



Assessment of Animal Welfare Measures for Sows, Piglets and Fattening Pigs

edited by

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WELFARE QUALITY REPORTS No. 10

Welfare Quality Reports
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September 2009

The present study is part of the Welfare Quality® research project, which has been co-financed by the European Commission, within the 6th Framework Programme, contract No. FOOD-CT-2004-506508. The text represents the authors' views and does not necessarily represent a position of the Commission who will not be liable for the use made of such information.

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Typeset by Joek Roex, Cardiff.
Printed in Sweden by SLU Service/Reproenheten, Uppsala.

ISBN 1-902647-80-7
ISSN 1749-5164

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PREFACE

The current book contains a number of chapters based on the work done by scientists working on the work package 2.2 of the EU-project Welfare Quality® ‘Integration of animal welfare in the food quality chain: from public concern to improved welfare and transparent quality’. One aim of Welfare Quality® has been to develop a scheme for assessing animal welfare.

The aim of the current work package was to test and validate possible measures of animal welfare in such a scheme for poultry, pigs and cattle. This book deals with the measures on pigs. The measures included in this book have been assessed for sows, piglets and fattening pigs (but not for boars).

Welfare Quality® has identified four welfare principles: good feeding, good housing, good health and appropriate behaviour. These four welfare principles has been further divided into twelve welfare criteria (see Table). The focus has been on animal based measures, while resource based measures and management based measures have been used to supplement these. The areas covered in the lives of the animals are on farm and at slaughter. The transport is only covered in the loading/unloading phase, because the effect of the transport can often be seen in the state of the animals at the slaughter plant.

The measures evaluated have been of three categories. The first category are measures that have not previously been validated, the second category is measures that have been validated, or have high face validity (there is e.g. no need to do a study to validate that wounds cause bad welfare) but for which we do not know the repeatability of the measure. The last category finally consists of measures for which there are already validated protocols (e.g. for body condition score), in these cases the project groups evaluated the alternatives and selected the most appropriate measure to be used.

Welfare principles	Welfare criteria
Good feeding	1 Absence of prolonged hunger
	2 Absence of prolonged thirst
Good housing	3 Comfort around resting
	4 Thermal comfort
	5 Ease of movement
Good health	6 Absence of injuries
	7 Absence of disease
	8 Absence of pain induced by management procedures
	9 Expression of social behaviours
Appropriate behaviour	10 Expression of other behaviours
	11 Good human-animal relationship
	12 Positive emotional state

This book is based on the work of different research groups, each chapter therefore deals with related aspects of animal welfare, e.g. ‘clinical measures’, that is related to various aspects of welfare e.g. body condition score, tail biting and vulva biting etc. This means that although there are only 21 groups of measures/chapters, the number of measures evaluated is much higher since each group contains information on a number of different measurements.

The current book consists of all of the measures that have been evaluated for inclusion in the welfare assessment scheme of Welfare Quality (whether they were later included or not). In addition we have included two appendices on possible management and resource based measures. These have however not been tested in the current project. Finally there is a third appendix with a brief note on statistics and sampling.

Described below is how each of chapters relate to the twelve animal welfare criteria.

1. Absence of prolonged hunger. There are several possible animal based measures for absence of prolonged hunger. A potential candidate for the frustration associated with hunger is the vocalizations around feeding (Chapter 1). At slaughter the stomach content might be an indicator (Chapter 2). Finally, an alternative for prolonged hunger might be body condition scoring (Chapter 3).
2. Absence of prolonged thirst. There is currently no good animal based measure for this criterion. The resource and management based measure suggested is the number of water cups and that they are functioning (Appendix 1 and 2).
3. Comfort around resting. The hypothesis that the behaviour around resting can be used as a measure of their comfort was investigated (Chapter 4). Another approach, using presence of bursitis as a measure was also investigated (Chapter 4).
4. Thermal comfort. The degree of social thermoregulation was investigated as a measure of thermal comfort for pigs kept in groups (i.e. fattening pigs and group housed sows). For all animals the occurrence of shivering and panting were investigated as other possible measures (Chapter 5).
5. Ease of movement. The main restriction the animals experience is the use of crates, it is included in the resource measures appendix. Slipping during unloading is a risk factor in developing lameness (Chapter 8).
6. Absence of injuries. There are two main types of injuries investigated for this welfare criteria. The first one is wounds on the body, which covers tail lesions, wounds, together with vulva lesions for the sows (Chapter 3). The second type of injury is lameness, the possibility to use a gait score to assess this was investigated, both on farm (Chapter 6) and at slaughter (Chapter 7).
7. Absence of diseases. Respiratory, enteric, neurological and reproductive problems can be assessed on farm in a valid and feasible way (Chapter 9). A number of additional diseases can be assessed at slaughter (Chapter 10). Number of dead animals on arrival at the slaughter plant is partly related to the level of diseases of the animals (Chapter 11). Two final measurements which were investigated as measures of disease were acute phase proteins (Chapter 12).
8. Absence of pain induced by management procedures. The most common procedures which might cause pain are castration and tail docking, followed by nose ringing.

The various aspects of these (e.g. age, proportion of tail cut) are management-based measures (Appendix 1). At slaughter the stunning effectiveness is clearly related to the pain experienced by the animals (Chapter 13).

9. Expression of social behaviour. Aggressive behaviour may be measured by its outcome, i.e. the presence of wounds (Chapter 2).
10. Expression of other behaviours. For the welfare criteria ‘expression of other behaviours’ several types of behaviours were investigated. There are behaviours that indicate poor welfare, e.g. abnormal behaviours, including stereotypies (Chapter 15). Other behaviours might indicate positive emotions (Chapter 16).
11. Good human–animal relations. The avoidance reaction of the pigs can be used to measure the human animal reaction, either on an individual level, for sows (Chapter 17), or at a group level, for fattening pigs (Chapter 18). The consequences of a bad human–animal relationship in the slaughterhouse can be seen in meat quality (Chapters 13 and 18)
12. Positive emotional state. Fearfulness is the opposite of a positive emotional state. The measurement of fear on farm (Chapter 19) and at slaughter (Chapters 20 and 21) was investigated. Finally it is possible to gather information concerning the overall emotional state of the animal by means of qualitative behaviour assessment (Chapter 22).

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September 2009

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PIG VOCALISATIONS AS A MEASURE OF HUNGER

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1.1 SUMMARY

The welfare of pregnant sows is often compromised around feeding; they may be frustrated through waiting for the food and there is a risk of aggression around feeding. One candidate measure of the perceived stressfulness of the feeding time in sows is their vocalization.

Sixteen groups of 3–6 pregnant sows were observed between 10 min before and 15 min after they were fed. The sows were either given the standard amount of food on the previous feeding or half of the amount, or they got double the amount. On the following feeding, vocalizations and aggression were recorded. The study aimed to answer four questions: 1. Was the amount of vocalizations dependent on the hunger/satiation level? 2. Was the amount of aggression different between the three treatments? 3. Was the amount of vocalizations correlated with the amount of aggression? 4: How repeatable is the vocalization recording method across different observers?

The results showed that:

1. The amount of vocalization frequency was not influenced by the treatments either during 5 min before or during 5 min after the sows were given food.
2. The amount of aggression during 5 min before reception of food was significantly affected by the treatments (mixed model, $F_{2,31.5}=5.95$, $p=0.006$). The Hunger treatment incited sows to a higher level of aggression (aggression occurring in 24% of the 15 s scans) than both the Control (11%) and the Satiety treatment (10%).
3. During the 5 min period before feeding, vocalizations were not significantly correlated with aggression. However, during the first 5 min of feeding, vocalizations were closely related to aggression (within groups, across treatments: Cochran-Mantel-Haenszel statistics for non-zero correlation, $DF=1$, value= 9.9, $p=0.002$; across groups: Spearman $n=16$, $r=0.85$, $p<0.0001$).
4. The inter-observer repeatability of vocalization recording was satisfactorily high for the pre-feeding vocalization, amounting to Pearson correlations of $r=0.90$ to $r=0.92$

during the experiment and $r=0.82$ to $r=0.87$ after the experiment. However, the inter-observer repeatability for post-feeding vocalization was lower, reaching $r=0.53$ to $r=0.71$ during the experiment and dropping to non-significant values after the experiment.

In conclusion, the validity of vocalizations as a measure of the stressfulness was only partly supported. Vocalizations were strongly related to aggression after the start of the feeding but not before the start of the feeding and vocalizations were not closely related to hunger level. The inter-observer repeatability during the post-feeding period was not good. For these reasons, the measure cannot be recommended for inclusion into the monitoring system at the current stage.

1.2 INTRODUCTION

It has been documented that in challenging situations such as piglet being separated from their mother (Weary et al., 1997), piglets being castrated (Puppe et al., 2005), beef calves being branded (Watts and Stookey, 1999) or cattle being handled just before slaughter (Grandin, 12001), the quantity and quality of animal vocalizations can give human observers valuable information about the animal's inner state and thus to serve as an indicator of farm animal welfare. The reason behind this link is that vocalizations in such situations are believed to be signals that have evolved to contain honest information about the current need of the signaller (Weary and Fraser, 1995; Watts and Stookey, 2000; Manteuffel et al., 2004) and that they are neurophysically closely linked to circuits underlying emotional states (Cheng and Durand, 2004).

In pig welfare assessment, most attention has been devoted to piglet vocalizations. One area where vocalizations could prove to be a useful measure of the stressfulness of the situation is feeding in pregnant sows. Feeding time might be quite stressful for pregnant sows as they are hungry and aggressive to each other. Around feeding time, pregnant sows are also very vocal. Because these vocalizations are high-pitched and they do not occur when sows are feeding individually ad lib amounts of food, it is reasonable to assume that the vocalizations are linked to hunger, aggression or possibly other unpleasant aspects of normal feeding procedure. If that is the case, then vocalizations could be used as a more feasible proxy measure of the stressfulness of feeding than, e.g., direct recording of oral behaviours (Douglas et al., 1998; Zonderland et al., 2004) or aggression (Strawford et al., 2008). The link in pregnant sows between hunger and aggression, on the one side, and vocalizations, on the other, has not been investigated yet, with a few notable exceptions. Robert et al. (2002) measured vocalizations before meals in concentrate and high-fibre diet fed sows and found that the latter, who were presumably feeling less hungry, vocalized less.

This study was designed to investigate to what extent calling by pregnant sows around the time of feeding is a valid indicator of their instantaneous welfare and therefore, whether this measure could be recommended as a candidate for the welfare monitoring scheme for pigs. The validity of this measure was evaluated through assessing how closely it is related to hunger and to aggression among sows. The relation to hunger was assessed through manipulation of the satiation level, whereas the relationship with aggression was examined through correlational analysis.

1.3 METHODS

1.3.1 Animals and Housing

The experiment was carried out on the experimental pig farm of the Institute of Animal Science in Prague between November 2005 and May 2006. Pregnant Large White x Landrace sows on this farm are housed in groups of 3–6 in straw-bedded, concrete-floored pens measuring 4 x 3 m. Food (commercial pre-mixed dry food for pregnant sows, 1.5 kg per sow per feeding) was fed manually twice daily at 5 a.m. and 1 p.m. into a trough measuring 2.7 m that allows up to six sow to eat simultaneously, unless prevented by mutual aggression or fear. The sixteen groups observed in the experiment consisted of 3–6 sows (median 5.5) on their 1st to 14th pregnancy. The groups have been stable for at least 10 days before they entered the experiment. The total number of pregnant sows housed in the same room ranged between 22 and 35 on the different observation days.

1.3.2 Treatments

The hunger level of the observed groups of sows has been manipulated through altering the amount of food on the morning feeding, i.e. 8 hours before the sows were observed during the afternoon feeding (see below). In the Hunger treatment (H), the sows were given half of the usual amount of food on the given morning, while in the Satiety treatment (S), food was doubled in the morning and in the Control treatment (C), the usual amount of food was provided. All the three treatments were always applied to a group on Monday, Wednesday, and Friday, with the order being randomized in a balanced way across the 16 groups.

1.3.3 Behavioural Recording

Observations were made during the afternoon feeding. Five observers agreed during training sessions before the start of the experiment on the observation method. Starting with 10 min before the food was given to the observed group of sows until 15 min after

this moment, vocalizations and aggression were recorded at 15 s intervals, announced by a short beep from a stopwatch. One observer was noting aggression within the observed group (defined as either a head-knock or a bite) with the one-zero sampling method. That is, each scanning interval of 15 s was attributed either an aggression score of 1 (if any knock(s) and/or bite(s) occurred) or 0 (no aggression during the interval). Vocalizations (defined as any vocal expression of a sow except a normal grunting) were recorded by a second observer both through the one-zero, and through the instantaneous sampling (i.e. whether vocalization could be heard at exactly the break of the 15 s intervals), and that both for the observed group and for the whole room. Thus, the observer recording vocalizations had a sheet with four columns, the first two for the focal group and the next two for the whole room. During the 15 s interval, (s)he was noting into the first and the third column whether any vocalization had occurred in the focal group and in the whole room, respectively. At the beep, (s)he recorded into the second and the fourth column whether vocalization was under way in the focal group, and in the whole room.

All the five observers alternated in recording vocalizations and aggression during the experiment. On 17 occasions, 2 observers were recording vocalization of the same group independently, and these data were used for the analysis of repeatability of the recording method. These data were complemented after the end of the experiment in further observation sessions in which pairs observers were recording the same group, without any previous manipulation. Altogether, 37 paired recordings of vocalization by two observers could be evaluated for the repeatability purposes.

1.3.4 Statistical Evaluation

As a first step, the time course of the vocalizations and aggression were examined for the period before and after food was provided. Based on this inspection, the period of 5 min before the food was delivered and 5 min after it was delivered was further evaluated.

In order to assess whether the amount of vocalization and the amount of aggression was affected by the manipulated level of satiation, mixed models were applied to the data with the dependent variables being the amount of vocalization and of aggression 5 min before the food delivery and 5 min after the food delivery. The fixed factors were the treatment (with three hunger levels C, S and H) and the number of sows in the focal pen. The identity of the group and identity of the observer entered the model as random factors. Two additional fixed factors (total number of sows in the room and the day of week, i.e. Monday, Wednesday and Friday) were included in the original version of the models, but as they were clearly non-significant, they were omitted from the final version of the model.

The relationship between aggression and vocalization was examined at two levels. At the between-group level, we first averaged the amount of vocalization and the amount of aggression across the three observations for each group, and then correlated the amount of aggression and the amount of vocalizations across the 16 groups. At the within group level, we made use of the Cochran-Mantel-Haenszel stratified statistics and assessed the

correlation between aggression and vocalization across the three observations within each group, with the group identity being the stratifying variable.

Finally, we assessed the repeatability of the vocalization recording among the observers using Pearson correlations. The repeatability was examined separately for the pre-feeding and post-feeding periods and also separately for the recordings made during the experiment itself and for the recordings made later specifically for the repeatability purposes.

1.4 RESULTS

1.4.1 Sensitivity of the Vocalization Recording Methods

As can be seen in Figure 1.1, the proportion of 15 s time intervals in which vocalization in the focal pen occurred (as recorded through the one-zero sampling method) ranged between 0.39 and 0.88 for the 10 min pre-feeding period and between 0.11 and 0.29 for the 15 min post-feeding period. The proportion of instantaneous 15 s scans with vocalization occurring at the moment, as recorded through the instantaneous sampling method, was within the range 0.13–0.55 before feeding and 0.01–0.10 during/after feeding.

Proportional measures are most sensitive around the value of 0.5 since in this region, they are not constrained in variation by either the 0.0 or the 1.0 limit. Therefore, the one-zero sampling method was chosen for further quantification and statistical evaluation of vocalizations in the focal pen.

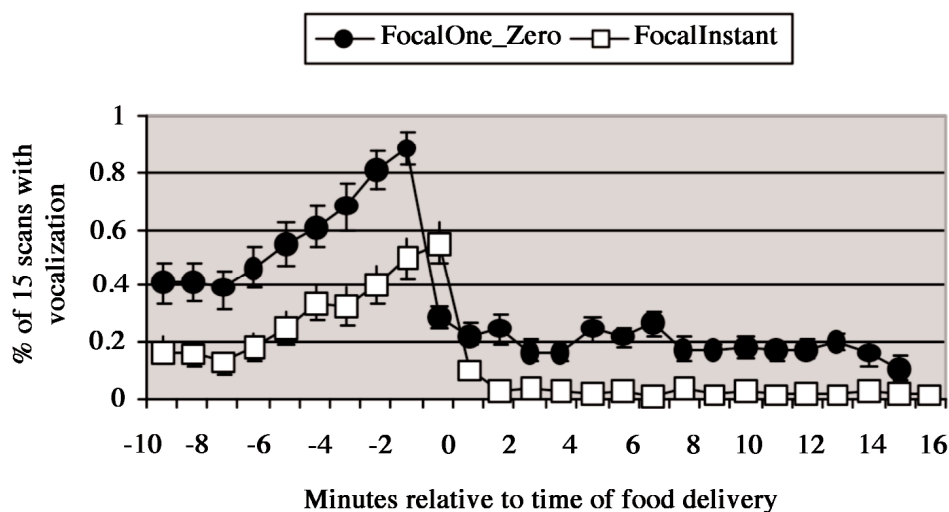


Figure 1.1 Time course of vocalizations of sows in the focal pens.

Notes: N=16 groups of sows, mean $\pm$ S.E. Full circles, the one-zero sampling method. Open rectangles, the instantaneous sampling method.

Figure 1.2 shows that for recording the vocalizations in the whole room (i.e. for a metagroup of 22–35 sows), the instantaneous method was better before feeding and the one-zero method during/after feeding.

1.4.2 Time Course of Vocalization and Aggression

Vocalization started to increase about 6 minutes before the food was provided, quickly dropped to much lower levels once food was available and then remained stable or very slightly decreased for about 10 minutes (Figure 1.1). Aggression increased gradually until food delivery, then made another upward jump when food was given, after which it gradually declined (Figure 1.3). Based on the inspection of these curves, we decided to take 5 min before the food delivery and 5 min after the food delivery as periods where both vocalisation and aggression were at the highest and therefore were most sensitive to the hunger manipulation. We also examined the same questions using a 10 min interval before and after food delivery. We got similar results, so this analysis is not presented in this report.

