preferred social, sexual and parental situations may have brain correlates. Brain measures can sometimes explain the nature and magnitude of effects on welfare.

Although the biological abilities of animals to adapt to the environments that they encounter are of major importance in determining the individual’s welfare, it is only in this way that welfare is related to what is, or is not, “natural”. Good welfare is certainly not limited to “natural” environments and there are many ways in which what happens to animals in the wild leads to poor welfare. Whilst the wild conditions may give some indications as to what are important resources for animals, welfare will depend on the coping ability of animals of the genetic strain kept in captivity.

The majority of indicators of good welfare, which we can use, are obtained by studies demonstrating positive preferences by animals (Dawkins, 1990). Methods of assessing the strengths of positive and negative preferences have become much more sophisticated in recent years. The price, which an animal will pay for resources, or pay to avoid a situation, may be, for example, a distance travelled, a weight lifted or the amount of energy required to press a plate on numerous occasions. The demand for the resource, i.e. the amount of an action which enables the resource to be obtained, at each of several prices can be measured experimentally. This is best done in studies where the income available, in the form of time or energy, is controlled in relation to the price paid for the resource. When demand is plotted against price, a demand curve is produced. In some studies, the slope of this demand curve has been measured to indicate price elasticity of demand but in recent studies (Kirkden et al., 2003) it has become clear that the area under the demand curve up to a particular point, the consumer surplus, is the best measure of strength of preference. Good welfare in general, and a positive status in each of the various coping systems, should have effects that are a part of a positive reinforcement system, just as poor welfare is associated with various negative reinforces. Once we know what animals strongly prefer, or strongly avoid, we can use this information to identify situations that are unlikely to fulfil the needs of animals and to design better housing conditions and management methods (Fraser and Matthews, 1997). However, as pointed out by Duncan (1978, 1992) and Dawkins (2004), all data from preference studies must be interpreted taking account of the possibilities that, firstly, an individual may show a positive preference for something in the short-term which results in its poor welfare in the long-term, and secondly, that a preference in a simplified experimental environment needs to be related to the individual's priorities in the more complicated real world.

In order to promote good welfare and avoid suffering, a wide range of needs must be fulfilled. These needs may require the animal to obtain resources, receive stimuli or express particular behaviours (Hughes and Duncan, 1988; Jensen and Toates, 1993; Vestergaard; 1996). Evidence for needs is either indications of poor welfare when an individual does not have the resource or opportunity for action, or the results of studies that show that the individual has strong positive or negative preferences. The list of the needs of pigs in the following section includes those which, if not fulfilled, result in death in a few minutes or days or weeks and those that do not result in death (for a review see e.g. Bracke et al., 1999 and Anonymous, 2001). However, the impact of an unfulfilled need on welfare depends on motivational mechanisms as much as on imminence of death. For example, avoidance of severe but non-lethal pain has high priority.

When the welfare of pigs or other animals is assessed, sets of measures often have to be integrated, for example, physiological measures, behavioural and pathological measures. Whilst a single measure can indicate poor welfare, because of the variety of coping mechanisms used (Koolhaas et al., 1999) and effects on individuals, a range of measures will usually provide better information about welfare.

Each assessment of welfare will pertain to a single individual and to a particular time range. In the overall assessment of the impact of a condition or treatment on an individual, a very brief period of a certain degree of good or poor welfare is not the same as a prolonged period. However, a simple multiplicative function of maximum degree and duration is often not sufficient. If there is a net effect of poor welfare and this is plotted against time, the best overall assessment of welfare, the magnitude of poor welfare, is the area under the curve thus produced (Broom, 2001). For further modelling of animal welfare see e.g. Bracke et al. (2002a, b).

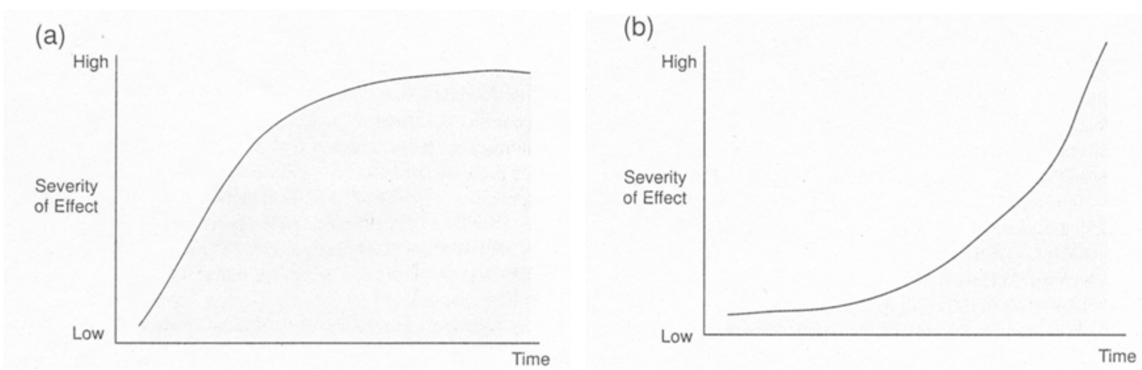



**Figure 1.** The net severity of poor welfare is plotted against the duration of that poor welfare in two examples here. The relative amount of poor welfare is greater in (a) than in (b) (modified after Broom, 2001).

**APPENDIX 2 - TAIL BITING SURVEY**

In order to perform the Risk Assessment process, missing data on tail biting were directly collected through a survey among the Member States. Concerning non-EU countries, information was provided by Norway and Switzerland.

The questionnaire, focused on legislation, current farm practices, and results from abattoir monitoring, was drafted by the Experts of the EFSA Working Group on pig welfare and was sent to national experts in the different the countries. The results presented hereafter relate to Austria, Belgium, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Netherlands, Portugal, Slovenia, Spain, Sweden, United Kingdom, Norway and Switzerland. Among EU countries, no information was provided by Bulgaria, Czech Republic, Hungary, Luxembourg (Grand-Duché), Malta, Poland, Romania, Slovakia. These latter countries produce less than 20% of the EU pig production.