1.4.3 Influence of Hunger on Vocalization

The mixed model showed no significant effect of the hunger manipulation on the amount of vocalization either before ($F_{2,46.8}=2.21$, $p=0.12$, Figure 1.4) or after the sows were given food ($F_{2,43.6}=21.52$, $p=0.23$, Figure 1.5).

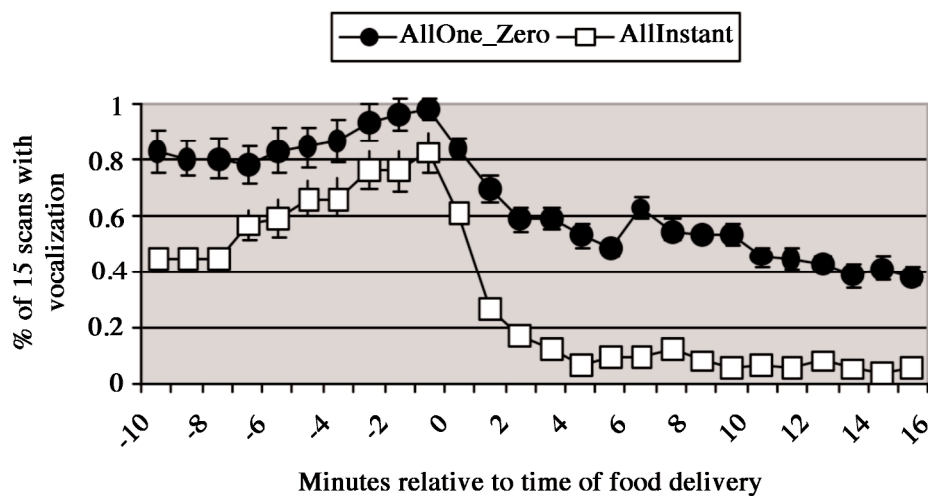


Figure 1.2 Time course of vocalizations of sows in the whole room.

Notes: N=16 groups of sows, mean $\pm$ S.E. Full circles, the one-zero sampling method. Open rectangles, the instantaneous sampling method.

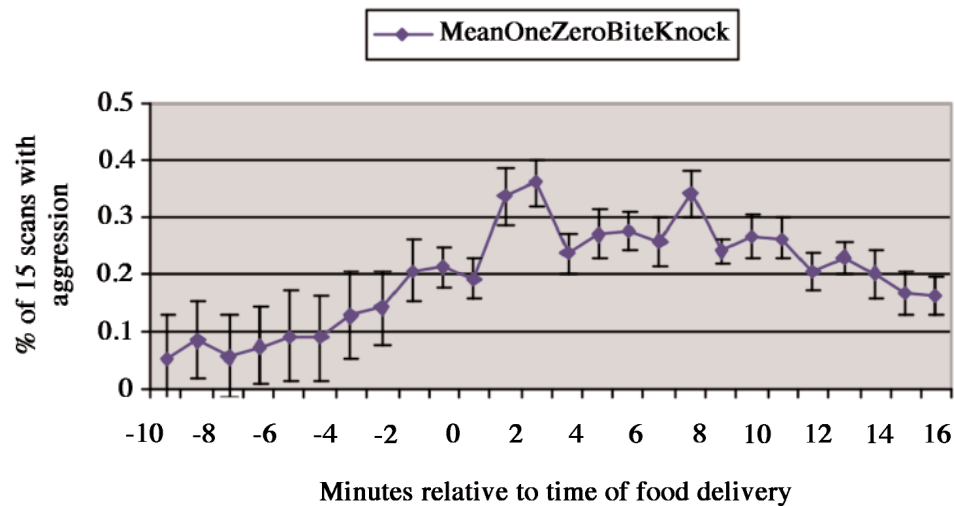


FIGURE 1.3 Time course of aggression among sows in the focal pens.
Notes: N=16 groups of sows, mean $\pm$ s.e.

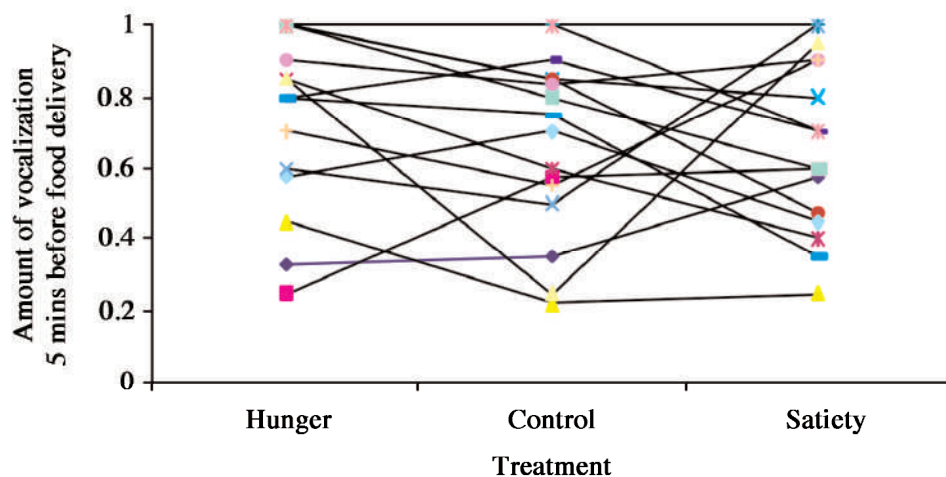


Figure 1.4 Amount of vocalization among sows in the focal pens under the three satiation levels.
Notes: N=16 groups of sows, each observed under all three treatments.

1.4.4 Influence of Hunger on Aggression

The amount of aggression during 5 min before reception of food was significantly affected by the treatments (mixed model, $F_{2,31.5}=5.95$, $p=0.006$, Figure 1.6). The Hunger treatment incited sows to a higher level of aggression (aggression occurring in 24% of the 15 s scans) than both the Control (11%, $p=0.02$) and the Satiety treatment (10%, $p=0.02$). However, the amount of aggression after the reception of food was not significantly affected by the treatments (mixed model, $F_{2,30.6}=2.66$, $p=0.09$, Figure 1.7).

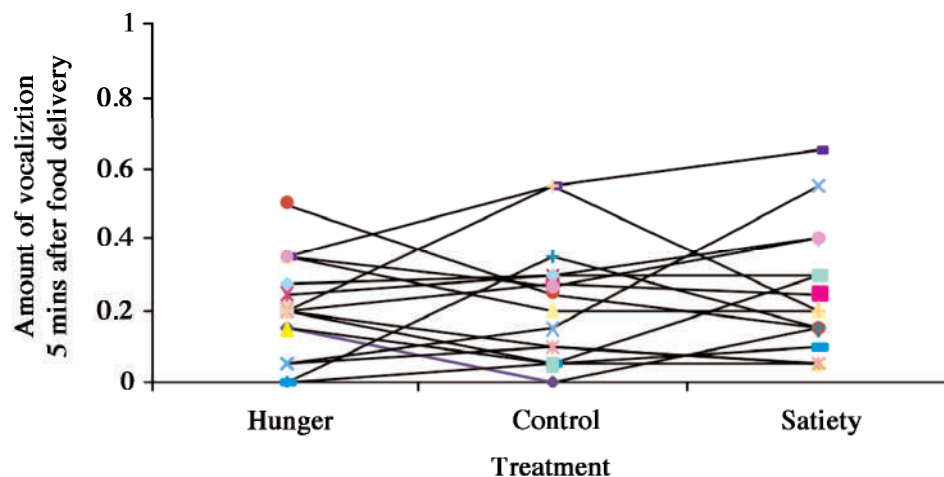


Figure 1.5. Amount of vocalization among sows in the focal pens under the three satiation levels.

Notes: N=16 groups of sows, each observed under all three treatments.

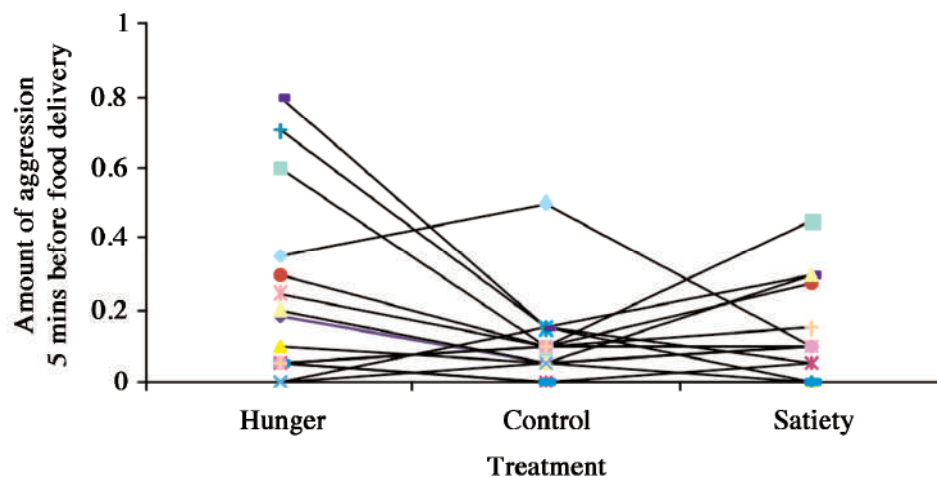


FIGURE 1.6 Amount of aggression among sows in the focal pens under the three satiation level.

Notes: N=16 groups of sows, each observed under all three treatments.

1.4.5 Correlation between Aggression and Vocalization

During the 5 min period before feeding, vocalizations were only non-significantly correlated with aggression (within groups, across the three treatments: Cochran-Mantel-Haenszel statistics for non-zero correlation, DF=1, CMH statistics value= 2.7, $p=0.10$; across groups: $n=16$, Pearson $r=0.41$, $p=0.12$, Figure 1.8).

However, during the first 5 min of feeding, vocalizations were closely related to aggression (within groups, across treatments: Cochran-Mantel-Haenszel statistics for non-zero

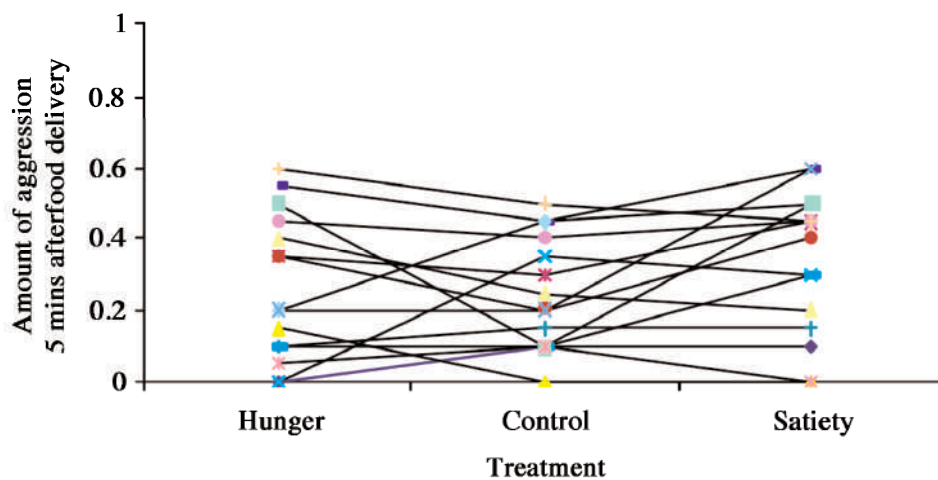


Figure 1.7 Amount of aggression among sows in the focal pens under the three satiation level.

Notes: N=16 groups of sows, each observed under all three treatments.

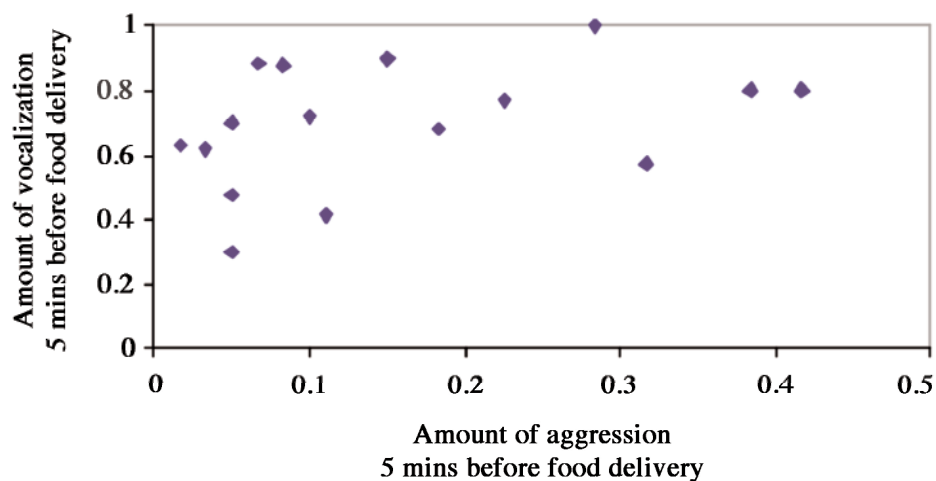


Figure 1.8 Amount of vocalization among sows in the focal pens as related to the level of aggression.

Notes: N=16 groups of sows.

correlation, DF=1, CMH statistics value= 9.9, $p=0.002$; across groups: Spearman $n=16$, $r=0.85$, $p<0.0001$, Figure 1.9).

1.4.6 Between-observer Repeatability of Vocalization Recording

Based on the 17 pairs of recording of the same group by two observers during the experiment, the inter-observer repeatability of vocalization recording was high for the pre-feeding vocalization, amounting to Pearson correlations of $r=0.90$ for one-zero recording and $r=0.92$ for instantaneous recording. The inter-observer repeatability for post-feeding

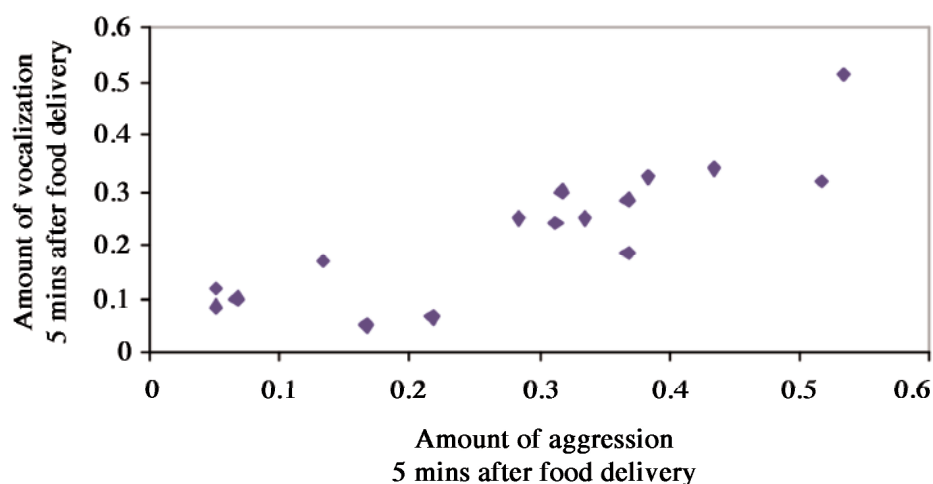


Figure 1.9 Amount of vocalization among sows in the focal pens as related to the level of aggression.

Notes: N=16 groups of sows.

vocalization during the experiment was lower, reaching $r=0.71$ to $r=0.54$, respectively, for the one-zero and instantaneous recording methods.

The additional 20 paired recordings which were done after the experiment to increase the data set for assessing repeatability yielded somewhat lower, yet still very good repeatabilities of $r=0.82$ to $r=0.87$ for the two methods for the pre-feeding vocalizations. However, the inter-observer repeatability for post-feeding vocalization dropped to non-significant values in this additional data set ($r=-0.10$ and $r=0.32$).

1.5 DISCUSSION

1.5.1 Sensitivity of the Vocalization Recording Methods

Measures expressed as proportions range between 0 and 1 and therefore are most sensitive around the value of 0.5 because in this middle region, they are not constrained in variation by either of the limit values. In our study, recording the vocalizations in one pen of 3-6 sows through instantaneous recording resulted in values close to zero, especially during the period after food was provided. The method was thus insensitive to differences between sessions and groups. Therefore, the one-zero sampling method was considered more suitable than the instantaneous one for quantification of vocalization in the focal pen.

For quantification of vocalization in the whole room (encompassing 22–35 sows), the situation was different. During the 10 minutes before feeding, the one-zero method gave too high scores (mostly between 0.8 and 1) and was thus inferior to the instantaneous method which yielded scores of 0.4–0.8. After feeding, the instantaneous method yielded too low scores even for the whole room, and the one-zero method was thus superior.

In general, these results confirm that using both the one-zero and the instantaneous sampling method at the same time expands the range over which the recording the level of vocalization is sensitive. Using this approach, it may be possible to compare widely differing levels of vocalizations such as those occurring in small versus large groups of sows.

1.5.2 Time Course of Vocalization and Aggression around Feeding

Vocalization increased during the last 6 minutes before the food was provided. This was probably due to the growing expectation as the moment of food delivery was approaching. Beside the fact that food was provided at an quite exact time (± 5 min), the sows had an additional cue that food delivery was imminent, namely the arrival of the stockperson that brought the food to the troughs a few minutes later.

After the food delivery, vocalizations dropped sharply as most sows started to ingest the food. Vocalization level then remained constant at a low level. Since the main purpose of the study was to use a very simple recording method that could be used reliably, we did not record the context in which individual calls occurred. However, our experience from the observations is that calls before food delivery were mainly emitted while the sows were looking into the direction from which the caretaker used to come, or in reaction to other sows calling, although a small part of calls were linked to mutual aggression. After the food was provided, sows mostly called in response to being attacked. This observation indicates that the level of vocalization around feeding might reflect a mixture of acoustic signalization stemming from two different motivations: a ‘baseline’ vocalization level related to mutual aggression, on which a pre-feeding increase in food-related calling is superimposed.

1.5.3 Validity of Vocalization as an Indicator of Hunger

Vocalization around feeding in pregnant sows showed some relation to aggression but no consistent link to hunger. Therefore, it is unlikely that the vocalization recorded by the present method can be used as a valid measure of welfare in pregnant sows around feeding.

More specifically, the three hunger/satiety treatments did not affect significantly vocalization either before or after feeding. Some of the groups had relatively similar vocalizations levels across the three treatments, while others varied greatly in vocalization on the three days, indicating that other factors not investigated in this experiment

influenced the level of vocalization behaviour. Besides altering the amount of food on morning feeding, i.e. 8 hours before the observation, no changes were made in the usual husbandry procedures on the farm, so the large between-days variation in vocalization in some sows probably represents a normal on-farm situation.