## 1. Legislation

Concerning the legislation on tail docking, the results of the questionnaire gave a brief overview of the current situation. In Figure 1, the legal framework (EU and/or national rules on tail docking) is shown for the EU and non-EU countries.

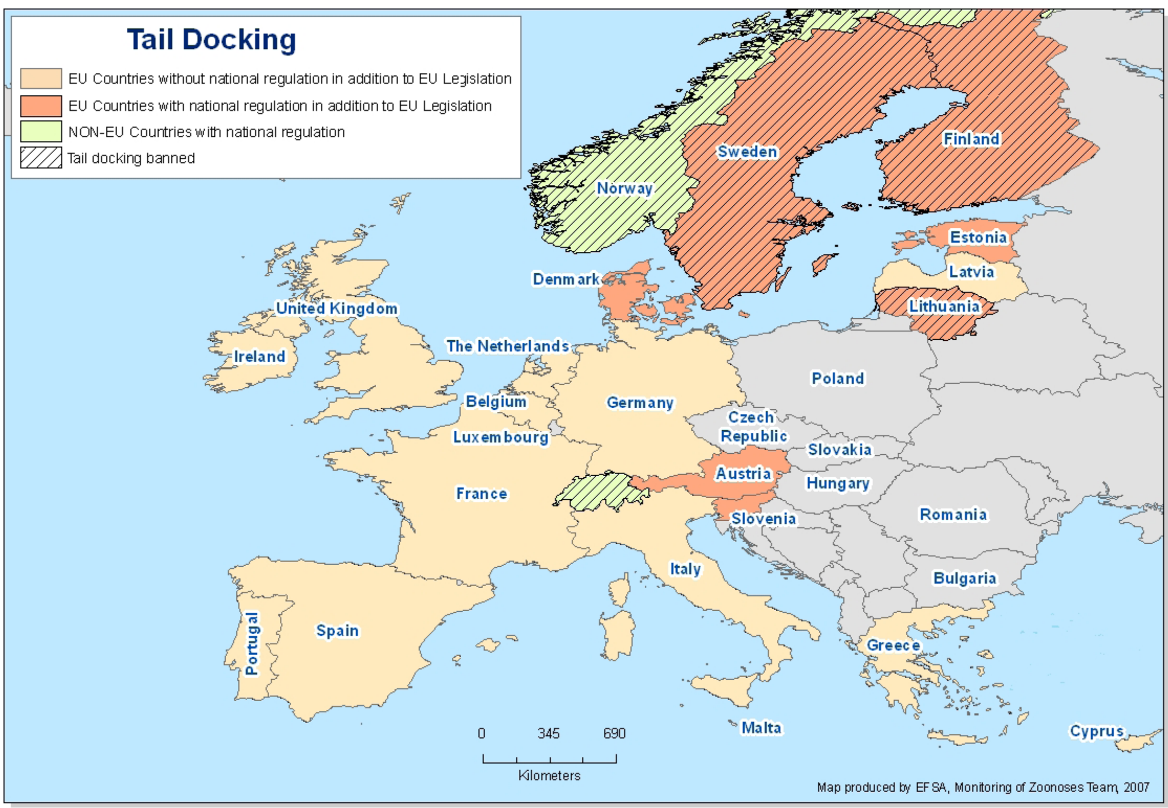



**Figure 1.** Legislation on tail docking

The legal framework for the countries with national regulation in addition to Dir. 1991/630/EEC (and its amendments Dir. 2001/93/EC and Dir. 2001/88/EC) can be summarised as follows:

- **Austria**: the current Austrian legislation implements the EU-directives with minor changes regarding the documentation :

*Keeping fattening pigs which had their tails docked is only allowed, if the fattening farm keeps records for every individual pen concerning:*

- *the type and amount of material for occupation offered and*
- *the type and prevalence of tail or ear biting".*

- **Finland:** according to the Animal Welfare Order (396/1996, changed 2002) "*docking of a part of the tail inflicts on an animal unnecessary suffering, pain and agony. Therefore it is prohibited. A veterinarian is allowed to remove a tail or a part of a tail due to therapeutic reasons, e.g. trauma. In this case appropriate anaesthesia must be used".*
- **Slovenia**: law on animal breeding, article 15: "*docking of tails is allowed for piglets until 4th day after birth" (cfr. in EC legislation it is allowed until day 7).*
- **Sweden:** tail docking is prohibited in the legislation. Law SFS 1988:534 2,4, 10 states that it is forbidden to make surgical interventions in animals unless it is motivated from a veterinary medical perspective. Reference is made to a list of such cases and tail docking is not on the list.
- **Denmark**: the current Danish legislation implements the EU-directives with minor changes regarding the age limit at tail docking: "*Tail docking of pigs must not be carried out routinely. Tail docking of suckling piglets may be carried out in 2nd-4th day of life if there is evidence that injuries to other pigs' tails have occurred due to lack of tail docking. The tail should be docked no shorter than at least half of the tail length is retained. Tail docking according to this may be carried out without the use of anaesthetics if it is performed by a veterinarian, or a person that has received training in the procedure and has experience in performing the procedure using proper methods and hygiene. Before carrying out tail docking, other measures shall be taken to prevent tail biting taking into account environment and stocking densities. Inadequate housing and management must be improved. If tail docking for medical reasons is practised after fourth day of life, it shall be performed under anaesthetic and additional prolonged analgesia by a veterinarian".*

Concerning the non-EU countries that provided information, Norway reports the Act of Animal Protection (LOV 1974-12-20 nr 73) and Switzerland the Animal Protection Ordinance.

## 2. Current farm practice

The second part of the questionnaire focused on farm practices, particularly related to the percentage of undocked pigs. The reported values are close to 100% of the pigs in the four countries in which this practice of tail docking is completely banned and also very high in Finland where tail docking is strongly discouraged by the legislation (Figure 2).