One possible reason for the weak effect of the treatments on vocalizations might be that the one-off change in food provisioning on the previous feeding did not change the perceived hunger level enough. However, this seems improbable because the treatments did affect the aggression level on the next feeding. During the 5 min before the provision of food, sows on the Hunger treatment were double that aggressive than sows from the two other group.

1.5.4 Validity of Vocalization as an Indicator of Aggression

Vocalization after food provisioning was strongly related to aggression level. In the between-group analysis, the correlation coefficient amounted to 0.85, and thus almost three quarters of variability in one of the variables could be explained by the other. As the causal relationship between the two phenomena is both logically clear and confirmed by personal observations and in other studies (aggression induces vocalization and not vice versa), this result indicates that vocalization may be a valid measure of between-sow aggression when food is available.

Before feeding, however, only a weak, if any, link between vocalization and aggression could be documented. Our explanation is that only a minor part of the before feeding vocalization was caused by aggression, while to majority was linked to the expectation of food delivery. It is impossible to conclude from our data whether aggression did not cause vocal reactions as reliably before feeding as it did after food delivery, or whether the effect was just overshadowed by the mass of pre-feeding non-aggression-related calls. Whichever is the case, pre-feeding vocalizations cannot be presently considered a valid measure of between-sow aggression.

1.5.5 Between-observer Repeatability of Vocalization Recording

The repeatability of vocalization scores arising from both the one-zero sampling and the instantaneous sampling was high for the 5 min period before food delivery. Although the sample sizes on which the repeatability values were based were not large, the Pearson correlation coefficients between 0.82–0.92 show that the amount of pre-feeding vocalizations in small groups of penned sows can be recorded reliably even if there are many other sows in the same room. The reason for this high repeatability may lay in the fact that during last minutes before feeding, sow vocalizations often involved either many of the sows in the pen and therefore could be readily distinguished from periods with no vocalizations. After the food was delivered, the vocalizations were emitted mostly by individual sows in response to aggression and therefore more ambiguity may have arisen

during their recording. Accordingly, the repeatability was much lower for vocalization recording during 5 minutes after food delivery.

The main source of doubt for vocalization recording, however, was the extremely low repeatability after food delivery in the additional sessions after the experiment was finished. We have no good explanation why this happened and why repeatability was so much lower, especially for the one-zero sampling method. Perhaps the motivation, and thereby also the concentration, of observers were inadvertently lower in this second phase when they knew that the experiment itself has already ended and the observations were run 'only' to check the reliability. Whatever the underlying cause, the discrepancy between the repeatability in the two phases (experiment, post-experiment) is a warning sign urging for further investigations into the repeatability of this method under different conditions.

1.6 CONCLUSION

In conclusion, the validity of vocalizations as a measure of the stressfulness of the feeding time for pregnant sows was only partly supported. Vocalizations were strongly related to aggression after the start of the feeding but not before the start of the feeding and vocalizations were not closely related to hunger level. The inter-observer repeatability during the post-feeding period also is not guaranteed to be satisfactorily until further improvements in the method are made. For these reasons, the measure cannot be recommended for inclusion into the monitoring system at the current stage, although it should not be dismissed from further examination for possible later inclusion.

VALIDITY OF MEASURES TO ASSESS FOOD DEPRIVATION IN PIGS AT SLAUGHTER

A. Dalmau, A. Velarde, L. Van Steenberghe and V. Hautekiet

2.1 SUMMARY

Fasting periods longer than 18 h causes hunger and aggressiveness in pigs, and therefore impairs welfare (Warriss, 1996). Stomachs weight and stomach contents have been used to assess short fasting times for meat quality reasons (Guise et al., 1995; Chevillon, 1994). However, it is uncertain if these measures can be used to assess long fasting times. Two different experiments were carried out. In the first one, the gastrointestinal tract of 155 pigs was scored by visual inspection and palpation at 10, 12, 18, 22 and 24 h fast. In the second one, under experimental conditions, 30 slaughter weight pigs were slaughtered at 18, 30 and 36 h fasting time. After removal, stomachs were weighed full, touched for subjective evaluation of gut content and then opened along the greater curvature, emptied, washed, shaken and re-weighed. The type of content was subjectively classified as solid, liquid and bile. The pH of the stomach content was measured with a pH-meter. The aspect of the stomach wall was assessed for presence of ulcerations and congestion. The full intestine tract without stomach and spleen was weighed full and then emptied, washed, shaken and re-weighed. Blood samples were taken 3 days before the beginning of the fasting period, at the beginning of the fasting period for the first group and just after sticking to analyse pig-MAP concentration in serum. The first experiment showed that visual inspection and palpation of the gastrointestinal tract does not differ between pigs of 18, 22 and 24 h fasting. Furthermore, after 10 h fasting almost all the stomachs and small intestine were scored as empty. Results of experiment 2, showed that there was no difference between 18 30 and 36 h fasting. No statistical differences were found in the presence of ulcerations between periods of fasting. Statistically but no consistent differences were found in relation to the presence of congestion on the stomach wall, as these differences were found between animals with 30h fasting and pigs with 18 and 36 h fasting. It is suggested that congestions may be affected by other factors not considered in the study. In fact, the stomach content after 30 h fasting was mainly liquid. On the other hand, pH at 18 h was higher than pH at 30 h and tended to be higher than pH at 36 h. Stomach content pH could be a valid measure to assess long fasting periods in pigs,

although more studies are required. Differences between treatments were found on full intestine weight and empty intestine weight. In both cases, the weight of the intestine was higher in the group of 18h fasting than in the group of 36 h fasting. There was also a difference between 18 and 36 h fasting on the empty intestine weight. These results may suggest a loss of intestine mass during the fasting period. The live weight loss between the start of the fasting period and the time of slaughter was higher with longer fasting periods. The weight loss would include fat, muscular and intestinal tissue. Therefore, the full intestine weight (without stomach and spleen) could be a valid measure to assess food deprivation. However, the results obtained with empty intestine weights and intestine content weight needs to be investigated in further studies.

2.2 INTRODUCTION

Fasting periods longer than 18 h causes hunger and aggressiveness in pigs (Warriss, 1996) and therefore impairs welfare. Stomachs weight and stomach contents have been used to assess short fasting times to meat quality reasons (Guise et al., 1995; Chevillon, 1994). However, it is uncertain if these measures can be used to assess long fasting times that induce hunger. Stomachs may empty before the animals feel hunger. The objective was to assess whether stomachs weight or stomach content are good indicators of food deprivation longer than 18 h. At the same time, serum pig-MAP concentration and aspect of the gastric mucosa were assessed.

2.3 METHODS

Two different experiments were carried out, one by the K.U. Leuven group (experiment 1) and the other in IRTA (experiment 2).

2.3.1 Experiment 1

Two trials were carried out on commercial conditions. In the first one, 86 slaughter pigs divided in three groups of 30, 31 and 24 animals were fasted for 12, 18 and 22 h, respectively, before slaughter. In the second trial, 69 slaughter weight pigs divided in three groups of 23 pigs each were fasted for 10, 18, and 24 h before slaughter. The duration of transport and lairage time co-determined the actual total fasting period but the latter never differed more than 40 minutes from the intended fasting period.

The gastrointestinal tract of each pig was scored by visual inspection and palpation (Box 2.1).

2.3.2 Experiment 2

A total of 30 slaughter weight pigs from the same farm and feeding system were used in this experiment. Pigs were all females, of the same breed and free of the RYR-1 gene. One week before the trial, the pigs were transported to the adjacent lairage pens next to the experimental abattoir (IRTA, Spain) and divided in 3 groups. The first group was slaughtered with a fasting time of 18 h, the second group with a fasting time of 30 h and the third group with a fasting time of 36 h. Water was available ad libitum.

2.3.3 Measurements

Pigs were weighted at the start of their fasting period and before slaughter. The carcass was weighted 45 min after slaughter and the carcass performance (carcass weight / live weight before slaughter) calculated. Three blood samples were taken from each animal with a vacutainer system to determine pig-MAP concentration in serum. The first sample was taken 3 days before the start of the fasting period, the second sample just when the first group began their fasting period, and the third sample just after sticking.

After slaughter, stomachs were removed from the carcass and weighed full, touched for subjective evaluation of gut content (empty or full) and then opened along the greater curvature, emptied, washed, shaken and re-weighed. The stomach content was also weighed and subjectively classified as solid, liquid and bile. The pH of the stomach content was measured with a pH-meter. The aspect of the stomach wall was assessed for presence of ulcerations (absence = 0, one = 1, 2 or more = 2) and congestion (absence = 0, moderate = 1, severe = 2). The full intestine tract without stomach and spleen was weighed and then emptied, washed, shaken and re-weighed.

2.3.4 Statistical Analysis

The statistical analysis was carried out with the PROC MIXED procedure of Statistical Analysis System (SAS; software SAS Institute Inc., Cary, NC; 1999–2001) for repeated measures to study Pig-MAP and PROC MIXED and PROC FREQ for loss weight, stomach and intestine weights and type of stomach content, presence of ulcerations and

Box 2.1 Subjective score used to assess gastrointestinal state.

score 0	Stomach and small intestines empty
score 1	Stomach empty and small intestines filled
score 2	Stomach filled 1/3
score 3	Stomach filled 2/3

congestion, respectively. In the case of Proc Mixed, when the analysis of variance indicated significant differences ($P < 0.05$), the least square means of fixed effects (LSMEANS) adjusted to Tukey's honestly significant difference (HSD) was used as a test of multiple comparison. In all cases, only comparisons with a significant effect ($P < 0.05$) are shown in the results section.

2.4 RESULTS

Experiment 1

A 100% of the animals with a score of 0 (stomach and small intestine empty) were found at 10, 18 and 24 hours fasting, with few differences between fasting periods according to the subjective visual inspection and palpation of the gastrointestinal tract (Table 2.1).

Experiment 2

Table 2.3 shows the results of the measurements. No differences were found in the live weight between pigs of different groups at the beginning of the fasting period (mean live weight 95.7 ± 2.46 kg.; $P = 0.3839$) and before slaughter (mean body weight 90.9 ± 2.39 kg.; $P = 0.2955$). However, the loss of weight was higher in the 36 h fasting group than in the 30 and 18 h fasting groups ($P = 0.0292$ and $P = 0.0057$, respectively). No differences were found on carcass performance between treatments ($77.9\% \pm 0.32$, $77.9\% \pm 0.32$ and $78.3\% \pm 0.32$ for 18, 30 and 36 h fasting, respectively). The subjective evaluation of stomachs contents by touching them showed no differences between treatments. All stomachs (except two with a great quantity of water inside) were classified as empty (0). No differences were found in full stomach weight or stomach content weight between the three fasting groups.

Differences between treatments were found on full intestine weight and empty intestine weight ($P = 0.03$; $P = 0.0124$, respectively). In both cases, the weight of the intestine was

TABLE 2.1 Frequency score for the filling of stomach and small intestines at different fasting levels.

Fasting level (hours)	% animals with score 0	% animals with score 1	% animals with score 2	% animals with score 3	Total number of animals
10	100	0	0	0	23
12	77	20	3	0	30
18	100	0	0	0	23
18	87	13	0	0	31
22	92	4	4	0	24
24	100	0	0	0	23

higher in the group of 18h fasting than in the group of 36 h fasting ($P = 0.02$ and $P = 0.01$, respectively). However, no differences were found in the intestine content weight ($P > 0.05$). When the total weight of the full stomach and the full intestine was considered, a tendency was observed ($P = 0.07$), being the weight higher in 18 h fasting group than in 36 h ($P = 0.07$; Table 2.2).

The pH of the stomach content was different between treatments ($P = 0.05$). In fact the pH after 18 h fasting was higher than after 30 h ($P = 0.004$), but not significantly different than after 36h fasting. Values of pH obtained were 4.96 ± 0.340 , 3.25 ± 0.340 and 3.99 ± 0.340 for 18, 30 and 36 h of fasting, respectively.

Differences were observed in the aspect of stomach content and the congestion of the stomach wall between treatments ($P = 0.002$; $df = 4$; $x^2 = 16.56$ and $P = 0.01$; $df = 6$; $x^2 = 16.04$, respectively). After 30 and 36 h fasting, no solid content was found in the stomach. After 18 h fasting only a 20% of the stomachs showed solid content (Table 2.3). Furthermore, the congestion of the stomach wall was lower after 30 h fasting than in the other treatments. On the other hand, no differences were observed in the presence of ulcerations in the stomach wall between treatments ($P = 0.30$; $df = 4$; $x^2 = 4.53$).

No differences were found in the serum concentration of pig-MAP between treatments ($P > 0.05$; Table 2.4).

2.5 DISCUSSION

In pigs, the 52-70% of the ingested dry matter is emptied from the stomach within 4 h (Low et al., 1985). The same authors reported that only a 5% of the dry matter of the food given to a 35 kg pig in experimental conditions is presented in the stomach after a 16 h fast.

TABLE 2.2 Stomach and intestine weights before and after emptying, stomach and intestine content weight and body weight difference between beginning of fasting period and day of slaughter after 18, 30 and 36 h of fasting (LSMEANS and SE).

	18 h	30 h	36 h
Live weight before slaughter (kg)	90.2 $\pm$ 1.74	94.0 $\pm$ 2.92	88.7 $\pm$ 2.38
Live weight difference (Beginning fasting-slaughter; g)	3800 $\pm$ 520a	4300 $\pm$ 520a	6300 $\pm$ 520b
Full stomach weight (g)	834 $\pm$ 61.8	871 $\pm$ 61.8	893 $\pm$ 61.8
Empty stomach weight (g)	571 $\pm$ 57.3	553 $\pm$ 57.3	652 $\pm$ 57.3
Stomach content weight (g)	284 $\pm$ 54.7	330 $\pm$ 54.7	252 $\pm$ 54.7
Full intestine weight (g)	6712 $\pm$ 239.6a	6041 $\pm$ 252.5ab	5721 $\pm$ 252.5b
Empty intestine weight (g)	2105 $\pm$ 159.7a	1787 $\pm$ 168.3ab	1383 $\pm$ 168.3b
Intestine content (g)	4607 $\pm$ 447	4254 $\pm$ 417	4338 $\pm$ 417
Full stomach and intestine weight (g)	7546 $\pm$ 266.2	6927 $\pm$ 281.4	6630 $\pm$ 281.4

TABLE 2.3 Aspect of the stomach content and congestion of the stomach wall after 18, 30 and 36 h of fasting.

		18 h	30 h	36 h
Aspect stomach content	Bile	60%	30%	100%
	Liquid	20%	70%	0%
	Solid	20%	0%	0%
Congestion stomach wall	0	20%	90%	20%
	1	30%	10%	50%
	2	50%	0%	30%

TABLE 2.4 Pig-MAP concentration (LSMEANS $\pm$ SE) in serum of pigs with 18, 30 and 36 h of fasting.

		18 h	30 h	36 h
Serum Pig-MAP (mg/ml)	Basal	.65 $\pm$.115	.80 $\pm$.115	.57 $\pm$.120
	Pre-fasting	.65 $\pm$.115	.87 $\pm$.115	.49 $\pm$.115
	Sacrifice	.50 $\pm$.115	.79 $\pm$.115	.52 $\pm$.115

The first experiment showed that visual inspection and palpation of the gastrointestinal tract does not differ between pigs of 18, 22 and 24 h fasting. Furthermore, since 10 h fasting almost all the stomachs and small intestine were scored as empty. In the experiment 2, all the stomachs of the pigs slaughtered after 18h fasting were scored as empty and did not show differences with the stomach of the animals slaughtered after 30 and 36 h fasting. A 70% of the animals after 30 h fasting had liquid content in the stomach, while pigs after 36 h fasting had a 100% of bile. Nevertheless, the difference may not have relationship with the fasting periods, but the fact that the group of animals of 30 h fasting had been drinking just before be slaughtered. This water drunk was the responsible of the unique difference observed by visual inspection and palpation between the 30 stomachs. In addition, it could explain also the differences observed in experiment 1 between animals with 12 and 10 h fasting (trials 1 and 2, respectively), where animals of 12 h presented a higher frequency of scoring 1 than animals with 10 h fasting.

Chevillon (1994) concluded that to assess the time of fasting of pigs in the slaughterhouse is better to weight the stomach content than to distinguish the aspect of its content at 24 h fast or lower. However, in our study, full stomach weight and stomach content weight are not valid measures either to distinguish between 18 h fasting and longer periods. Nevertheless, the stomach content weight is lower than the weight obtained by Guise et al. (1995) and Chevillon (1994). Chevillon (1994) concluded that to have a stomach content lower than 500 g, a time between 20 and 24 hours fasting is needed. We observed a content weight around 280 g since 18 h fasting.

No statistical differences were found in the presence of ulcerations between periods of fasting. Statistically but no consistent differences were found in relation to the presence of congestion on the stomach wall. The incidence of stomachs without congestion was higher with 30h fasting than with 18 or 36 h fasting. It is suggested that congestions may be affected by other factors not considered in the study. In fact, the stomach content of animals 30 h fasting was mainly liquid.

On the other hand, pH at 18 h was higher than pH at 30 h and tended to be higher than pH at 36 h. These results confirm that stomach content pH could be a valid measure to assess long fasting periods in pigs, although probably more studies are needed to confirm these data.

In contrast to the stomach measures, weight of the full intestine could be a valid parameter to distinguish between animals with 18 h and 36 h fasting. After 18 h, the main part of the food has left the stomach to the intestine, so, with long fasting periods the differences in content are more likely to be in the intestines than in the stomachs. Nevertheless, it was also observed differences between 18 and 36 h fasting observed on the empty intestine weight. These results may suggest a loss of intestine mass during the fasting period. In fact, the empty intestine weight represents a 2.3 %, 1.9% and 1.6% of the total body weight for animals with 18, 30 and 36 h fasting, respectively. The live weight loss between the start of the fasting period and the time of slaughter was higher with longer fasting periods. The weight loss would include fat, muscular and intestinal tissue. Therefore, the full intestine weight (without stomach and spleen) could be a valid measure to assess food deprivation. However, the results obtained with empty intestine weights and intestine content weight need to be investigated in further studies.

Finally, the level of acute phase protein, such as pig-MAP, is not a valid measure to assess food deprivation at slaughterhouse. Acute phase protein increases their concentration after 24 h of the presence of adverse stimulus. Warriss (1996) reported that suffering starts after 18 h fasting. In our study time of potential suffering is considering of 12h in the group of 30h and 18h in the group of 36h.

2.6 CONCLUSIONS

The subjective scoring based on visual inspection and palpation of gastrointestinal tract used is not a valid method to assess fasting periods higher than 18 h.

The stomach weight and the stomach content weight are not valid measures to assess fasting periods higher than 18 h.

The stomach wall aspect and the content aspect are not valid measures to assess fasting periods higher than 18 h.

The pH of the stomach content could be a valid measure to assess fasting periods higher than 18 h. However, further studies are required to know if it is necessary to empty the stomach for measuring the pH or it can be done through the stomach wall.

The full intestine weight could be a valid measure to assess fasting periods higher than 18 h. Nevertheless, the repeatability and feasibility of the measure needs to be studied in more detail and the differences on empty intestine weight and intestine content weight between treatments observed in this study needs to be clarified in further studies.

STANDARDISATION OF CLINICAL SCORING IN PIGS

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3.1 SUMMARY

A review of the scientific literature revealed many different methods for assessing clinical scoring in pigs, ranging from simple counts of skin damage to detailed topographical and qualitative severity scales. However, relatively few of these studies have investigated validation, repeatability and inter- and intra-observer reliability, all of which are important considerations when attempting to design an on-farm welfare assessment tool. Following review and discussion of the available literature, a protocol was formulated for on-farm assessment of clinical scoring considering four different parameters:

1. body lesions (sows, weaners and finishers);
2. tail biting (weaners and finishers);
3. vulval lesions (sows);
4. body condition (sows).

It was agreed that all parameters would be assessed using a three-point scale, ranging from 0–2. A score of zero would be indicative of acceptable welfare, a score of one would indicate some compromise of welfare, and a score of two would be indicative of poor and unacceptable welfare.

3.2 BODY LESIONS

3.2.1 GENERAL BACKGROUND

The Swedish veterinarian, Ingvar Ekesbo, proposed that the state of the integument of an animal might be an indicator for well-being. Gloor (1986) elaborated on this, stating that the extent of lesions on the skin reflects the quality of the animal's physical and social environment. Following on from Ekesbo's suggestion that the state of integument might be a good indicator of well-being, de Koning (1985) investigated whether this was indeed the case for sows and, if so, how a method based on this parameter should be carried out. The methodology used by de Koning involved inspecting 52 locations on the body of sows for the presence of lesions. Lesions were classified according to type and extent using a 0–5 severity scale, since a pilot study had found that lesions varied in nature as well as topographically. De Koning concluded that the relevance of the state of the integument of an animal with respect to well-being is dependent on both the type and location of the lesion, since different types of lesion were found to prevail at different body locations in different housing environments, and that the environment can have a direct influence on the integument and also an indirect influence, through the induction of injurious behaviour.

The detailed topographical and qualitative severity scale devised by de Koning has since been modified by many researchers when assessing body lesions, whilst other researchers have simply made counts of the number of lesions/injuries on various body parts. Both methods of assessing body lesions will be reviewed.

3.2.2 BODY LESIONS – SEVERITY SCORING

Background

Severity scoring systems that have been used range from counting and measuring/categorising all of the lesions on specific body areas (Ekesbo-type methods) to simplified scoring systems using an arbitrary scale (e.g. 0–5). In the majority of these studies, the body is subdivided into different regions (this may be as few as four and as many as 52) for ease of assessment. A severity score is assigned to each region and the scores are often then combined or averaged to produce an overall skin damage score.

Whilst many studies have documented different methodologies for assessing body lesions, relatively few have investigated elements of validation, repeatability and inter- and intra-observer reliability. These are important factors within the Welfare Quality project, and so were given special consideration in the review.

Validation

Body lesions have been validated by measures of aggression. Burfoot et al. (1995) investigated a scoring method to assess damage caused by aggression between sows after mixing. This involved classifying damage as bruises, scratches, wounds, and severe wounds, and counting each type in each of four body regions (head/shoulders, flank, rear and vulva). Totals were added together to give an overall score for each sow. The total skin damage on day five after mixing was correlated with the total number of times a sow was attacked during these five days ($r=0.633$; $P<0.001$). A significant correlation was also found between the total lesion score and the number of violent and moderate attacks a sow received ($r=0.519$; $P<0.001$).

Stewart et al. (1993) assessed lesion scores in gilts under three different feeding regimes (individual, group and ad-lib feeding). Lesion scores were assessed over seven body areas using a scale from 0 (no damage) to 5 (more than five separate wounds where the epidermis had been penetrated) for each region. Throughout the gestation period, average total lesion scores were highest for group-fed animals, which competed daily for feed. A significant rank category effect was observed within group-fed sows, where the lowest ranking animals had greater numbers of scratches and cuts, particularly around the face and neck, which may be indicative of aggression at feeding time.

Durrell et al. (2002), investigating sow behaviour in voluntary cubicle pens and dynamic groups in split-yard systems, scored skin damage on eleven different sites of the body. Each site was scored separately (head, neck, shoulder, middle, hip, rear, front leg, back leg, front back, middle back and rear back), according to the percentage of the site containing lesions and the severity of the lesions on this site on a scale from 1 (mild) to 5 (severe). An estimate of the proportion that each site occupied out of all the sites was combined by taking measurements of all the sites from a random sample of sows. This information on the proportion of the whole body each site occupied, along with the percentage score and severity score for each site, was used to calculate a whole body percentage and mean severity score for each sow, which were then multiplied together to provide a single skin lesion score. Skin lesion score was found to be higher in sows in the split-yard system, and these sows tended to engage in more social and agnostic interactions than sows in voluntary cubicle pens.

Inter- and Intra-observer Reliability

Inter- and intra-observer reliability were investigated in the study of Burfoot et al. (1995), with each sow assessed for skin damage by one experienced observer and two less experienced observers. Counts of total damage in each body region and in total were consistently similar between observers (Spearman rank-order correlation coefficients between observers A and B: $r_s=0.879$, $P<0.001$; B and C: $r_s=0.861$, $P<0.001$; A and C: $r_s=0.804$; $P<0.001$). However, rank-order correlations of different categories of severity were lower, indicating that, in general, the classification, rather than the total count, of damage depended on the observer (Table 3.1).

TABLE 3.1 Spearman rank correlation coefficients for damage classification by observers A, B, and C.

Observers	Bruise	Scratch	Wound	Severe wound
A and B	.201a	.704	.699	.748
A and C	.041 a	.478 a	.658	.473 a
B and C	.266 a	.369 a	.598	.248 a

Notes: a denotes a significant difference between observers at $P < 0.001$; after Burfoot et al., 1995.

Methodologies Used and Factors Influencing their Outcome

As mentioned previously, many studies have modified the technique described by de Koning (1985), based on Ekesbo's theory. Boyle et al. (2000) used a modification of de Koning's technique when investigating the effect of three different gestation housing systems on the initial responses of gilts to the farrowing crate. Thirty-four locations on the left- and right-hand sides of the body were inspected for the presence of lesions. Lesions were classified and evaluated on a 0-6 scale, where 0 = normal and 6 = severe wound plus swelling. Increases in the skin lesion score of gilts in all three treatment groups (stalls, loose-bedded, loose-unbedded) were observed after 24h in the crate, however lesions on the loose-bedded gilts appeared to heal faster because their skin was healthier on entry to the farrowing house. Boyle et al. (2002) further investigated the effects of gestation housing on skin lesions in sows in farrowing crates using the methodology described previously. Addition of scores at 10 and 14 locations on the front and hind limbs respectively yielded front and hind limb lesion scores for each sow. The forelimb lesion score of individually stall housed sows was found to be significantly higher than loose housed sows post-farrowing. Loose housing during gestation resulted in improved manoeuvring ability and comfort of sows in the farrowing crate with beneficial implications for skin health.

The restriction of movement imposed on sows in farrowing crates can have important welfare implications (Barnett et al., 2001). Bonde et al. (2004) reported on associations between lying-down behaviour problems and skin lesions of sows housed in farrowing crates. Five different body areas were assessed using a severity score, which varied depending on the region. For the hind feet, hock and carpus, scores were 1 or 2, where 1 was no lesions and 2 was a wound. For the shoulder, scores ranged from 1: no lesions, 2: scratches, 3: wound, and finally for the udder and teats, scores were 1: no lesions, 2: scratches or wounds. The study found that the type of flooring affected the herd prevalence of shoulder lesions, being higher on fully-slatted floors and in crates with a wet or soiled floor. The prevalence of skin lesions on the legs varied between herds, and this could be associated with the flooring in the farrowing crates. The effects of different floor types in farrowing crates on sow welfare were also investigated by Lewis et al. (2002), in which skin lesions at 58 locations (29 on each side of the body) were scored from 0 to 6 according to severity. A severe lesion score for each sow was calculated by the addition of all scores greater than 2. Damage to the skin of the hind limbs and the severity of lesions found on sows housed on steel slats indicated that sows had greater difficulty manoeuvring on this floor type, possibly because it was more slippery.

Guy et al. (2002) evaluated the welfare of growing-finishing pigs in three different housing systems also using a modified de Koning (1985) scoring system. Nine separate areas of the body were examined, with the number and severity of cuts, scratches and bruises in each area recorded using a 0–5 scale (0 = no damage, 5 = severe or infected wound). Skin damage scores were lower in outdoor paddocks and straw yards than in fully-slatted accommodation. In a similar study comparing the welfare of growing pigs in four intensive housing systems, Lyons et al. (1995) used the same modified de Koning technique. Results from this study found that pigs with straw had significantly lower injury scores than pigs without straw. This may have been due to the beneficial cushioning properties of straw, and also the occupational value of straw, since pigs without straw tended to direct more behaviour towards pen mates than pigs with straw.

Lesion scores of group housed sows in relation to floor space were investigated by Weng et al. (1998). The distribution of lesions was categorised into eight body sections: face and ears, neck, shoulder, central body, udder, rump, tail and vulva. Each lesion in each section was recorded and measured. The severity of damage in each section was categorised from 0–4, according to the total length of the lesions: 0 = none, 1 = 1–3 cm, 2 = 3–6 cm, 3 = 6–9 cm and 4 = >9 cm. The study found that all body regions had the highest count of lesions after sows had been in the smallest pens, with damage levels reducing as pen area increased.

Some researchers have used more simplified scoring systems. In most of these studies the body has been subdivided into different regions, although not as numerous as those in Ekesbo-type methodologies. Gjein (1994) recorded lesions on sows as either present or absent on the vulva, body, head, legs above the feet and shoulder. Bådsgård et al. (1996) proposed a simple and straightforward method of examining skin lesions using a score value from 0 to 3, where 0 refers to normal state, 1 refers to mild clinical symptoms, 2 refers to clinical symptoms with considerable effect on the animal, and 3 refers to severe clinical symptoms and a definite need for corrective action. Olsen (2001) used a 0–2 severity scale to assess skin damage in growing pigs, where 0 = no lesions, 1 = lesions on less than 30% of the skin area, and 2 = lesions on more than 30% of the skin area. Assessing skin lesions post-mixing in weaner pigs, Baumgartner (2005) classified each body region as 0 = without lesion, 1 = few scratches, 2 = many scratches, 3 = abrasion, and 4 = signs of inflammation.

3.2.3 BODY LESIONS – COUNTS

Background

A count of the number of lesions on the body can be a more objective method of assessing body injuries than categorical severity scores. Whilst the latter offers speed and simplicity, it lacks precision.

Validation

Whittaker et al. (1999) compared the level of skin damage in straw-bedded pigs and unbedded pigs by counting the total number of skin lesions on the head and front quarters, middle, hind quarters, tail and vulva. Although levels of aggression were higher in strawed than in unbedded pens, they found no difference in the total number of skin lesions between the treatments.

Aggression in the post-mixing period is well documented. Olesen et al. (1996) found that when pigs were regrouped at weaning, long fights (≥ 10 s duration) were positively correlated with total wounds ($r=0.36$; $P<0.05$). However, there was no significant correlation between total fights and total wounds ($r=0.22$), indicating that long fights were more severe than short fights. D'Eath (2002), measuring the severity of aggressive behaviour received post-mixing, reported that pigs with higher aggressiveness scores (aggressiveness score derived from the number of tests in which each resident pig attacked an intruder) had a greater number of skin lesions.

Erhard et al. (1997) reported that aggressive pigs had a higher number of lesions both immediately after mixing and two days later. Similarly, Spoolder et al. (2000a) found that the duration and frequency of fights in the immediate post-mixing period and skin damage (total lesions) measured on day one after mixing correlated well. However, this was only true when pigs were mixed at 75 kg ($P=0.004$) but not at 55 kg. In a recent study, Turner et al. (2006) found that the post-mixing skin lesion score of growing pigs (total lesions) was significantly correlated with the frequency of reciprocal fights (Farm 1, $r=0.397$, $P<0.001$; Farm 2, $r=0.221$, $P<0.05$) and with the mean fighting bout length (Farm 1, $r=0.388$, $P<0.001$; Farm 2, $r=0.253$, tendency $P<0.1$). On only one farm participating in the study, the frequency of reciprocal fights and mean fighting bout length were significantly correlated ($r=0.360$, $P<0.001$).

Barnett et al. (1996) counted the number of scratches on four body regions of gilts, and also measured the length of the lesions in an attempt to quantify the skin damage. Significant regressions were found between the number and length of lesions and the number of aggressive interactions ($P<0.05$). For example, the mean ($\pm$ SE) number and length of lesions, measured three days after mixing, increased by 1.3 ± 0.57 and 3.0 ± 1.22 cm respectively for each aggressive interaction between 15 and 90 minutes after grouping.

Inter- and Intra-observer Reliability

D'Eath (2005) inadvertently assessed inter-observer reliability when counting skin damage. One observer collected skin lesion counts for two-thirds of groups, with another observer collecting the remainder. Systematic differences between the counts from the different observers emerged during analysis, and so data from the second observer were discarded. Conversely, Turner et al. (2006) reported good inter-observer reliability. Lesions scores (total number of lesions) used in their analyses were recorded by a single observer,

although a second observer also independently lesion scored 48 animals, and scores from the two observers were closely correlated ($r=0.91$, $P<0.001$).

Methodologies Used and Factors Influencing their Outcome

To facilitate the ease of counting lesions in the live animal, many studies have subdivided the body into different regions, using the sum of all the regions for the total score. Luescher et al. (1990) used a slight variation of this, in which each five scratches resulted in a score of one. Scott et al. (2006) compared the level of skin damage in straw-bedded pigs and unbedded pigs by counting the number of lesions on each of seven body regions. They found no difference in skin lesion scores between pigs with or without straw bedding, even though pigs without straw bedding spent significantly more time in pig-directed behaviours. Whilst Spoolder et al. (2000a) found no difference in pen-mate manipulation between bedded and unbedded pigs, they reported a smaller number of skin lesions on pigs without straw. It was considered that differences in skin cleanliness may have influenced this comparison of total lesion count.

Spoolder et al. (2000b), investigating the effects of different stocking densities on the welfare of finishing pigs, used counts of skin damage to indirectly assess levels of aggression. They found that skin lesion scores did not differ between the different stocking density treatments, nor did the amount of pig-directed behaviour. However, Turner et al. (2000) reported that the number of skin lesions on growing pigs was elevated by low space allowance in their study.

Group size can also influence lesion counts. Spoolder et al. (1999) found that the number of skin lesions per pig was significantly affected by group size, increasing with increasing group size. The same study also considered the effects of feeder space allowance on welfare. Whilst no effect of the number of food hoppers was found on the level of skin damage, the total number of aggressive interactions at the food hopper was affected by the number of food hoppers. Feeder related aggression was not affected by group size. Conversely, Turner et al. (2002) observed a significant interaction between feeder space allowance and group size 21 days post mixing. Pigs offered the smallest feeder space and housed in groups of 80 had the highest lesion score, whilst those given a larger feeder space and also housed in groups of 80 had the lowest score. This effect of feeding space was not seen in groups of 20.

Leeb et al. (2001) investigated skin lesions in group-housed pregnant sows using a modified form of the Ekesbo method. Eleven body regions were examined for the presence of lesions, and body regions with injuries (with more than three scratches, longer than 5 cm) were counted and categorised as belonging to either the front or rear part of the body. The study found that the frequency of injuries varied in different body regions, and that bite wounds were positively correlated ($r=0.588$; $P<0.01$) with group size (3 to 40 sows).

Abattoir Assessment of Body Lesions

The Meat and Livestock Commission (UK) (MLC, 1985) have documented a scoring system for assessing lesions on the carcass (Figure 3.1), which involves a score of 1-5 being assigned to the whole carcass, where 1 = unblemished and 5 = severe blemish.

Geverink et al. (1996) scored skin damage in finishing pigs post-mortem after scalding and evisceration. The body was divided into three areas: front (cranial to the caudal point of the shoulder), middle and hind regions (caudal to the hipbone). A four-point scale that took production utilisation (saleable meat) into account was used: 1 = no damage, 2 = slight damage, 3 = skin damage affecting quality, 4 = extreme skin damage with possible rejection of tissue. The study found that skin damage in the hind region was always lower than skin damage in the front and middle regions, and that the amount of time spent in the lairage was significantly associated with skin damage.