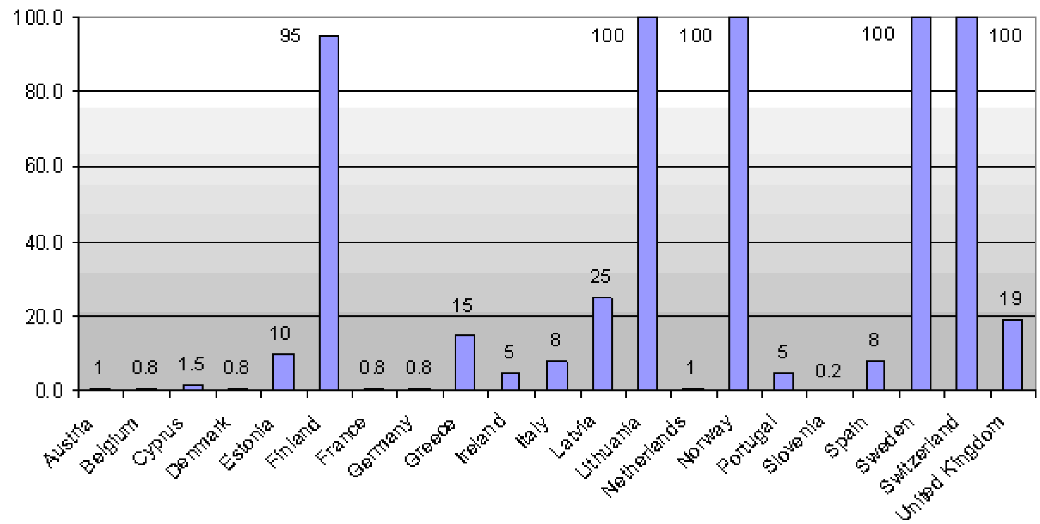



**Figure 2.** Percentage of undocked pigs in surveyed countries.

Concerning the undocked pig distribution, the survey highlighted that in most of the countries in which tail docking is allowed, this practice is not performed mainly in the organic farms, due to the specific regulation (Reg. CE 1804/99) (Austria, Belgium, Denmark, France, Germany, Greece, Latvia, Netherlands, UK and, although the organic pig production represents a very low percentage of the overall production, Finland and Italy).

Undocked pigs are also reared in welfare-labeled farms in countries like Denmark, France, Netherlands and UK, or quality-programme farms in Finland. The undocked pigs are bred in "standard" pig farms in Cyprus ("back yard" farms), Estonia, Greece, Ireland, Italy, Portugal and Spain.

In relation to the distribution of the tail docking in the surveyed countries, the questionnaire pointed out the distribution of tail biting and the percentage of affected pigs, as described in Table 1.

**Table 1.** Percentage of tail biting in surveyed countries.

| EU Country | Percentage of tail bitten pigs | Data source |
|---|---|---|
| *Austria* | 30 of farms with bitten pigs;<br>20 to 30 of bitten pigs in those affected farms | Survey non available-Expert Opinion |
| *Belgium* | 2-5 | Survey non available-Expert Opinion |
| *Cyprus* | 1-2 | Survey non available-Expert Opinion |
| *Denmark* | 1.2 to 3.1 | Busch *et al.*, 2004; Bonde et al., 2006 |
| *England* | 0.9 | NADIS, 2006 |
| *Estonia* | 1 | Survey non available-Expert Opinion |
| *Finland* | < 5 (up to 30 for the whole life span, considering minor lesions) | Survey non available-Expert Opinion |
| *France* | n.a. | Survey non available |
| *Germany* | n.a. | Survey non available |
| *Greece* | n.a. | Survey non available |
| *Rep. of Ireland* | 3 | Survey non available-Expert Opinion |
| *Italy* | n.a. | Survey non available |
| *Latvia* | 50 (mainly in big, intensive standard commercial farms) | Survey non available-Expert Opinion |
| *Lithuania* | n.a. | Survey non available |
| *Netherlands* | 1 | Survey non available-Expert Opinion |
| *Portugal* | 5-50 | Survey non available-Expert Opinion |
| *Slovenia* | <1 | Survey non available-Expert Opinion |
| *Spain* | n.a. | Survey non available |
| *Sweden* | 1.3-1.5 | Survey non available-Expert Opinion |
| **Non-EU Country** | **Percentage of tail bitten pigs** | **Data source** |
| *Norway* | 1-2 | Survey non available-Expert Opinion |
| *Switzerland* | 0.6 to 1.6 | Schnider R. (2002) |

n.a. = data not available

## 3. Results from abattoir monitoring

In the third part of the questionnaire, data on abattoir monitoring were collected. In most of the surveyed countries (Austria, Cyprus, France, Germany, Greece, Italy, Latvia, Lithuania, Portugal, Slovenia, Spain, Switzerland) neither routine records of tail biting condemnations nor recent national surveys of tail bitten carcasses at abattoir were reported.

In some countries, although no recent monitoring programme was indicated in the questionnaire, some data from abattoirs showed the distribution and the impact of tail biting condemnations. Detailed information for each surveyed country was reported, in particular:

- **Belgium**: data exist only for quality label products and the percentage of tail biting was less than 1%.
- **Estonia**: the amount of condemned carcasses due to tail lesions was 1-1.3% only in docked pigs.
- **Finland**: regarding the overall percentage of condemned carcasses, a value of 0.67%-2.13% was indicated depending on the slaughterhouse. Considering abscesses as relevant indicators for earlier and healed lesions, the estimation for overall percentage was less than 5%.
- **Ireland**: the percentage of carcasses with tail lesions (in one slaughter plant) was 0.8, including partial (0.6%) and total (0.2%) condemnation. Almost all partial and 40% of total condemnations were due to tail lesions in either undocked or docked, but with long stump pigs.

- **Netherlands**: concerning the overall percentage of condemned carcasses, a value of 0.1% was reported.
- **Norway**: the overall percentage of tail biting condemnations was 0.5% and no case was reported for docked pigs.

For some other countries, abattoir surveillance programmes were reported as following:

- **Denmark**: recording of condemnation and tail lesions is performed at abattoir, but specification on causes of condemnation is not routinely given. Danish Meat Association has recently presented some results at a national meeting (Busch, 2007, personal communication; Bond, personal communication): an overall percentage of 0.15-0.20 of carcasses per year (2001-2005) showed tail lesions and were condemned; however, this may be due to other causes as well (i.e. 10-20 % of pigs with tail lesions are condemned). The outcomes from two national surveys on tail bitten carcasses were published:
    1. Busch, 2007, personal communication - nationwide yearly abattoir data from all pigs slaughtered Jan 2001-Oct 2006 (approximately 25 millions pigs per year);
    2. Bonde et al., 2006. Abattoir data from pigs from 16 organic (21,500 carcasses) and 52 conventional herds (203,000 carcasses) in 2004.