3.2.4 DISCUSSION – BODY LESIONS

Many different methods exist for assessing body lesions, ranging from simply recording whether lesions are present or absent, to more detailed investigations involving multiple body locations. Counting and categorising/measuring all lesions on specific body areas has the advantage of precision, whereas simple scoring systems using arbitrary scales are

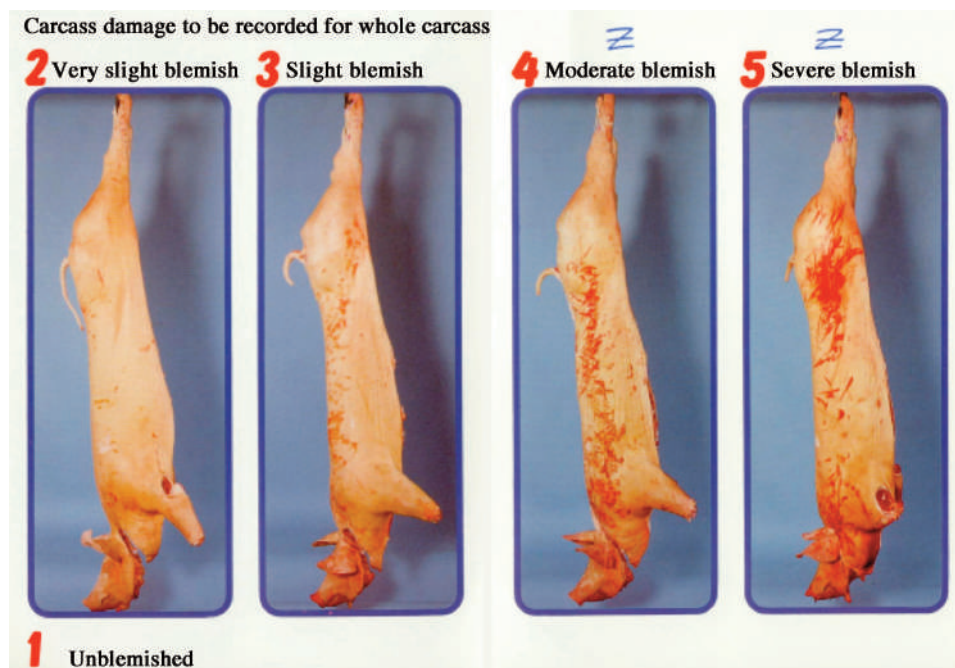


FIGURE 3.1 UK Meat and Livestock Commission's scoring system for lesions on the carcass.

Source: MLC, 1985.

quick and easy to use. However, one must consider the relative trade-off in this process and the ultimate aim of lesion scoring. Skin damage assessments have been well validated with aggressive behaviour around times of high interaction, but associations with long term housing characteristics have been less clear. There is little available literature on inter- and intra-observer reliability, and amongst that which is available, variable conclusions have been reported.

3.3 TAIL BITING

3.3.1 BACKGROUND

Tail biting is a serious welfare problem in modern pig production. It can be difficult to representatively assess over time due to its sporadic and unpredictable nature, and also because it requires the euthanasia of seriously afflicted animals. The vast majority of the available scientific literature detailing tail biting in pigs uses a simple scoring system of yes/no for the presence of a bitten tail; however some researchers have developed qualitative severity scoring methods.

3.3.2 ON-FARM ASSESSMENT

Schmolke et al. (2003), investigating the effects of group size on the performance of growing-finishing pigs, used a five-point severity scale to assess tail biting damage: 1 = no marks on the tail, 2 = some scratches evident on the tail, 3 = open wound with some bleeding, 4 = severe wound and flesh missing from the tail, and 5 = shortened tail stub and swollen. In the interests of the animal's welfare, pigs were removed from the pen when they achieved a score of 4 or 5. The study found that whilst the average tail biting damage scores were similar among the different group sizes, tail-biting injury scores increased throughout the experimental period.

One of the most detailed studies on tail biting severity is that of Zonderland et al. (2003), who assessed tail biting damage according to three parameters: tail length, tail injuries and blood (Figure 3.2). Tail length was categorised using five different classes: 1 = complete tail, 2 = tail almost complete, 3 = $\frac{3}{4}$ to a half tail, 4 = $\frac{1}{4}$ to a half tail, and 5 = less than $\frac{1}{4}$ tail. Tail injuries were classified as: 1 = no visible damage, 2 = small bites and 3 = one or more wounds on the tail. Visible blood on the tail was categorised as: 1 = no blood visible on the tail, 2 = dark brown/black old blood, possibly with a crust, 3 = dark



FIGURE 3.2 Parameters for scoring tail damage.

Source: Zonderland et al., 2003.

red/brown blood that is sticky, 4 = fresh red blood visible on the tail. There is no information available on inter-observer reliability in scoring by these methods.

3.3.3 ABATTOIR ASSESSMENT

The prevalence of tail biting within a population can be most easily assessed in abattoir studies. However, many seriously injured animals are euthanased on farm and are therefore not detected by this approach. A study by Valros et al. (2004) investigated the prevalence of tail damage in slaughter pigs in Finland. After stunning and scalding, the same two observers recorded the condition of tail damage according to its length and state. Tail length was recorded as either normal or short (<10 cm). The state of the tail was classified as: 0 = healthy, 1 = healed tail injury and 2 = fresh tail biting wounds. Healed tails were shorter than normal or otherwise damaged, but the skin of the tail was intact. Freshly bitten tails had fresh wounds with broken skin, as well as infections and swelling in most cases. If a tail was scored as being short and freshly bitten, it was considered to be a case of severe tail biting. Information on a total of 10 852 pigs from 479 farms was collected. The prevalence of total damage was found to be 34.6%, but the majority of this was healed tail damage. No information on inter-observer agreement in scoring was reported.

3.3.4 DISCUSSION – TAIL BITING

Due to its intermittent nature and unforeseeable occurrence, literature on the repeatability and reliability of assessing tail biting damage is lacking. Simply recording tail biting as present or absent is a quick and simple process. However, it may not give a true reflection of the scale of the problem. Qualitative severity scores can provide more information on the nature of the tail biting problem at the time of sampling, for example, whether there are active tail-biters within the pen, or whether tails have healed and there are no fresh outbreaks.

It is known that on some farms injurious behaviour in growing pigs is expressed as ear or flank biting rather than tail biting. However, scientific studies of these phenomena and detailed methodologies are lacking.

3.4 VULVAL LESIONS

In a survey examining risk factors for vulva biting in sows in south-west England, Rizvi et al. (1998) found that 70% of the farms surveyed had reported incidences of vulva biting. Factors shown to increase the risk of vulva biting include group size, feeding once a day, electronic sow feeders, large numbers of sows per drinker, keeping a boar in the same pen and providing water automatically. Whilst tail biting is often regarded as a form of

redirected foraging behaviour, vulva biting is more often regarded as an aggressive act. However, the problem is exacerbated by increased feeding motivation.

Vulva biting can vary from superficial cuts to removal of the whole vulva. Buré (1991) examined the influence on vulva biting of supplying additional roughage in an electronic sow feeder. Six different categories were identified for vulval lesions: 1 cut <1 cm; 1 cut 1–2 cm; >1 cut <2 cm; >1 cut 2–3 cm; >1 cut >3 cm, and cut to pieces. The study found that both the total number of wounded vulvas and the severity of vulva injuries decreased when additional roughage (in the form of straw pellets) was provided. Cuts longer than 3 cm, or severe damage to the vulva were no longer seen. No information on inter-observer reliability in scoring by these methods has been reported.

Documented methodologies for assessing the severity of wounds on the vulva are lacking, although it is a serious concern, with culls due to vulva biting having important economic implications in addition to the associated welfare problems.

3.5 BODY CONDITION IN SOWS

3.5.1 VISUAL ASSESSMENT OF BODY CONDITION

Maintaining an optimal body condition of sows is not only imperative to achieving adequate production levels within a herd; it also improves animal welfare (Maes et al., 2004). Body weight, either absolute weight or weight change, has been shown to be unsatisfactory on its own for determining nutrient requirement of breeding sows, and has been replaced by a visual/palpation scoring system which evaluates the adequacy of the nutrient supply according to body condition score (Whittemore, 1998). The components of a visual score are likely to include: 1, perceived fat cover (roundness) over the rump, loin and back; 2, roundness of the ham; 3, depth of the fully-fleshed ham extending down the leg; and 4, general appearance (Whittemore and Schofield, 2000).

A 1-5 scale for visually assessing body condition of sows has been widely used (e.g. Muirhead and Alexander, 1997; Gatlin et al., 2002; Bracken et al., 2003; Bonde et al., 2004; Maes et al., 2004; Young et al., 2004), where a score of 1 is assigned to a very thin sow, a score of 5 given to a very fat sow, and a score of 3 being the optimal body condition (Figure 3.3). Charette et al. (1996) also employed a 1–5 scale to assess body condition; however, their scale included half-point increments. The extent to which this is justified has not been assessed.

Other researchers have used different scales in the assessment of body condition. Gjein (1994) used a three-point scale, where score 1 was attributed to thin sows, score 2 to

The body condition is assessed using visual scoring (+ palpation) according to a 5-point scale.

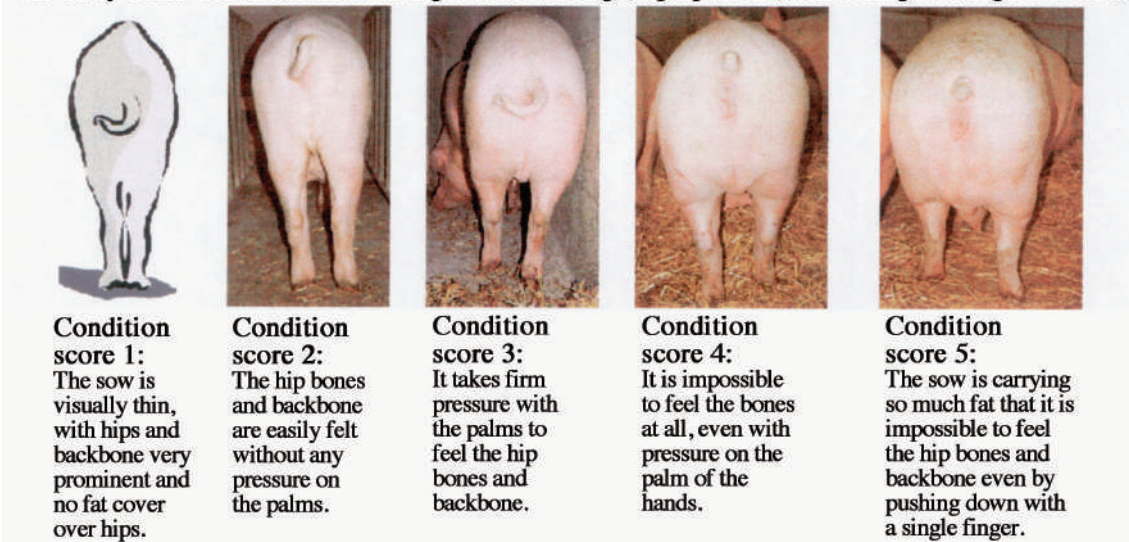


FIGURE 3.3 Visual depiction and description of the widely used 1-5 scale to assess body condition of sows.

Source: MAFF, 1998.

normal sows and score 3 to fat sows. Greer et al. (1991) assessed body condition using a 0-5 scale, whereas Hoffman and Bilkei's (2003) scale ranged from 1-6. In their study, a score of 1 to 2 was regarded as thin, a score of 3 to 4 was regarded as normal, a score of 5 was overweight but acceptable, and a score of 6 was overweight and not acceptable. Ebenshade et al. (1986) used a visual appraisal of body condition ranging from 1 (thin) to 9 (fat). Yang et al. (1989) similarly used a 1-9 scale; sows scoring less than 4 were considered to be in a poor body condition, whilst target condition scores were around 6.

Despite its importance, it is not easy to evaluate body condition in an objective way under practical conditions (Maes et al., 2004). One major shortcoming is that it suffers from the subjectivity of the person scoring (Whittemore and Schofield, 2000; Maes et al., 2004). Charette et al. (1996) considered the repeatability (the agreement between measurements made by the same means, on the same animal by the same observer; intra-observer reliability) and the reproducibility (the agreement between measurements made by the same means, on the same animal by different observers within a short period of time; inter-observer reliability) of body condition scoring of sows. Each sow was evaluated independently by five observers on three occasions on the same day. Repeatability was found to be good; however reproducibility was not. Whilst the average scores were similar between observers, the distributions were quite different between observers.

Other problems with visual body condition scoring include that of a sow which appears to be thin, but still has a fairly high thickness of back fat when measured ultrasonically (Muirhead and Alexander, 1997). Visual scoring may also be influenced by the degree of muscling, and can vary with production stage and parity of the sows (Maes et al., 2004). Inherent variation in conformation between breeds (Whittemore and Schofield, 2000) can

further confound visual assessment of body condition score, and increase the difficulty of the process in herds with more than one breed of sow.

3.5.2 MEASUREMENT OF BACK FAT THICKNESS

The measurement of back fat thickness is a more objective and precise method to assess the body condition of sows (Charette et al., 1996), and can be used as a tool to assess animal welfare (Maes et al., 2004). Simple handheld ultrasonic machines with a digital readout are now available, but have not been fully evaluated for use in sows, as opposed to slaughter pigs. Maes et al. (2004) reported only a moderate correlation between the subjective scoring of body condition and the P2 back fat measurement ($r=0.30-0.60$). Similarly, Young et al. (2004) visually determined body condition score and measured back fat levels at the P2 position. They found that feeding sows in gestation based on back fat level resulted in a numerically higher percentage of sows at farrowing in the target back fat range, and numerically fewer inappropriate sows at farrowing compared with feeding based on body condition score. Feeding based on back fat and weight resulted in a lower proportion of sows too fat at farrowing and a similar percentage of thin sows compared with the visual body condition scoring system. In addition to visually assessing body condition as discussed previously, Charette et al. (1996) investigated a new method of representing body condition based on a principal component analysis of live weight and back fat thickness. They found that repeatability was good, and that reproducibility was consistent. However, the measurement of sow liveweight is not routinely carried out on farms, and requires large specialist equipment.

3.5.3 ABATTOIR ASSESSMENT OF BODY CONDITION

Literature on the assessment of body condition of sows at the abattoir is lacking. The usefulness of such a measure is uncertain, since often cull sows are 'fattened' before sale, and so a true picture of the farm situation might not be obtained.

3.5.4 SUMMARY AND CONCLUSIONS

Visual estimation of body condition of sows is a quick, straight forward process, capable of producing reliable results without the need for specialised equipment. However, it is a subjective measure with potential for significant inter-observer variability, and a measure which can vary with breed, stage of production and parity.

The measurement of back fat thickness provides a more objective and precise assessment of body condition, and can be a valuable tool in monitoring and improving health, welfare, productivity and efficiency within the breeding herd. One should, however, consider that this technique requires specialised equipment and handling facilities, and takes longer to complete.

3.6 OVERALL DISCUSSION

Once the Welfare Quality scheme is operational, assessors are likely to have to complete their on-farm assessment within one day, monitoring not only clinical scoring, but all the other aspects of the Welfare Quality protocol in addition. Therefore, when discussing proposals for the on-farm assessment, it is crucial that these are feasible within the time and resource constraints. Methodologies such as those of de Koning (1985) and Boyle et al. (2000), where lesions at 52 and 34 different body locations respectively were assessed, undoubtedly provide a detailed reflection of skin damage for a given animal. However, such methods are totally infeasible for routine on-farm welfare assessment due to the time necessary for completion. Similarly, methods such as those of Weng et al. (1998) and Buré (1991), where the severity of the lesion was categorised according to length, are also infeasible for the same reason. Whilst ultrasonic measurement of back fat in sows may be more objective and precise than visual body condition scoring, specialist equipment and handling facilities are required, both of which have implications for cost, time and biosecurity in transfer between farms.

3.7 OVERALL CONCLUSION

Review and discussion of the different methodologies that have been documented for clinical scoring indicated that very few methodologies had information on repeatability and inter- and intra-observer reliability. The feasibility (e.g. speed, precision) of the methods was considered, and viewed as one of the most important factors, since no matter how precise and objective the methodology is, if it cannot be conducted with relative ease, in widely varying facilities and within a reasonable time period, it will not be suitable for an on-farm welfare assessment scheme. It was agreed that although precisely how each measurement should be taken would vary from parameter to parameter, all should be assessed using a common 0–2 severity scale. The qualifying description for each point on the scale is specific to the individual parameter, however for all parameters, a score of 0 is indicative of acceptable welfare, a score of 1 indicates that there has been some

compromise of welfare, and a score of 2 indicates a serious and unacceptable welfare problem. Farms can then be classified by the proportion of animals or pens falling into each of these categories. It is proposed that the 0–2 scale will simplify matters for both the assessor on the farm, and also for the farmer, who at a glance, will be able to identify in which specific systems the welfare level on his/her farm is unacceptable.

VALIDATION OF BEHAVIOUR AROUND RESTING IN PIGS

K. Scott, J.H. Guy and S.A. Edwards

4.1 SUMMARY

Two potential categories of measurement for comfort around resting were identified. 1) Resting posture – sitting, sternal, semi-lateral or lateral recumbency – which might indicate the physical comfort of flooring, but also reflect thermal comfort. 2) The ease with which posture changing occurs – the time taken to change from one posture to another and the extent of slipping in this process may indicate the adequacy of floor type to give security of movement, and/or the mobility of animals after resting on floors differing in comfort. To validate these measures, the behaviour of growing pigs when housed on fully slatted, part slatted (solid concrete lying area) and deep straw bedded flooring was compared. The prevalence of skin lesions and pressure injuries (e.g. bursitis) were used as validation measures of discomfort.

The measures of resting posture did not show good validity. There was no significant correlation of any posture measure with lesions or bursitis resulting from floors giving different levels of support and cushioning. Posture measures were shown to be influenced by age of pig within the finishing period, and to show a diurnal pattern which was not necessarily consistent between different environments. It was also shown that assessment during a one hour period was not always representative of behaviour over a more extended period. For these reasons, this measure is not recommended for use in on-farm assessment. The time taken to complete the standing to lying transition did show good indications of validity. It differed between floor surfaces giving different levels of support and cushioning, and was correlated with lesion and bursitis scores. Although the behavioural measure is feasible, the same information may be obtained more easily from such physical scores.

It is concluded that it would be better to use a physical indicator of comfort rather than a behavioural measure, since this would be quicker to measure and less prone to other influencing factors. The prevalence of bursitis is suggested as the preferred animal-based measure of floor comfort. This work focused on the growing/finishing pig as the best test system for the measures, but it is likely on the basis of the literature that the results will

translate to sows. Pressure from hard floors is likely to cause less discomfort in lighter weight pigs.

4.2 GENERAL INTRODUCTION

The aim of this study was to assess the validity of behaviours around resting as indicators of comfort and thus welfare of pigs. As the remit was for validation, only limited assessments of reliability and repeatability have been carried out.

A review of the scientific literature on resting behaviour was conducted that considered the methodologies used previously by different researchers, and whether these have been validated and assessed for inter- and intra-observer reliability. This was carried out in order to define possible measures and select appropriate candidates for experimentation. Two potential categories of measure were identified.

a) Resting behaviour

Two components of resting behaviour can be considered. The first is the resting posture – sitting, sternal, semi-lateral or lateral recumbency. This might indicate physical comfort of flooring, but also reflects thermal comfort. The second is the duration of resting behaviour as diurnal pattern or bout length – indicative of restlessness or discomfort

Whilst the former can be carried out on a reasonable timescale by scanning ongoing behaviour, the latter by definition would require substantial observation time. This could only sensibly be done by video recording, making it unsuitable for single visit assessment of farms.

b) Posture changing behaviour

Two components of posture changing behaviour can be considered. The first is the ease with which posture changing occurs – time to change from one posture to another, and extent of slipping in this process. This might indicate adequacy of floor type to give security of movement, and/or the mobility of animals after resting on floors differing in comfort. The second is the frequency of posture changing – indicative of restlessness or physical discomfort.

Whilst the former can be carried out on a reasonable timescale, the latter by definition would require substantial observation time. Since it is also very likely to be sensitive to time of day and/or point in the diurnal activity cycle on any given farm, posture changing frequency during a short observation period is extremely unlikely to provide a reliable

index. Assessment could only sensibly be done by video recording over a long (ideally 24h) period of time, making it unsuitable for single visit assessment of farms.

In looking at validation of these potential measures, the approach taken was to look at the behaviour of pigs when housed on floor types which previous scientific studies suggest would differ in the degree of comfort they provide. This was based on studies of pig preference and of physical injury incurred. There has recently been an extensive review of flooring for pigs by an EFSA working group of the Scientific Committee on Animal Health and Welfare (EFSA, 2005). Beattie et al. (1998) reported that pigs given the choice between various floor types spent more time on straw than concrete. This preference has been shown in a number of experiments, but is only expressed at or below thermoneutral conditions. Choice experiments on bedded vs. unbedded floors show a clear preference for pigs to lie in straw at low or normal ambient temperatures, and on bare concrete as temperature increases (Fraser, 1985; Marx and Mertz, 1989; Ducreux et al., 2002). There is also evidence that finishing pigs prefer to lie on a solid floor, compared to slatted floors (e.g. Steiger et al., 1979; Dregus, 1977; Schmid, 1993; Aarnink et al., 1993).

In assessing the relative physical comfort of the pig on different floorings, behavioural measures such as the frequency of different resting postures adopted by pigs can be validated against physical measures such as the prevalence of skin lesions and adventitious bursitis on the legs. An adventitious bursa is an acquired fluidfilled sac, which develops as a result of pressure in the subcutaneous connective tissue, where a natural bursa is not normally present (Moultotou et al., 1999). The lesions can remain as fluid filled sacs or become solid after a marked formation of granulation tissue. Pigs on softer flooring without abrasive surfaces or edges have been shown in many experiments to exhibit fewer signs of physical trauma (Lyons et al., 1995; Guy et al., 2001; Scott et al., 2006). The extensive work of Smith (1992) showed that there was an association between pigs with bursitis and rearing on hard floors. In later survey data, Moultotou et al. (1998, 1999) again showed that the risk of bursitis increased as floor type progressed through deep straw, sparse straw, part-slatted and fully slatted flooring.

Therefore in carrying out these studies, behaviour of pigs on fully slatted, part slatted (solid concrete lying area) and deep straw flooring was compared. The prevalence of skin lesions and pressure injuries (e.g. bursitis), were used in combination with long term duration and bout length of resting behaviour (or frequency of posture changes) as validation measures of discomfort.

4.2.1 1 RESTING POSTURE AS AN INDICATOR OF FLOOR COMFORT

Introduction

Pigs have been shown to spend 80% of their time resting, and during this time more than 60% of lying pigs adopt a fully recumbent position (Eckel et al., 2003). Therefore, it can

be suggested that lateral recumbency may indicate the highest degree of comfort. Boyle et al. (2002) stated that less lateral and more ventral (sternal) lying can be indicators of stress. However, using absolute measures of different lying postures may be misleading, since levels of activity can differ on different floor types for reasons other than comfort. For example, pigs with straw bedding show less time lying because of greater environmental stimulation (e.g. Lyons et al., 1995; Scott et al., 2006). It may therefore be more relevant to look at the relative frequency of different lying postures, rather than their absolute frequency.

Another posture often associated in the literature with floor types believed to offer less comfort is dog-sitting. Pigs weaned on to flat-deck cages more frequently sit in a dog-like position and are less inclined to rest in the normal lying position than those on straw (Fraser and Broom, 1990). Similarly, growing pigs on fully slatted floors show greater prevalence of dog-sitting (e.g. Lyons et al., 1995; Scott et al., 2006). The objectives of this study were therefore to determine whether the absolute or relative frequencies of dog sitting or different lying postures differ between floor types, whether validation measures of leg lesions and bursitis differ between these floor types, and finally whether lying posture frequencies correlate with these physical injuries.

The hypotheses for this work were (i) that pigs on straw will demonstrate reduced sitting and increased fully lateral recumbency when resting, compared with those on other surfaces, due to increased comfort. (ii) that pigs in part slatted pens, with a solid lying area, will demonstrate reduced sitting and increased fully lateral recumbency when resting, compared with those on fully slatted floors. (iii) that these differences in lying posture will correlate with leg lesion and bursitis scores.

Methods

Animals and housing

Groups of 7-9 Large White x Landrace finishing pigs, with a mean weight of around 60 kg, were assigned to pens of each floor treatment. Three floor treatments were used that were representative of key commercial pig farming practices: Part-slatted, fully-slatted and deep straw-bedded. Four replicate pens were studied per floor treatment at each of two time points during the finishing period, at approx 70 kg and 100 kg liveweight.

- (1) Part-slatted (PS): each pen was made up of a solid concrete 'lying area' with a concrete slatted dunging area. Slat width measured 80 mm with a gap of 20 mm between slats.
- (2) Fully-slatted (FS): each pen consisted of only a concrete slatted area. Slat width measured 83 mm with a gap of 20 mm between slats.
- (3) Straw (ST): each pen consisted of a raised concrete feeding area, and a solid concrete lying area which was deep bedded with straw to a depth of 15–20 cm.

Skin lesion inspections

A bursitis scoring system followed that outlined by Lyons (1995) and a lesion scoring system was designed following a preliminary study that considered the prevalence and nature of leg lesions on commercial pigs (Table 4.1). Lesions were scored for each leg for the upper, middle (hock) and lower section, and for the accessory digit and claw (upper surface only). Classification of a lesion was as follows: (a) Graze: the epidermis is scratched and reddened (b) Wound: where the epidermis is penetrated and open (modification of Boyle et al., 2000) (c) Healed wound: an open wound that has healed as a result of granulation.

Behavioural observations

Observations of lying behaviour were made using 24-hour time-lapse videos (Panasonic AG216 time lapse VCR and a Panasonic WJ-FS 216 Multiplexer). At 10 minute intervals over a 24 hour period, the number of pigs adopting the following behaviours in each pen was recorded: Sternal lying, lateral lying, semi-recumbent lying, standing and sitting. Definitions of postures shown in Table 4.2 were modified from Boyle et al. (2002).

Statistical analyses

Lesion and bursitis score data were first averaged for left and right legs at each score point, and subsequently averaged across all score points to give a composite score for the front and hind legs. For analysis, mean value for all pigs within a pen was calculated, and the

TABLE 4.1 Classification and evaluation of lesions and bursitis.

Score	Definition of lesions	Definition of bursitis (after Lyons, 1995)	Further explanation of bursitis
0	No graze	No bursitis	
1	1 graze	Small raised swelling	The size of a grape
2	2 grazes	Moderate swelling	The size of a walnut
3	> 2 grazes	Fairly extensive swelling	1 bursa > walnut size and ≤ grapefruit size
4	wound (healed)	Very severe swelling	The size of a grapefruit
5	fresh wound	Eroded bursa with infection	Bursa of any size with infection

Note: a separate score was given for lesion and bursitis at each region of each leg.

Table 2. Classification of postures recorded during 24-hour observations at 70 kg and 100 kg.

	Posture
Sternal	Lying on sternum/belly with front legs extended forwards, or all legs tucked under the body.
Lateral	Lying on the side with all 4 legs extended.
Semi-recumbent	Half lying on side; weight distributed between legs and body.
Standing	Body supported by all 4 legs in an upright position.
Sitting	'Dog sitting' posture: sitting on the flanks with front legs extended and on the floor.

Source: adapted from Boyle et al., 2002.

pen used as the statistical unit. The effects of floor, liveweight and time of day on posture frequency and lesion scores were tested using a general linear model and paired comparisons were made with a Tukey test (Minitab Release 13.1). Pearson's correlations were used to analyse the relationship between lesions and lying postures, and lesions and bursitis score.

Results

Did floors show the predicted difference in lesion scores and bursitis?

Mean lesion scores in this study were relatively low, ranging from 0-1 across all systems. The most significant effect of floor type on score value was seen between the straw system and the fully-slatted system on the lower fore, fore accessory digit, hind hock, lower hind, hind accessory digit and hind claw ($P < 0.01$). Middle fore lesions also differed significantly between these two systems ($P < 0.05$). A significant difference was also observed between straw and part-slatted on the lower fore, fore accessory digit, hind hock and lower hind ($P < 0.01$) and hind accessory digit and hind claw ($P < 0.05$). There was also a significant difference between these systems on the upper fore ($P < 0.05$), which was not seen between straw and fully-slatted. Mean scores for straw were lower than those for part-slatted and fully-slatted apart from on the fore claw, where it was not significantly different to the other systems. No significant difference between lesion score on part-slatted and fully-slatted systems was observed apart from on the hind accessory digit ($P < 0.05$).

The score points were averaged in order to gain composite values for front legs and hind legs. Mean scores were highest on fully-slatted flooring and lowest on straw (Figure 4.1). Scores for part-slatted and fully-slatted systems were not significantly different ($P > 0.05$). Scores for straw were significantly different to both part-slatted and fully-slatted conditions ($P < 0.05$).

In general, bursitis scores were quite low in this study across all systems. For front upper bursitis and hind upper bursitis there was no significant difference between systems ($P > 0.1$). However, there were significant differences for front middle bursitis and hind hock bursitis ($P < 0.01$) between part-slatted and fully-slatted systems and straw and fully-slatted systems.

The score points were averaged in order to gain composite values for front legs and hind legs. For hind leg bursitis, scores from fully-slatted pigs were significantly worse than from pigs in part-slatted and straw systems (Figure 4.1) ($P < 0.05$). However, for fore leg bursitis, there was no significant difference between part-slatted and fully-slatted systems, and part-slatted and straw ($P > 0.05$), but there was a significant difference between fully-slatted and straw ($P < 0.05$). A significant, positive association was found between bursitis and foot lesions ($r = 0.652$, $p < 0.001$), but not between bursitis and other lesion scores.

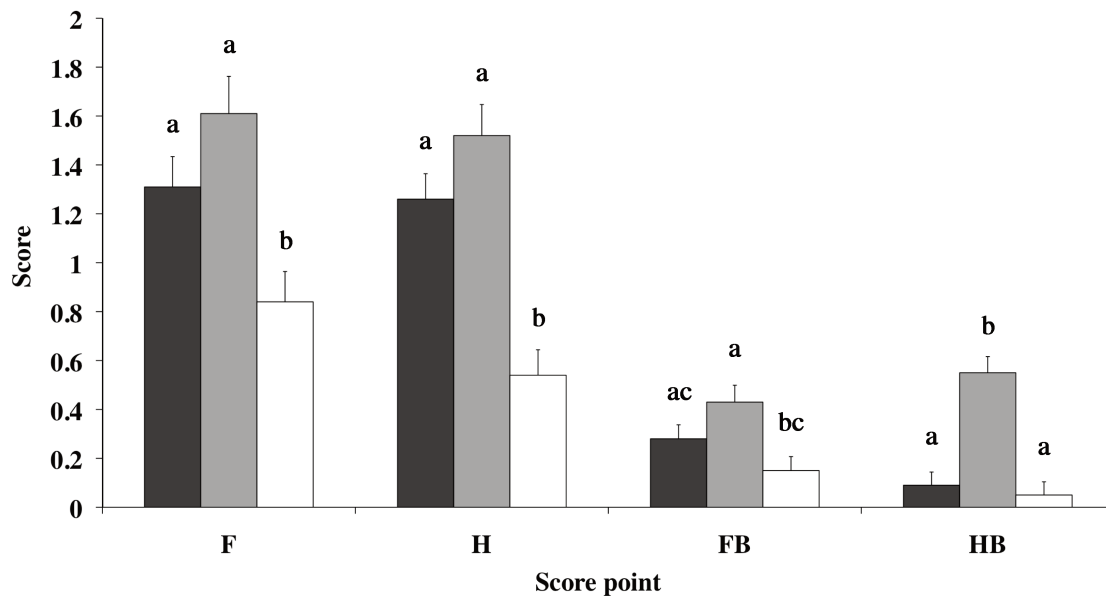


Figure 1. Mean lesion score and mean bursitis score at each score point.

Notes: Lesion score for fore legs (F), Lesion score for hind legs (H), Bursitis score for fore legs (FB) and Bursitis score for hind legs (HB) on different floorings: ■ Part-slatted; ■ Fully-slatted; □ Straw. Means accompanied with different letters within each score group differ significantly ($P < 0.05$).

Did resting posture differ between floor types?

At 70 kg, pigs were lying for 79.0% of observations on part slats, 82.9% on full slats and 81.9% on straw. At 100 kg, values were 84.1% on part slats, 84.2% on full slats and 82.7% on straw.

At 70 kg, the effect that floor had on sternal lying was not significant ($P > 0.1$) (Figure 4.2). The highest percent of lateral lying was found on the part-slatted system and the effect floor had on this posture was significant ($P < 0.01$). A higher percent of pigs lay semi-recumbent on fully-slatted flooring and the effect floor had on such lying was also significant ($P < 0.05$).

At 100 kg there was a significant effect of flooring on sternal, lateral ($P < 0.05$) and sitting postures ($P < 0.01$) (Figure 4.3). The highest percent of sternal, semi-recumbent and sitting, and the lowest percent of lateral lying, was observed in the fully-slatted system. However, there was no significant effect of flooring on percent standing ($P > 0.05$).

Is resting posture influenced by liveweight?

There was an increase in the mean percent of pigs lying laterally between 70 and 100 kg ($P < 0.001$) (Table 4.3). Mean percent lying and mean percent of total lying in the lateral position increased with increasing weight across all systems ($P < 0.001$). There was no significant interaction between floor and weight for any posture ($P > 0.1$).

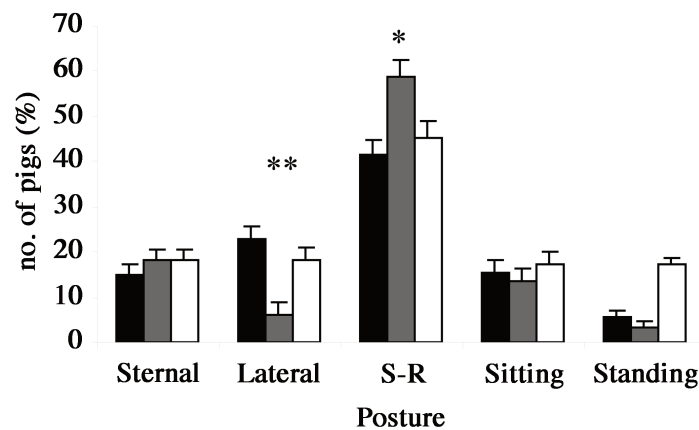


FIGURE 4.2 Percentage of pigs (mean + S.E.) in each posture over a 24 hour observation period at 70 kg on different floorings.

Notes: ■ Part-slatted; ■ Fully-slatted; □ Straw.

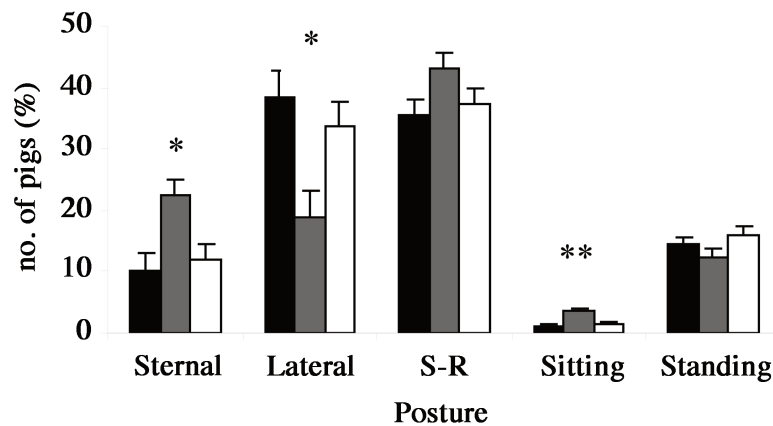


FIGURE 4.3 Percentage of pigs (mean + S.E.) in each posture over a 24 hour observation period at 100 kg on different floorings.

Notes: ■ Part-slatted; ■ Fully-slatted; □ Straw.

TABLE 4.3 Mean percentage of pigs in each posture for each floor system at 70 kg and 100 kg.

	Part Slatted		Full Slatted		Straw		S.D	Significance		
	70 kg	100 kg	70 kg	100 kg	70 kg	100 kg		Floor	Weight	Floor x weight
Sternal	15	10	18	22	18	12	2.59	*	ns	ns
Lateral	23	38	6	19	18	34	3.54	***	***	ns
Semi-recumbent	41	35	59	43	45	37	3.15	**	***	ns
Sitting	15	1	14	4	17	1	1.95	ns	***	ns
Standing	6	14	3	12	1	16	1.72	ns	***	ns
Total lying	80	84	83	84	82	83	1.45	ns	ns	ns
Mean % lying in lateral	29	46	7	22	23	41	4.21	***	***	ns

Notes: Total lying = sternal+lateral+semi-recumbent; Mean % lying in lateral = (lateral % /total lying%)*100.

Is the influence of floor on resting posture affected by time of day?