    The surveys reported an overall of 0.9-1.0% pigs (2001-2003) and 1.2-1.4% pigs (2004-2006); these results led to an increased focus on tail lesions/infections at the Danish abattoirs from 2004 (Busch, 2007, personal communication). Particularly, in 2004 surveys indicate a percentage of 1.4 docked pigs (52 conventional indoor herds with various systems) and of 1.06 % undocked organic pigs (16 organic herds) (Bonde et al., 2006).
- **England**: the causes of condemnations are not routinely traceable. Meat Hygiene Service statistics for 2005 indicated a percentage of 0.19 of carcasses condemned for pyaemia and British Pig Health Scheme data for 2006 report that 0.7% showed tail lesions. A national survey (Hunter et al., 1999) indicated that the 2.4% of docked pigs showed healed or mild wounds, 0.6% was chewed without swelling and 0.1% inflammation/infection; the 6.9% of undocked pigs had healed or mild lesions, 1.8% showed no swelling and 0.5% inflammation/infection.
- **Sweden:** tail biting condemnations at abattoirs are routinely recorded. The percentage of carcasses condemned due to tail lesion was 7-8% of those recorded with tail biting (i.e. 0.1 % of total). National surveys of tail bitten carcasses at abattoirs reported a percentage of pigs with signs of tail biting (fresh or healed lesion, inflammation, infection) of 1.4%.

## APPENDIX 3 – RISK ASSESSMENT OUTCOMES: TABLE AND GRAPHICS

Target Population: From weaning to slaughter trip – Docked pigs in Europe

Life span considered: 140 days (except for tail docking 170 days)

| Hazard description | Hazard characterization | | | | | | | Exposure assessment | | | | | | Risk Characterization | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adverse effect | Magnitude | | Quantitative assessment of likelihood (%) | | | Qualitative assessment of the uncertainty | Duration (%) | Intensity | Quantitative assessment of P. of Exposure (%) | | | Qualitative assessment of the uncertainty | Risk estimate [CI95%] | Qualitative uncertainty of the risk estimate |
| | | Severity (0-4) | Duration (%) | min | ml | max | | | | min | ml | max | | | |
| Tail docking | Fear and Acute Pain | 2 | 0.05 | 100 | 100 | 100 | Low | 0.001 | Full | 100 | 100 | 100 | Low | 0,025 [0,025 - 0,025] | Low |
| Tail docking | Infection with inflammation | 2 | 4 | 1 | 3 | 5 | High | 0.001 | Full | 100 | 100 | 100 | Low | 0,060 [0,035 - 0,085] | High |
| Tail docking | Chronic Pain | 1 | 80 | 0 | blank | 100 | High | 0.001 | Full | 100 | 100 | 100 | Low | 9,998 [0,999 - 19,000] | High |
| Genetic selection for high lean tissue growth rate (low fatness) | Being tail bitten | 3 | 20 | 0.1 | 1 | 2 | High | 100 | * | 70 | 90 | 95 | High | 0,133 [0,057 - 0,213] | High |
| Castration in males[1] | Being tail bitten | 3 | 20 | 0.5 | 1 | 3 | Medium | 96 | Full | 40 | 45 | 47 | Low | 0,080 [0,043 - 0,137] | Medium |
| Lack of farrowing house bedding / enrichment | Being tail bitten | 3 | 20 | 0.1 | 0.2 | 0.4 | High | 100 | Full | 75 | 85 | 90 | Low | 0,027 [0,017 - 0,040] | High |
| Absence of bedding having previously had bedding since weaning | Being tail bitten | 3 | 20 | 2 | 5 | 15 | Medium | 8 | Full | 2 | 5 | 10 | Medium | 0,045 [0,019 - 0,095] | Medium |
| Fully slatted floor during suckling period | Being tail bitten | 3 | 20 | 0.1 | 0.2 | 0.4 | High | 84 | Full | 40 | 45 | 50 | Low | 0,014 [0,009 - 0,021] | High |
| High stocking density | Being tail bitten | 3 | 20 | 0.5 | 1 | 2 | Medium | 8 | End point approximately 110kg/m² | 60 | 80 | 90 | Medium | 0,124 [0,077 - 0,187] | Medium |
| Mixing of animals excluding at weaning time | Being tail bitten | 3 | 20 | 0.1 | 0.5 | 1 | High | 8 | Full | 30 | 40 | 50 | High | 0,031 [0,014 - 0,049] | High |
| Large Herd size | Being tail bitten | 3 | 20 | 0.05 | 0.1 | 0.15 | High | 100 | More than 5000 growing pigs | 70 | 75 | 80 | Low | 0,011 [0,008 - 0,015] | High |
| Lack of long straw | Being tail bitten | 3 | 20 | 1 | 3 | 5 | Low | 100 | Full | 70 | 80 | 90 | Low | 0,359 [0,209 - 0,514] | Low |
| Lack of straw and 100 % slatted floor | Being tail bitten | 3 | 20 | 1.3 | 3.5 | 6 | Medium | 100 | Full | 40 | 50 | 60 | Low | 0,264 [0,156 - 0,384] | Medium |
| Lack of straw and absence of adequate enrichment | Being tail bitten | 3 | 20 | 1.5 | 5 | 8 | Medium | 100 | No particulate rooting substrate, no distructable toy ** | 50 | 70 | 85 | Medium | 0,506 [0,289 - 0,740] | Medium |
| High feeding competition | Being tail bitten | 3 | 20 | 0.5 | 1 | 2 | Medium | 16 | More than 10% pigs waiting *** | 20 | 40 | 60 | High | 0,063 [0,035 - 0,103] | High |
| Delay of feed supply | Being tail bitten | 3 | 20 | 0.5 | 1 | 2 | High | 1 | More than 12h delay if adlib fed, or less in animals fed in meals | 5 | 10 | 15 | High | 0,016 [0,009 - 0,026] | High |
| Abrupt change of feed composition | Being tail bitten | 3 | 20 | 0.1 | 0.2 | 0.5 | High | 800 | Full | 80 | 90 | 95 | Low | 0,030 [0,017 - 0,049] | High |
| Inadequate dietary sodium | Being tail bitten | 3 | 20 | 0.2 | 0.5 | 1 | Medium | 12 | Less than 0.17% of the diet | 0.1 | 0.3 | 0.5 | Low | 0,000 [0,000 - 0,000] | Medium |
| Aminoacid deficiency | Being tail bitten | 3 | 20 | 0.2 | 0.5 | 1 | Medium | 16 | Less than lean tissue growth requirements | 0.1 | 0.5 | 0.8 | Medium | 0,000 [0,000 - 0,001] | Medium |
| Poor herd health status | Being tail bitten | 3 | 20 | 0.5 | 1 | 2 | Medium | 100 | Presence of enzootic disease | 40 | 50 | 60 | Medium | 0,079 [0,049 - 0,120] | Medium |
| Presence of clinical disease in the individual | Being tail bitten | 3 | 20 | 0.5 | 1 | 2 | Medium | 8 | Full | 2 | 5 | 8 | Medium | 0,008 [0,004 - 0,013] | Medium |
| Being in a group with growth retarded pigs | Being tail bitten | 3 | 20 | 1 | 2 | 3 | Medium | 80 | 1 pig 25% < average | 1 | 3 | 5 | Medium | 0,009 [0,005 - 0,014] | Medium |
| Heat stress | Being tail bitten | 3 | 20 | 0.2 | 0.5 | 1 | High | 16 | Above the upper critical temperature**** | 15 | 20 | 30 | Medium | 0,016 [0,009 - 0,026] | High |
| Cold stress | Being tail bitten | 3 | 20 | 0.2 | 0.5 | 1.5 | High | 4 | Below the lower critical temperature**** | 3 | 5 | 8 | Medium | 0,004 [0,002 - 0,009] | High |
| High air speed (draughts) | Being tail bitten | 3 | 20 | 0.5 | 1 | 2 | Medium | 16 | Above 0.5 m/s | 4 | 7 | 12 | High | 0,011 [0,006 - 0,019] | High |
| Poor air quality (low ventilation) | Being tail bitten | 3 | 20 | 0.1 | 0.2 | 0.4 | High | 12 | Above 25 ppm $NH_3$ | 10 | 30 | 50 | High | 0,009 [0,005 - 0,016] | High |
| Absence of natural light | Being tail bitten | 3 | 20 | 0.1 | 0.2 | 0.3 | High | 100 | Full | 20 | 50 | 80 | High | 0,015 [0,008 - 0,023] | High |
| Presence (no removal) of tail bitten and tail biting animals | Being tail bitten | 3 | 20 | 10 | 30 | 60 | Low | 16 | Full | 0.5 | 1 | 1.5 | Medium | 0,046 [0,023 - 0,078] | Medium |