The 24-hour period was split into day (07.00–18.50) and night (19.00–06.50). At 70 kg, the effect floor had on posture showed a significant interaction with time of day for lateral, standing, total lying ($P<0.001$) and percent of total lying in lateral posture ($P<0.01$). This interaction was due to an apparent anomaly on the part-slatted system, which showed that pigs on part-slatted flooring lay more during the day than at night and stood more at night. The data for this flooring were checked at all levels of analyses, nevertheless no mistakes were found. Pigs on straw lay more at night and more pigs also adopted a lateral position at night than all other systems, but during the day the lowest percentage of pigs lying were recorded on straw. Those on the fully-slatted treatment showed the highest percent of sternal lying at night and also semi-recumbent lying.

At 100 kg, the effect floor had on posture again showed significant interactions with time of day ($P<0.05$). Part-slatted flooring showed a higher mean percent lying in lateral posture during the day, which was in contrast to the other two conditions where more of this lying posture was viewed at night. A greater percent of pigs lay sternally on the fully-slatted floor in both the day and night compared to the other systems. The highest mean percent standing during the day was observed on straw. This resulted in a significant effect of time on percent standing ($P<0.001$) and also a significant interaction between floor and time period on percent standing ($P<0.05$).

Does a short term lying posture reflect the longer term pattern of the pen?

The correlations between assessments made for each hour of the day with the full 12h daytime mean were calculated. A summary of these correlations is given in Table 4.4. Sitting prevalence was poorly assessed in a limited time period, as was the proportion of total lying time which was in the lateral posture. However, a one hour period seemed adequate to provide a representative estimate of the total time in lateral lying.

Does lying posture relate to lesion and bursitis score?

There appeared to be no significant relationship between percentage of pig observations in each posture and mean lesion scores ($P>0.1$, Table 4.5). There was also no significant relationship between posture and hind limb bursitis ($P>0.1$). However, there was a low but significant relationship between mean fore limb bursitis ($P<0.05$) and percent lying. Generally, all r values were around zero, suggesting that there was limited or no correlation between tested factors.

Discussion

In this study, pigs on straw showed increased levels of activity. This was shown by both a higher number of pigs standing over 24 hours and a higher percent standing during the daytime compared to the other systems. This confirms Tuytten's (2005) theory, that increased lying can be an indicator of lack of stimulation in the surrounding environment.

TABLE 4.4 Correlations between assessments made for each hour of the day with the full 12h day mean for different resting postures (combined results for 70 and 100 kg).

	Sitting %	Lateral %	Total lying %	% Lying in lateral
Correlation co-efficient (r)	-.42-.12	.51-.77	-.16-.78	-.23-.45
range				
No. of significant (P<.05) correlations/12 daytime hours)	1/12	12/12	7/12	3/12

TABLE 4.5 Pearson's correlation values (r) between injury mean scores and defined postures across all systems.

	Sternal		Lateral		S-R		Sitting		Standing		Total lying		%lying in lateral	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Mean F	.14	.45	.04	.87	-.10	.66	-.22	.30	.18	.39	.14	.52	.02	.94
Mean H	.11	.61	-.04	.84	.02	.92	-.17	.42	.13	.54	.10	.62	-.06	.77
Mean FB	.06	.80	-.12	.58	.26	.21	-.07	.76	-.13	.54	.45	.03	-.14	.50
Mean HB	.24	.26	-.24	.27	.26	.23	-.16	.44	.04	.86	.31	.14	-.26	.22

Notes: F = Fore legs, H = Hind legs, FB = Front bursitis, HB = Hind bursitis. Total lying = sternal+lateral+semi-recumbant and Mean % lying in lateral = (lateral %/total ly-ing%)*100. S-R = semi-recumbent.

Increased activity can be linked to the fact that pigs on straw are exposed to a high degree of environmental enrichment due to the presence of a manipulable material. Lyons et al (1995) reported that the mean percentage of time lying within a 24-hour period was greater for pigs on slats than those on solid concrete flooring, with or without bedding. Such findings were mirrored in this experiment, where a higher percent of pigs was observed lying in the fully-slatted system at both weights compared to the other two test floors. This suggests that lying time may also be an indication of floor comfort, with pigs on less comfortable floors possibly being more reluctant to change posture.

There was a significant interaction between floor and time period on postures adopted. This arose due to the fact that 70 kg pigs on part-slats produced anomalous results. Results showed that pigs stood more at night and lay down more during the day. This is contrary to results shown on fully-slatted floors and on straw, and also results in the scientific literature, which state that although pigs rest for a considerable proportion of the day, during the night more than 90% of pigs are shown to rest (Ekkel et al., 2003). As a result, limited time sampling of lying behaviour at any particular time of day must be viewed with caution because of the possibility of atypical diurnal patterns in some situations.

This study hypothesised that lateral lying indicated a higher degree of comfort compared to other resting postures. There was a significant increase in percentage of pigs lying in lateral posture with increased weight. Whilst this overall increase in lateral lying could be due to an increase in subcutaneous fat cover, resulting in a greater degree of cushioning, the greater severity of pressure bursae would not indicate greater comfort. Over 24 hours, at 100 kg, more pigs lay sternally and less laterally on full-slats, which might suggest that reduced 'comfort' of the floor did not encourage such lying. The interpretation of lateral

lying in relation to comfort may therefore need to be qualified by liveweight correction factors.

Lying posture is strongly linked to critical temperature (Huynh et al., 2005). Such a value is related to food intake (generating heat internally), size of the animal (surface area: volume), number of pigs in the group and the thermal conductivity of the flooring. Pigs on straw will generally feel 5 °C warmer than those on slats due to the increased insulation from the floor, which enables them to conserve heat (Morgan et al., 1998). The interpretation of lateral lying in relation to comfort will therefore need to be qualified by temperature correction factors.

The physical characteristics of the surface, such as abrasiveness, slipperiness and hardness can also play a part in damaging the feet and limbs (Moultotou et al., 1998). Lesions are a reflection of the abrasive nature of the floor and presence of bursitis shows a floor that is unyielding under pressure. The three floor types under analyses in this study all have varying qualities, which may involve one or a combination of these factors. In general, animals on the straw system had significantly lower lesion scores compared to the other two systems; however this was less marked in the upper leg region. Pigs on full and part slats were found to have significantly worse lesions on score points on the lower areas of the legs than animals housed on straw.

In this study, the effect of flooring on bursitis score was only significant on the middle score region of the front leg and hind hock region. Such results were expected due to the fact that bursitis is most common and as a result most researched on the hind hock region (Moultotou et al., 1998). When score points were combined to give means for front and back legs separately, the effect floor had on bursitis was only significant for the mean hind bursitis score. Pigs housed on straw had a significantly lower score than those on full slats. Moultotou et al (1998) also found evidence that pigs on part-slatted and full slatted flooring had a higher prevalence of bursitis and pigs on straw had lower prevalence. Bursitis scores on the full slats were significantly worse than those on part-slats (as seen by Smith and Taylor, cited in Moultotou et al., 1998) at front middle and hind hock and hind legs combined. A pig lying on full slats has to support its weight on a smaller surface area than when lying on a solid floor (Moultotou et al., 1998.) As a result there is an increase in pressure on weight-bearing points. This increases the trauma to superficial lymphatic vessels, thus causing the development of bursae.

The lack of a significant correlation between resting posture and lesion/bursitis score fails to provide good validation of this behavioural measure as an indicator of comfort.

4.2.2 POSTURE CHANGING BEHAVIOUR AS AN INDICATOR OF FLOOR COMFORT

Introduction

The ease with which posture changing occurs can be measured as the time to change from one posture to another, or the extent of slipping and injury in this process. This might indicate adequacy of floor type to give security of movement, a more dynamic aspect of comfort, and/or the mobility of animals after resting on floors differing in comfort. Standing and lying behaviours consist of a predictable sequence of movements, with stages between movements when the animal can pause in a relatively stable transition state. For example, lying down comprises three main stages (Anil et al., 2002): kneeling, sliding one leg forward and rotating front part of the body to rest the shoulder on the floor, and lowering of the hindquarters onto the floor. It has been suggested in sows that the duration of one or more of these stages might be sensitive to both animal and environmental factors (Marchant and Broom, 1996; Boyle et al., 2002). However, no information has been found in the literature regarding growing pigs.

Methods

The same 3 floor types as used in the first part of this chapter were studied. At approximately 100 kg liveweight, a portable digital camera was used to take real time records of the pigs in each pen during posture changing between standing and lying, and between lying and standing. The film was analysed with Windows Media Player, which allowed for 0.04s time frames to be analysed, and stage timings were obtained.

For analysis of posture changes, the individual stages reported by Baxter and Schwaller (1983) were used.

Standing to lying transition:

- Stage 1 One front limb is lifted and placed onto the floor so that the finisher drops to a half-kneeling position. The second is the lifted, placed onto the floor, and the finisher drops into a full kneel.
- Stage 2 The finisher may pause before movement continues.
- Stage 3 The finisher slides one knee forward along the floor and rotates the upper part of the body to bring a shoulder and side of head to rest onto the floor.
- Stage 4 Again, the finisher may pause before movement continues.
- Stage 5 The finisher lowers hindquarters and rotates slightly causing the rear legs to slide sideways. The hindquarters then drop so that the upper thigh of one limb lands on the floor.

Lying to standing transition:

- Stage 1 The finisher rises up onto their fore knees and pushes up with their forelimbs one after the other, rising to a sit.
- Stage 2 The finisher may pause before continuing movement.
- Stage 3 The finisher lifts its entire hindquarters off the floor, into a full standing position, in one single motion.

Statistical analyses

The times for each stage of posture transition, and total time for completion of the transition, were averaged within pen. The effects of floor type were then investigated by analysis of variance with pen as the statistical unit.

Results

Does floor type affect posture changing behaviour?

A significant effect of floor type was observed on the total amount of time taken to change posture from a standing position to a lying position (Figure 4.4).

Timings of the individual stages of the transition from standing to lying also showed significant floor effects (Table 4.6).

There was a significant positive correlation between the total time for the standing to lying transition and the time taken for each of the individual stages which showed significant differences between floor types (Stage 1: $r = 0.804$, $P = 0.002$; Stage 3: $r = 0.907$, $P < 0.001$; Stage 5: $r = 0.918$, $P < 0.001$), indicating that these measures were interchangeable.

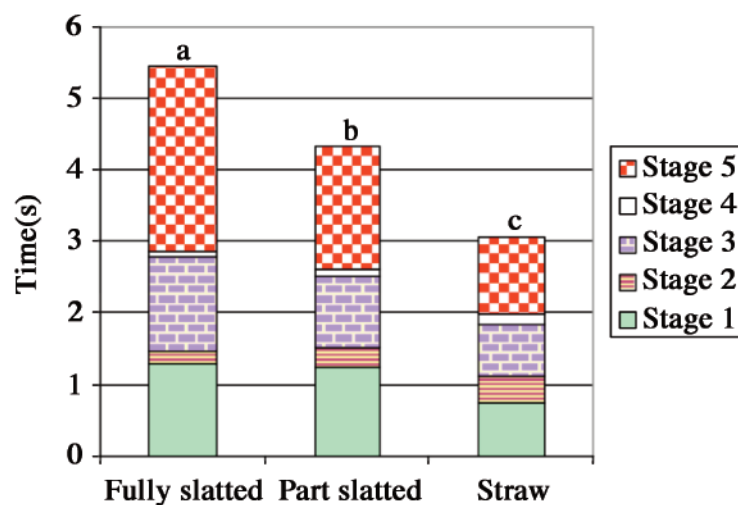


FIGURE 4.4 The mean total time taken for the transition from standing to lying on different floor types.

TABLE 4.6 The effects of different floor types on the mean timings (s) for each of the five stages comprising the transition from standing to lying.

Transition stage	Fully-slatted	Straw	Part-slatted	S.E.M	Significance
Stage 1	1.28a	.72 b	1.23 a	.062	***
Stage 2	.18	.40	.27	.131	ns
Stage 3	1.33 a	.70 b	1.02 a,b	.121	*
Stage 4	.08	.16	.08	.031	ns
Stage 5	2.57 a	1.09 b	1.73 c	.143	***
Total time	5.43 a	3.06 b	4.34 c	.276	***

There were no significant effects of floor type on the total amount of time taken to change posture from lying to standing (Figure 4.5), although Stage 3 of this transition was significantly longer for pigs on fully-slatted pigs than pigs on straw or part-slatted floors (Table 4.7).

There was a significant positive correlation between the total time for the lying to standing transition and the time taken for Stage 1 of the transition ($r = 0.957$, $P < 0.001$), and also for Stage 3 ($r = 0.824$, $P = 0.001$), which showed significant differences between floor types.

For the standing to lying transition, the cumulative frequency of the total time taken to lie down for each floor type was plotted (Figure 4.6). This showed that on straw bedded flooring, the great majority of pigs completed the transition within 5 seconds of initiation. In contrast, only 60% of pigs on fully slatted floors did so.

Does the ease of posture change relate to lesion and bursitis score?

Lower leg and claw lesions and mid leg (hock) bursitis scores were moderately but significantly correlated with the total amount of time taken for the transition from standing to lying. For the transition from lying to standing, few significant correlations with physical injury were seen (Table 4.8).

Discussion

The duration of the transition from standing to lying gave a measure which differentiated between floorings giving different levels of support and cushioning. A more detailed investigation of the individual stages within the transition did not indicate that any of these would be more informative than the total duration. The latter is much easier to measure, requiring no subjective opinion on the exact timing of each phase.

The duration of the lying to standing transition was much less informative, which might reflect the existence of different types of standing seen in normal standing and as an alarm response (Marchant and Broom, 1996). Such variability with circumstances renders this a less useful measure in limited observation time.

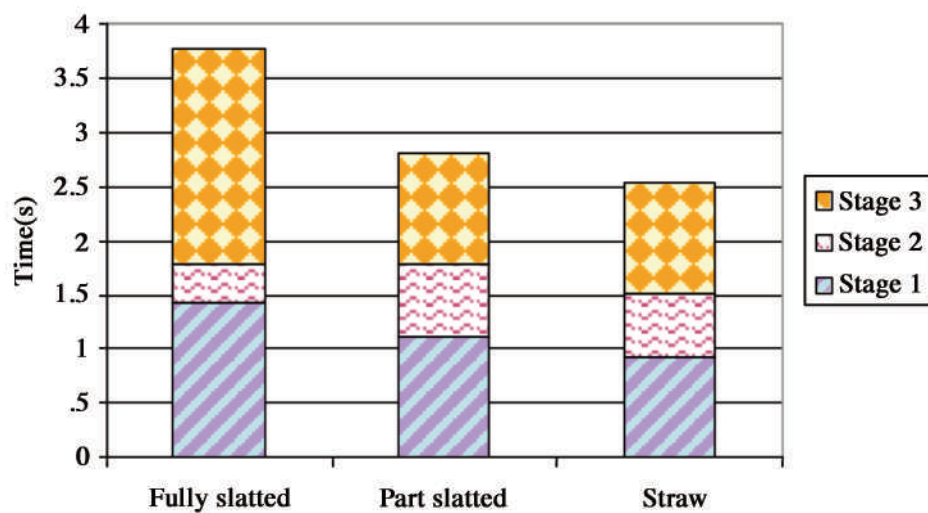


FIGURE 4.5 The mean total time taken for the transition from lying to standing on different floor types.

TABLE 4.7 The effects of different floor types on the mean timings (s) for each of the three stages comprising the transition from lying to standing.

Transition stage	Fully-slatted	Straw	Part-slatted	S.E.M	P-value
Stage 1	1.42	.92	1.11a	.184	ns
Stage 2	.36	.60	.67 b	.151	ns
Stage 3	2.00	1.01	1.03b	.142	**
Total time	3.78	2.54	2.81	.427	ns

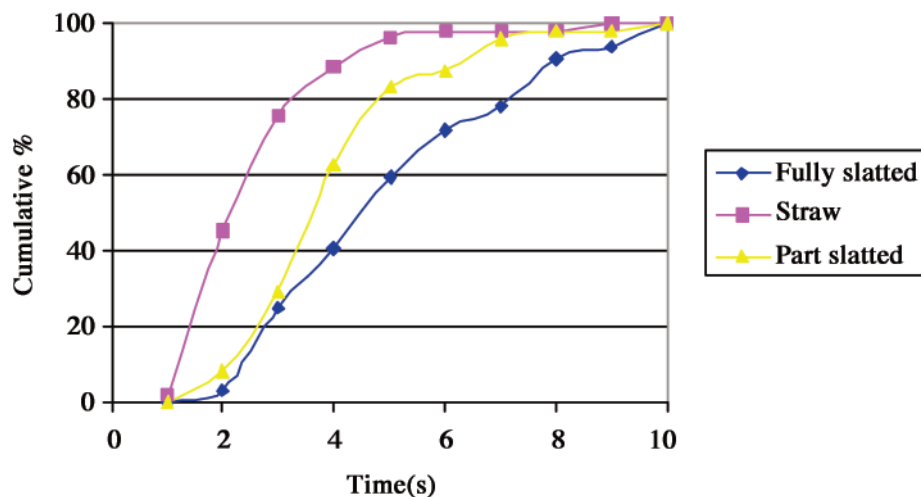


FIGURE 4.6 The effects of different floor types on the cumulative percentage of pigs completing the transition from standing to lying within different times.

Whilst a speedy transition from standing to lying might be taken to reflect either good confidence and control, such as provided by a cushioned floor with good grip, or a total lack of control, such as results from a slip and fall, the observations made and correlations

TABLE 4.8 Correlations between injury scores on the legs and the total time taken for the transitions from standing to lying and from lying to standing.

	Total time for transition from standing to lying		Total time for transition from lying to standing	
	r	P	r	P
<i>Leg lesions:</i>				
Fore mid leg	.377	ns	.224	ns
Fore lower leg	.863	<.001	.572	.052
Fore accessory digit	.852	<.001	.529	.077
Fore claw	.699	.011	.176	ns
Hind upper leg	.026	ns	-.136	ns
Hind hock region	.183	ns	.364	ns
Hind lower leg	.287	ns	.206	ns
Hind accessory digit	.624	.030	.562	.057
Hind claw	.602	.038	.206	ns
<i>Bursitis:</i>				
Fore upper leg	.433	ns	.857	<.001
Fore mid leg	.578	.049	.422	ns
Hind upper leg	.375	ns	.125	ns
Hind hock bursitis	.589	.044	.394	ns

with injury suggested the former to be the case. However, since reasonable correlations with injury scores exist, and since the latter are easily and quickly measured, it is debatable whether the extra time and difficulty of recording the behavioural measure is really justified.