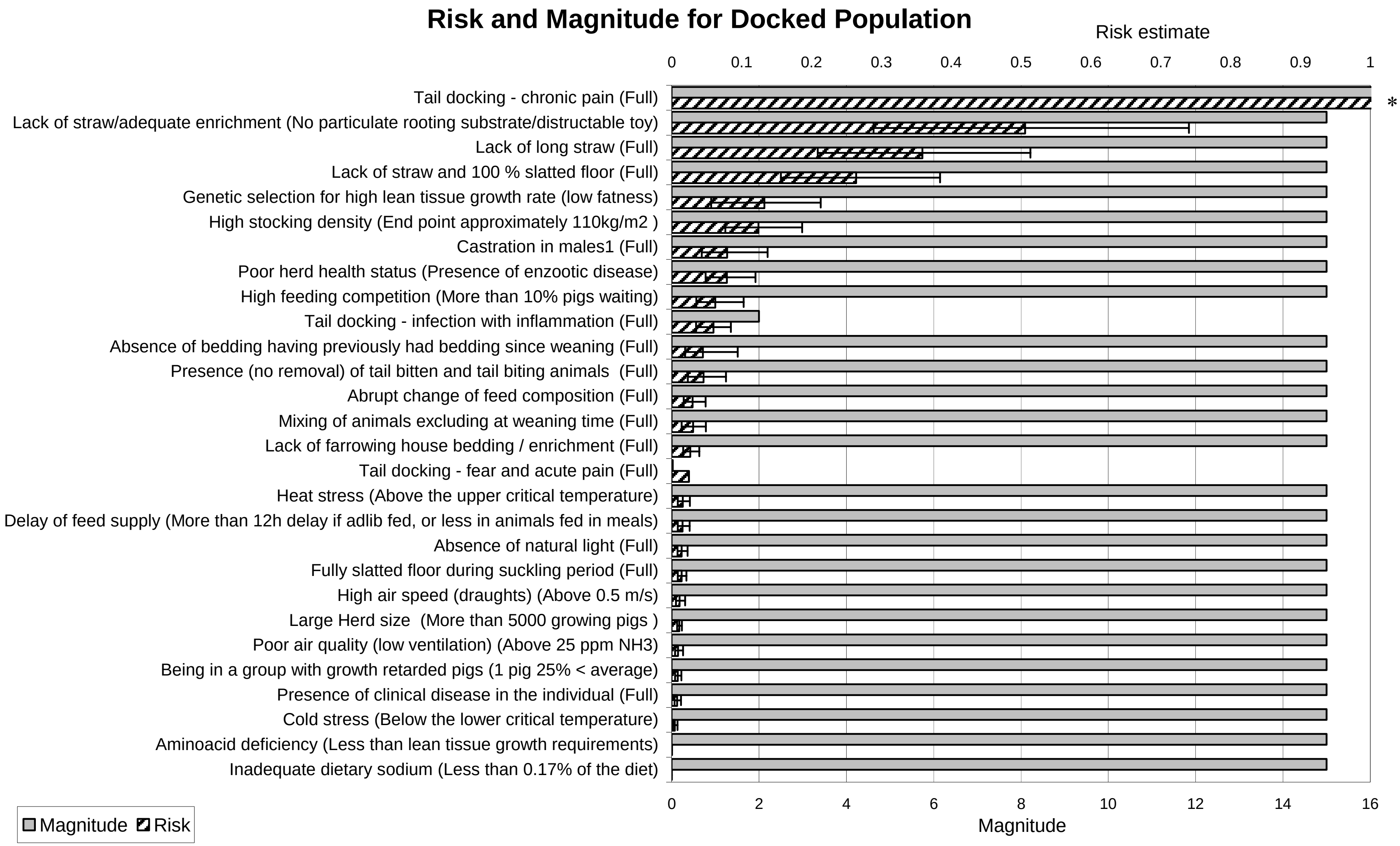
* some evidence exists between lean tissue and tail biting predisposition but not sufficient for defining limits. A high lean tissue growth rate might be considered to be >150g.

** Less adequate enrichment such as balls, chains, rubber toys, lumps of hard wood may be present.

*** e.g. more than 5 pigs per feeding place for dry pellet feeding.

**** Critical temperature range is between 12 and 30 degrees Celsius for a 60 kg pig fed ad libitum in fully slatted housing.

[1]The literature clearly shows that being a castrate gives significantly greater risk of being bitten than being a gilt. Being an entire male may give slightly more risk than a gilt, but data are not conclusive. Whilst this therefore suggests castration may increase risk, there is no direct comparison between castrates and entire males. We cannot therefore be certain that castration per se is a risk.



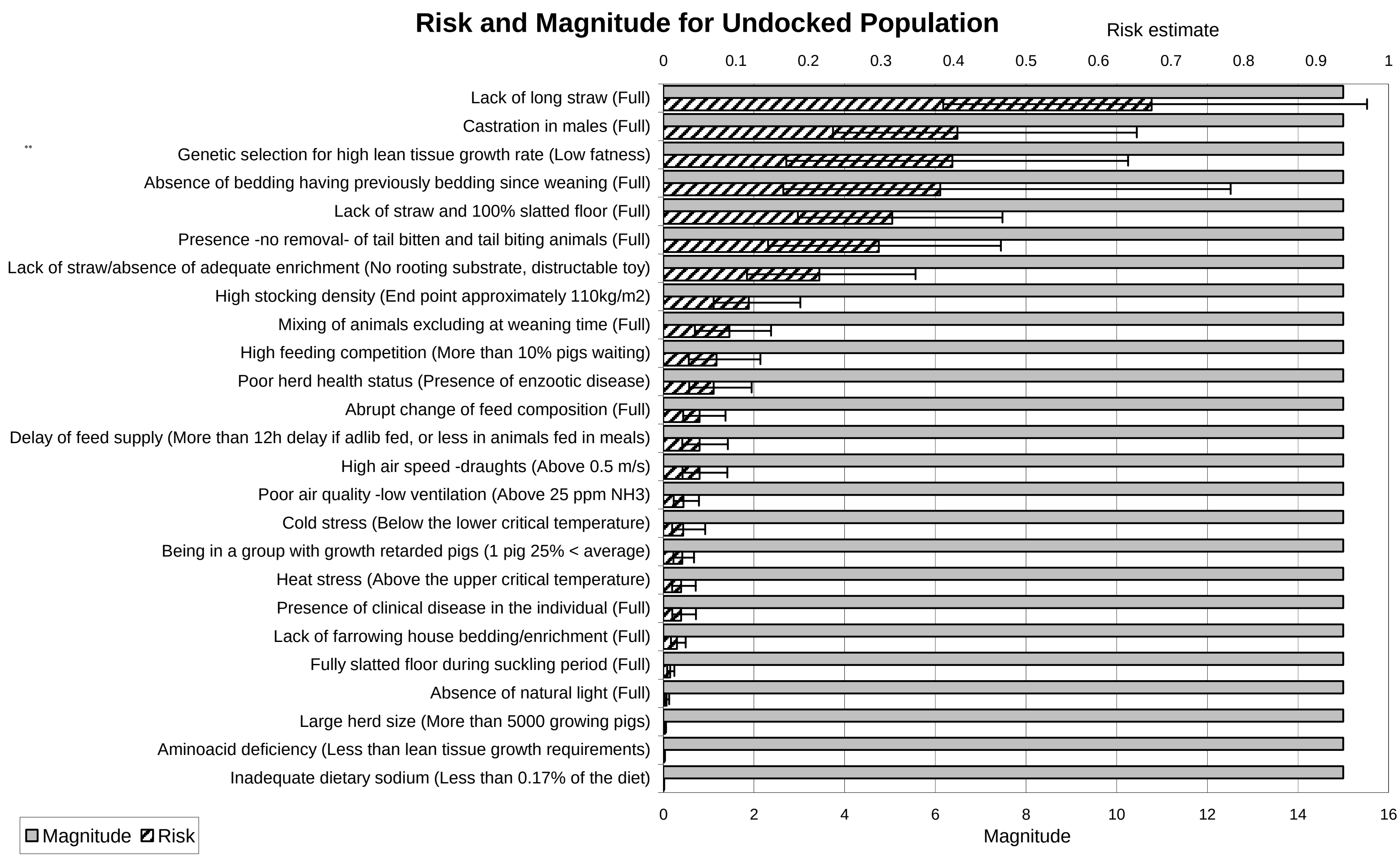

*The estimated risk and magnitude of Tail docking – chronic pain (Full) are out of scale; the values are 9.99 and 20, respectively.*

Target Population: From weaning to slaughter trip – Undocked pigs in Europe[4]
Life span considered: 140 days (except for tail docking 170 days)

| Hazard description | Hazard characterization | | | | | | | Exposure assessment | | | | | | Risk Characterization | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adverse effect | Magnitude | | Quantitative assessment of likelihood (%) | | | Qualitative assessment of the uncertainty | Duration | Intensity | Quantitative assessment of P. of Exposure (%) | | | Qualitative assessment of the uncertainty | Risk estimate [CI95%] | Qualitative uncertainty of the risk estimate |
| | | Severity (0-4) | Duration (%) | min | ml | max | | | | min | ml | max | | | |
| Genetic selection for high lean tissue growth rate (low fatness) | Being tail bitten | 3 | 20 | 0.3 | 3 | 6 | High | 100 | * | 70 | 90 | 95 | High | 0,399 [0,169 - 0,641] | High |
| Castration in males[1] | Being tail bitten | 3 | 20 | 3 | 6 | 15 | Medium | 96 | Full | 35 | 40 | 45 | Low | 0,405 [0,234 - 0,653] | Medium |
| Lack of farrowing house bedding / enrichment | Being tail bitten | 3 | 20 | 0.3 | 0.6 | 1.2 | High | 100 | Full | 10 | 20 | 30 | Medium | 0,019 [0,011 - 0,031] | High |
| Absence of bedding having previously had bedding since weaning | Being tail bitten | 3 | 20 | 6 | 15 | 45 | Medium | 8 | Full | 5 | 15 | 25 | Medium | 0,382 [0,165 - 0,782] | Medium |
| Fully slatted floor during suckling period | Being tail bitten | 3 | 20 | 0.3 | 0.6 | 1.2 | High | 84 | Full | 5 | 10 | 15 | Medium | 0,009 [0,005 - 0,015] | High |
| High Stocking density | Being tail bitten | 3 | 20 | 1.5 | 3 | 6 | Medium | 8 | End point approximately 110kg/m$^2$ | 15 | 25 | 35 | Medium | 0,118 [0,070 - 0,189] | Medium |
| Mixing of animals excluding at weaning time | Being tail bitten | 3 | 20 | 0.3 | 1.5 | 3 | High | 8 | Full | 30 | 40 | 50 | Medium | 0,091 [0,044 - 0,148] | High |
| Large Herd size | Being tail bitten | 3 | 20 | 0.15 | 0.3 | 0.45 | High | 100 | More than 5000 growing pigs | 2 | 5 | 10 | Medium | 0,002 [0,001 - 0,004] | High |
| Lack of long straw | Being tail bitten | 3 | 20 | 3 | 9 | 15 | Low | 100 | Full | 40 | 50 | 60 | Medium | 0,673 [0,386 - 0,970] | Medium |
| Lack of straw and 100 % slatted floor | Being tail bitten | 3 | 20 | 3.9 | 10.5 | 18 | Medium | 100 | Full | 15 | 20 | 25 | Medium | 0,316 [0,186 - 0,468] | Medium |
| Lack of straw and absence of adequate enrichment | Being tail bitten | 3 | 20 | 4.5 | 15 | 24 | Medium | 100 | No particulate rooting substrate, no distructable toy ** | 5 | 10 | 15 | Low | 0,215 [0,115 - 0,348] | Medium |
| High feeding competition | Being tail bitten | 3 | 20 | 1.5 | 3 | 6 | Medium | 16 | More than 10% pigs waiting *** | 5 | 15 | 30 | High | 0,073 [0,035 - 0,134] | High |
| Delay of feed supply | Being tail bitten | 3 | 20 | 1.5 | 3 | 6 | High | 1 | More than 12h delay if adlib fed, or less in animals fed in meals | 5 | 10 | 20 | High | 0,050 [0,026 - 0,089] | High |
| Abrupt change of feed composition | Being tail bitten | 3 | 20 | 0.3 | 0.6 | 1.5 | High | 800 | Full | 30 | 50 | 70 | High | 0,050 [0,028 - 0,086] | High |
| Inadequate dietary sodium | Being tail bitten | 3 | 20 | 0.6 | 1.5 | 3 | Medium | 12 | Less than 0.17% of the diet | 0.1 | 0.3 | 0.5 | Low | 0,001 [0,000 - 0,001] | Medium |
| Aminoacid deficiency | Being tail bitten | 3 | 20 | 0.6 | 1.5 | 3 | Medium | 16 | Less than lean tissue growth requirements | 0.1 | 0.5 | 1 | High | 0,001 [0,000 - 0,002] | High |
| Poor herd health status | Being tail bitten | 3 | 20 | 1.5 | 3 | 6 | Medium | 100 | Presence of enzootic disease | 5 | 15 | 25 | Medium | 0,070 [0,036 - 0,122] | Medium |
| Presence of clinical disease in the individual | Being tail bitten | 3 | 20 | 1.5 | 3 | 6 | Medium | 8 | Full | 2 | 5 | 10 | High | 0,024 [0,012 - 0,045] | High |
| Being in a group with growth retarded pigs | Being tail bitten | 3 | 20 | 3 | 6 | 9 | Medium | 80 | 1 pig 25% < average | 1 | 3 | 5 | High | 0,026 [0,014 - 0,042] | High |
| Heat stress | Being tail bitten | 3 | 20 | 0.6 | 1.5 | 3 | High | 16 | Above the upper critical temperature**** | 5 | 10 | 20 | High | 0,025 [0,012 - 0,045] | High |
| Cold stress | Being tail bitten | 3 | 20 | 0.6 | 1.5 | 4.5 | High | 4 | Below the lower critical temperature**** | 5 | 10 | 20 | High | 0,027 [0,012 - 0,058] | High |
| High air speed (draughts) | Being tail bitten | 3 | 20 | 1.5 | 3 | 6 | Medium | 16 | Above 0.5 m/s | 5 | 10 | 20 | High | 0,050 [0,026 - 0,088] | High |
| Poor air quality (low ventilation) | Being tail bitten | 3 | 20 | 0.3 | 0.6 | 1.2 | High | 12 | Above 25 ppm $NH_3$ | 10 | 30 | 50 | High | 0,028 [0,014 - 0,049] | High |
| Absence of natural light | Being tail bitten | 3 | 20 | 0.3 | 0.6 | 0.9 | High | 100 | Full | 1 | 5 | 10 | Low | 0,004 [0,002 - 0,008] | High |
| Presence (no removal) of tail bitten and tail biting animals | Being tail bitten | 3 | 20 | 40 | 70 | 90 | Low | 16 | Full | 0.5 | 3 | 5 | High | 0,297 [0,144 - 0,465] | High |

* some evidence exists between lean tissue and tail biting predisposition but not sufficient for defining limits. A high lean tissue growth rate might be considered to be >150g.
** Less adequate enrichment such as balls, chains, rubber toys, lumps of hard wood may be present.
*** e.g. more than 5 pigs per feeding place for dry pellet feeding.
**** Critical temperature range is between 12 and 30 degrees Celsius for a 60 kg pig fed ad libitum in fully slatted housing.
[1]The literature clearly shows that being a castrate gives significantly greater risk of being bitten than being a gilt. Being an entire male may give slightly more risk than a gilt, but data are not conclusive. Whilst this therefore suggests castration may increase risk, there is no direct comparison between castrates and entire males. We cannot therefore be certain that castration per se is a risk.

[4] Lack of tail docking was not included as a hazard. There is very limited scientific data on which to base an estimate of the magnitude of risk, and this will also be very system dependent.


Risk and Magnitude for Undocked Population
Risk estimate
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Lack of long straw (Full)
Castration in males (Full)
Genetic selection for high lean tissue growth rate (Low fatness)
Absence of bedding having previously bedding since weaning (Full)
Lack of straw and 100% slatted floor (Full)
Presence -no removal- of tail bitten and tail biting animals (Full)
Lack of straw/absence of adequate enrichment (No rooting substrate, distructable toy)
High stocking density (End point approximately 110kg/m2)
Mixing of animals excluding at weaning time (Full)
High feeding competition (More than 10% pigs waiting)
Poor herd health status (Presence of enzootic disease)
Abrupt change of feed composition (Full)
Delay of feed supply (More than 12h delay if adlib fed, or less in animals fed in meals)
High air speed -draughts (Above 0.5 m/s)
Poor air quality -low ventilation (Above 25 ppm NH3)
Cold stress (Below the lower critical temperature)
Being in a group with growth retarded pigs (1 pig 25% < average)
Heat stress (Above the upper critical temperature)
Presence of clinical disease in the individual (Full)
Lack of farrowing house bedding/enrichment (Full)
Fully slatted floor during suckling period (Full)
Absence of natural light (Full)
Large herd size (More than 5000 growing pigs)
Aminoacid deficiency (Less than lean tissue growth requirements)
Inadequate dietary sodium (Less than 0.17% of the diet)
0
2
4
6
8
10
12
14
16
Magnitude
Magnitude
Risk

## GLOSSARY

**Agonistic behaviour**
Behaviour which has a role in social interaction but which is not sexual or other reproductive behaviour, for example threatening, aggressive or collaborative behaviour.

**Appetitive behaviour**
Actions which show that an animal is preparing for, or attempting to carry out, a behaviour which it is motivated to perform.

**Boar** (Directive 91/630)
Male pig after puberty, intended for breeding.

**Cope**
Have control of mental and bodily stability. This control may be short-lived or prolonged. Failure to cope may lead to reduced fitness.

**Drained Floor**
A solid floor that is sloping (or perforated) so that fluids drain from it.

**Exploration**
Any activity which has the potential for the individual to acquire new information about its environment or itself.

**Fattening pigs**
This term includes weaners, growers and finishers, as defined below.

**Foraging**
Appetitive feeding behaviour, i.e. moving around and otherwise showing behaviour in search of food.

**Gap**
An open area in a slatted (perforated) floor which would allow manure and other liquids to pass through (also called slot, slit, void, perforation, hole).

**Grooming**
The cleaning of the body surface or rearrangement of pelage by licking, nibbling, picking, rubbing, scratching or application of aqueous liquids.

**Growers and Finishers**
Pigs from 10 weeks to the age at which pigs kept for meat production are typically slaughtered (90 – 120 but locally up to 170kg). Animals which will be kept for reproduction are included in this category and in the weaner category, when they are of these ages.

**Hierarchy**
A sequence of individuals or groups of individuals in a social system which is based upon some ability or characteristic related to the ability to acquire some resource (usually access to food).

**Need**
A requirement, which is part of the basic biology of an animal, to obtain a particular resource or respond to a particular environmental or bodily stimulus.

**Piglets**
Young pigs from birth to weaning.

**Sow** (Directive 91/630)
Adult female

- sows from weaning of piglets to 4 weeks after service: dry or pregnant adult female,
- pregnant sows: female after 4 weeks after service until farrowing,
- farrowing sows: between the perinatal period (starting two days before farrowing) until weaning.

**Slat**
The solid part of a slatted floor.

**Slatted Floor**
Floor consisting of slats (supporting the pigs) and gaps (allowing manure and other liquids to pass through) (also called perforated, slotted floor).

**Solid Floor**
A continuous flat surface without gaps.

**Space Allowance**.
The measure of floor area (and height) per individual animal (or per unit of body weight) of animals present in an animal accommodation.

**Stereotypy**
A repeated, relatively invariate sequence of movements which has no obvious function, and develops under inadequate environmental and/or social conditions, such as chain chewing, bar biting and vacuum chewing in pregnant sows.

**Stocking Density**
The number or body weight of animals per unit area in their accommodation.

**Stress**
An environmental effect on an individual which over-taxes its (behavioural and/or physiological) control systems and reduces its fitness or appears likely to do so.

**Thermoneutral zone**
The temperature range within which metabolic heat production and energy expenditure are minimal, most productive processes are at their most efficient level and an animal is thermally comfortable without the need to change heat production. The zone is limited by the lower critical temperature (LCT) and the upper critical temperature (UCT), above and below there are energy costs of thermoregulation.

**Upper Critical Temperature**
The temperature above which pig cannot maintain body temperature and thermoregulatory efforts are needed.

**Weaner**
A young pig from the time of weaning from its mother (usually about the age of 3-4 weeks) to 10 weeks at which time (plus or minus 2 weeks) many pigs are moved to different accommodation. In the common breeds of pigs the weight range of weaners is 5 – 35kg.

**Welfare**
The state of an individual as regards its attempts to cope with its environment (i.e. to fulfil its biological needs to obtain resources and respond to stimuli).

## Abbreviations

| | |
|---|---|
| **EC** | European Commission |
| **EFSA** | European Food Safety Authority |
| **EU** | European Union |
| **LCT** | Lower critical temperature |
| **MS** | Member State |
| **SVC** | Scientific Veterinary Committee of the European Commission |
| **TIM** | Tail-in-mouth |
| **UCT** | Upper critical temperature |