Previous studies with sows suggested that both the chronic effect of lack of exercise on muscle strength, and the acute effects of floor type might influence transition time (Marchant and Broom, 1996; Bonde et al., 2004). As a result, effects of liveweight and differences between breeds were demonstrated in addition to housing effects, and would need to be taken into account in benchmarking this behavioural measure.

4.3 OVERALL CONCLUSIONS

The measures of resting posture did not show good validity. There was no significant correlation of any posture measure with lesions or bursitis resulting from floors giving different levels of support and cushioning. Posture measures were shown to be influenced by age of pig within the finishing period, and to show a diurnal pattern which was not necessarily consistent between different environments. It was also shown that assessment during a one hour period was not always representative of behaviour over a more extended period. For these reasons, this measure is not recommended for use in on-farm assessment. The time taken to complete the standing to lying transition did show good indications of validity. It differed between floor surfaces giving different levels of support and cushioning, and was correlated with lesion and bursitis scores. Although the behavioural

measure is feasible, the same information may be obtained more easily from such physical scores.

It is concluded that it would be better to use a physical indicator of comfort rather than a behavioural measure, since this would be quicker to measure and less prone to other influencing factors. The prevalence of bursitis is suggested as the preferred animal-based measure of floor comfort. This work focused on the growing/finishing pig as the best test system for the measures, but it is likely on the basis of the literature that the results will translate to sows. Pressure from hard floors is likely to cause less discomfort in lighter weight pigs.

THE REPEATABILITY OF MEASURES OF THERMOREGULATION IN PIGS

K. Scott, J.H. Guy and S.A. Edwards

5.1 SUMMARY

A review of the scientific literature was conducted to identify possible components of thermoregulatory behaviour and select appropriate candidates for experimentation. Six possible components were identified; degree of social thermoregulation /huddling, resting posture and location, shivering (cold environment), panting (warm environment), increased activity (cold environment) or decreased activity (warm environment), and wallowing (warm environment). The repeatability and inter-observer reliability of most of the above components were uncertain, therefore a study was designed to ascertain i) whether short term observations correlated with longer term assessments, ii) whether there was a good day-to-day repeatability, and iii) whether there was a good inter-observer agreement. Three separate studies were conducted to examine the effects of temperature: one with heat-stressed weaner pigs, one with cold-stressed weaner pigs and one with heat-stressed finishing pigs.

Results from the study with cold-stressed weaner pigs showed that huddling behaviour could be assessed reliably during both short and long term observation periods, with good inter-observer agreement. Resting posture was more variable. Heat-stressed weaner pigs showed more lateral lying. Cold-stressed weaner pigs displayed more sternal lying during the short-term observations, however this difference was not reflective of the longer-term assessment. Heat-stressed finishing pigs actually displayed more sternal lying in both short- and long-term observation periods, and less lateral lying during the short-term observation period only. Increased respiration rate (panting) was reliably and repeatedly seen in heat stressed pigs. Wallowing cannot be observed when pigs are on fully slatted floors, but may be useful if a solid lying area is present. Shivering was not observed. Activity levels varied depending on the observation period; heat-stressed weaner pigs were less active in both the short- and longer-term observation periods, however the results were not consistent for the other studies. All measures showed good repeatability from day to day.

Although shivering and extreme panting were not observed, we conclude, based on evidence from the literature, that these measures are better assessments of extreme thermoregulatory behaviour than resting posture. We also recommend that the degree of huddling behaviour is used as a component of the assessment, since it is a quick and straightforward method that we have found to be reliable at less extreme temperatures.

5.2 INTRODUCTION

A review of the scientific literature on thermoregulation was carried out, considering the methodologies that different researchers have used, and whether these have been validated and assessed for inter- and intra-observer reliability. Six components of thermoregulation were identified:

- degree of social thermoregulation /huddling
- resting posture (sternal, semi-lateral or lateral recumbency) and location (wet/dry floor)
- shivering (cold environment)
- panting (warm environment)
- increased activity (cold environment) or decreased activity (warm environment)
- wallowing.

Pigs have developed advanced behavioural, morphological and physiological regulatory methods in order to maintain their body temperature within their thermo-neutral zone. Whilst morphological adaptations are often the result of long-term exposure to extremes of temperature, behavioural and physiological modifications may be evident after a relatively short exposure to suboptimal climatic conditions. For example, huddling behaviour (as a result of hypothermia) and panting (as a result of hyperthermia) may be used as valid indicators of poor welfare. These relatively swift responses to changes in the thermal environment may be observed within a reasonable time period; however other behavioural modifications may require substantial observation time. Restlessness may be indicative of a lack of thermal comfort (Geers et al., 1986). However, due to the substantial observation period required, it is unsuitable for on-farm assessment. Previous studies have shown that lying posture and excretory behaviour are affected by ambient temperature (e.g. Blackshaw and Blackshaw, 1994; Beattie et al., 1996). At high ambient temperatures, pigs lie on their side with their limbs fully extended, in order to be able to transfer as much heat as possible to the environment, whereas at low temperatures, pigs adopt a compact posture with their limbs tucked underneath the body, thus minimising contact with the floor (Close et al., 1981). However, the expression of such behaviours may be dependent on floor type. Floor type may also affect the ability of pigs to use modified excretory behaviour in thermoregulation. Where solid floors are present, pigs can wallow in excreta for evaporative cooling. However, wallowing is not possible in housing with fully-slatted floors.

In order to ascertain whether short-term observations (as can be conducted on-farm in a reasonable time period) provide a reliable representation of longer term assessments, direct observations made within a 1-hour period were compared with 24-h video assessments. Temperature treatments were applied over five consecutive days in an attempt to investigate whether the direct observations showed good repeatability from day to day. The reliability of any assessment tool is an important consideration when designing an on-farm welfare scheme. There is a lack of literature on the inter-observer reliability of thermoregulatory behaviour; therefore the extent to which different observers showed good agreement in the assessment of the components of thermoregulatory behaviour was also investigated in this study.

Three separate trials were carried out, one with heat-stressed weaner pigs, one with cold-stressed weaner pigs and one with heat-stressed finishing pigs. Each trial involved eight pens of pigs in a crossover design of experiment. Control pigs were maintained at temperatures in the middle of their thermoneutral zones and experimental pigs at either higher or lower temperatures, each for a period of one week. The balanced crossover design allowed the effects of liveweight on the measured parameters to also be assessed.

The aims of this study were therefore to assess whether short term observations of behaviour (degree of social thermoregulation and lying posture) could provide an adequate reflection of longer time assessment, and also to investigate the repeatability of the assessment measures and inter-observer reliability.

5.2.1 HEAT-STRESSED WEANER PIGS

Methods

Animals and housing

Pen groups of 20 ± 1 Large White x Landrace weaned pigs (weaning age 28d) were allocated equally between two controlled environment rooms. Each room contained four pens (each 3.4 x 1.9 m) with fully-slatted plastic flooring.

Liveweight and feed recording

Animals were weighed on the day that the temperature treatment was applied (Day 0), and again seven days later (Day 7). Pigs were fed ad libitum, with feed intake monitored daily from Day 3 onwards. Water was freely available from four nipple drinkers per pen. As the trial was a crossover design, pigs were at two different stages of growth (15 kg or 22 kg liveweight) when they experienced the different temperature treatments.

Temperature treatments

Temperatures used in the trial were calculated using the SFBIU Computer Programme (Bruce and Clark, 1978). Predicted upper and lower critical temperatures were calculated using information on expected liveweight, feed intake and floor type. In room one the control temperature (experienced first) was 25°C and the hot temperature was 28°C, whilst in room 2 the control temperature was 24°C and the hot temperature (experienced first) was 29°C. Animals were weaned into the room on Day -8 and allowed one week to adapt to their new environment. The temperature treatment was applied on Day 0, and returned to the normal commercial setting on the afternoon of Day 7. Pigs were housed in commercial conditions for a further seven days before the entire process was repeated with the crossover temperature treatment. Maximum and minimum temperatures were recorded daily from Day 0 to Day 7. Temperature and air velocity at pig level was recorded daily by hand for each pen from Day 3 to Day 7.

Behavioural observations

Daily observations were made during a 1-h period (13–14:00) on each of five consecutive days (Days 3–7). Observations did not begin until ten minutes after entering the room to allow the pigs to become accustomed to the observer's presence. Scan samples conducted at five minute intervals recorded the number of pigs showing specific behaviours according to a predetermined ethogram (Table 5.1).

Two timelapse recordings of behaviour were made during the week of observations to determine behavioural patterns over a 24-h period (Panasonic AG216 time lapse VCR and Panasonic WJ-FS 216 Multiplexer). Each tape was analysed using 30 minute scan samples over the 24-h period according to a modified version of the ethogram used for direct observations (Table 5.1). The number of pigs in each section of the pen was also recorded at this time (Area A= front of pen and feeding area, Area B=rear of pen and drinker area).

Respiration rates

Respiration rates were measured on a sub sample of three resting pigs per pen on Days 3–7 by counting the number of breaths taken in a one-minute period.

Statistical Analyses

Behaviour, growth and feed intake data were analysed using a two-way analysis of variance by the General Linear Model (GLM) function within Minitab. Treatment and experimental period (confounded with liveweight) were included as factors.

Results

Although daily feed intake was higher in control pigs than hot pigs, the difference was not statistically significant (Table 5.2).

TABLE 5.1 Behavioural ethogram used in the study.

Behaviour	Description
<i>Social thermoregulation*</i>	
Huddling	The pig is lying with over 50% of its body in contact with another pig
Touching	The pig is lying in physical contact with another lying pig
Not touching	No physical contact with another lying pig
<i>Lying posture*</i>	
Sternal	The pig is lying on its sternum/belly with front legs ex-tended forwards, or all legs tucked underneath the body
Lateral	The pig is lying flat on one side of its body, all four legs are extended and the body is not supported by the legs
Semi-lateral	The pig is reclining (half lying on its side), with its body supported by one or two legs. Its body weight is distributed between its legs and body.
<i>Thermoregulatory behav.</i>	
Shivering	The pig's body, or any body part, is vibrating slowly and irregularly
Panting	The pig is breathing rapidly in short gasps
Wallowing	The pig is rolling or rubbing its body in a wet mixture of faeces and urine
Dunging	The visible defecation made by an animal (note location in pen where this occurs)

Notes: (after Huynh et al., 2005).

TABLE 5.2 The effects of temperature on voluntary food intake and Daily Liveweight Gain (DLWG).

	Temperature Treatment			
	Control	High	S.E.M	Significance
Weight Day 0 (kg)	16.33	16.73	1.284	ns
Weight Day 7 (kg)	2.51	19.90	1.576	ns
DLWG (kg)	.598	.455	.0638	ns
Daily Food Intake (kg/pig/day)	.853	.813	.0617	ns
Daily Food Intake (MJ ME/day)	12.67	12.07	.777	ns

The actual pen temperature and the calculated critical temperature for each room at each temperature treatment are given in Table 5.3. During the control temperature period, the set temperature was close to the mid-point of the thermo-neutral range. At the high ambient temperature, the actual pen temperature was close to the upper critical temperature (UCT). Critical temperatures were also affected by experimental period; at both the control and high temperatures, the younger pigs (period 1) had a higher lower critical temperature (LCT) and UCT compare to the older (period 2) pigs.

The effects of temperature on the degree of social thermoregulation, lying posture and location within the pen during direct observations are summarised in Table 5.4. At a high ambient temperature, pigs reduced the amount of physical contact they had with other pigs ($P<0.01$), and showed a higher frequency of lateral ($P<0.01$) and semi-lateral lying ($P<0.001$). Pigs at the high ambient temperature tended to lie less frequently in a sternal posture than pigs at the control temperature ($P=0.07$). Pigs at the high ambient temperature were more often observed lying (total of all three postures) than pigs at the control

TABLE 5.3 Comparison of the actual pen temperature and the calculated critical temperatures

Temperature treatment	Period (age)	Mean pen temperature	LCT	Mid-point of thermoneutral range	UCT
Control	1: Young	24.71	16.02	22.82	29.63
Control	2: Old	22.60	10.98	19.13	27.29
High	3: Young	28.86	16.93	23.51	30.10
High	4: Old	27.84	11.10	19.24	27.38

TABLE 5.4 The effect of temperature treatment on the degree of social thermoregulation, lying posture and location within the pen (direct observations).

Proportion of Observations	Temperature Treatment			
	Control	High	S.E.M	Significance
Huddling	0	0	–	
Touching	.258	.073	.0413	P<.01
Not Touching	.740	.927	.0414	P<.01
Sternal lying	.248	.210	.0134	P=.07
Lateral lying	.021	.114	.0173	P<.01
Semi-Lateral lying	.095	.242	.0203	P<.001
Total lying (all 3 postures)	.365	.566	.0338	P=.001
<i>Relative frequency of:</i>				
Sternal lying	.687	.381	.0363	P<.001
Lateral lying	.060	.192	.0197	P<.001
Semi-lateral lying	.252	.426	.0309	P=.002
In area A	.602	.533	.0169	P<.05
In area B	.399	.466	.0170	P<.05

temperature ($P=0.001$); therefore activity level was affected by temperature treatment. Significant effects of temperature were also observed on the relative frequencies of the different lying postures (Table 5.4). Control pigs were more often observed in a sternal posture when lying ($P<0.001$), whereas hot pigs were more often observed lying laterally ($P<0.001$) and semi-laterally ($P<0.01$). The mean respiration rate was significantly increased during the period of high ambient temperature compared to that during the control temperature (59.6 v. 47.6 breaths/minute, S.E.M. 1.08, $P<0.001$).

Results of the longer-term assessment carried out with the use of 24-h time-lapse video recording are presented in Table 5.5. As with the short-term observations, pigs kept at high ambient temperatures were less often observed touching, and tended to lie more frequently in a lateral posture ($P=0.08$). However in contrast with the direct observations, whilst there was a significantly higher frequency of sternal lying in control pigs than hot pigs ($P<0.01$), the frequency of semi-lateral lying was unaffected by temperature. Pigs at the high ambient temperature were more frequently observed lying during both short- and long-term observations than control pigs (Table 5.5). The relative frequencies of sternal and lateral lying did not differ between the different observation periods. Hot pigs displayed a higher frequency of semi-lateral lying than control pigs during the 1-h observation period, however only a numerical and not statistical difference was observed during the 24-h observation period. During both short and longer-term observations, pigs at the high

TABLE 5.5 The effects of temperature treatment on the degree of social thermoregulation, lying posture and location within the pen (video observations).

Proportion of Observations	Temperature Treatment			
	Control	High	S.E.M	Significance
Huddling	0	0	–	
Touching	.448	.107	.0249	P<.001
Not Touching	.549	.890	.0249	P<.001
Sternal lying	.240	.141	.0139	P<.001
Lateral lying	.219	.327	.0243	P=.008
Semi-Lateral lying	.278	.313	.0167	ns
Total lying (all 3 postures)	.738	.782	.0114	P<.05
<i>Relative frequency of:</i>				
Sternal lying	.325	.182	.0147	P<.001
Lateral lying	.301	.417	.0186	P=.001
Semi-lateral lying	.374	.401	.0135	ns
In area A	.638	.527	.0188	P=.001
In area B	.360	.473	.0186	P=.001

ambient temperature spent more observations in section B of the pen (closer to drinkers) and less in section A than control pigs.

5.2.2 COLD-STRESSED WEANER PIGS

Methods

Animals and housing

As in experiment 1, pen groups of 22 ± 1 Large White cross weaned pigs (weaning age 28d) were allocated equally between two controlled environment rooms. As the trial was a crossover design, pigs were at two different stages of growth (12 kg or 19 kg liveweight) when they experienced the different temperature treatments.

Temperature treatments

Predicted upper and lower critical temperatures were calculated using information on expected liveweight, feed intake and floor type (Bruce and Clark, 1978). In room one the control temperature (experienced first) was 25°C and the cold temperature was 20°C, whilst in room 2 the control temperature was 24°C and the cold temperature (experienced first) was 21°C.

All other procedures and experimental measures were as described for Experiment 1.

Results

Performance data are summarised in Table 5.6. There were no significant effects of temperature on pig liveweight on Day 0 or on Day 7. DLWG was significantly lower for pigs at the low ambient temperature compared with those at the control temperature ($P<0.05$); however, there were no significant effects of temperature on daily energy intake.

The actual temperature and the calculated thermoneutral range for each pen at each of the different temperature and experimental period combinations is given in Table 5.7. During the control temperature, the individual pen temperature was close to the mid-point of the thermoneutral range for both younger and older pigs. At the low ambient temperature, individual pen temperatures were midway between the mid-point of the thermoneutral range and the LCT for pigs at both stages of growth. With the degree of building insulation and pig density, external air at ambient temperature was unable to cool the rooms enough to achieve the lower set temperature. Critical temperatures were also affected by stage of growth; at both the control and low temperatures, younger pigs had a higher UCT and LCT compared with the older pigs.

The effects of temperature on the degree of social thermoregulation, lying posture, shivering and location within the pen are summarised in Table 5.8. Pigs maintained at a low ambient temperature displayed a higher frequency of huddling behaviour ($P=0.001$), and increased the amount of physical contact they had with other pigs ($P<0.05$). A significant interaction between temperature treatment and stage of growth was observed on the frequency of touching ($P<0.01$); older/heavier pigs under low ambient temperatures displayed a higher frequency of touching; however the opposite was true for younger/lighter pigs.

Lying posture was significantly affected by both temperature and the stage of growth. Younger/lighter pigs and pigs maintained at a low ambient temperature lay more frequently

TABLE 5.6 The effects of temperature treatment on liveweight, voluntary food intake and DLWG.

	Temperature Treatment			
	Control	Cold	S.E.M	Significance
Weight Day 0 (kg)	13.34	13.92	.563	ns
Weight Day 7 (kg)	17.27	17.25	.661	ns
DLWG (kg)	.563	.475	.021	$P<0.05$
Daily Food Intake (MJ ME/pig/day)	10.23	10.64	.376	ns

TABLE 5.7 Comparison of the actual temperature and the calculated thermoneutral range.

Temperature treatment	Period	Mean pen temperature	LCT	Mid-point of thermoneutral range	UCT
Control	1. Young	25.5	20.95	26.27	31.58
Control	2. Old	24.1	17.31	23.55	29.77
Low	1. Young	23.4	20.57	25.86	31.14
Low	2. Old	21.3	16.72	23.16	29.58

TABLE 5.8 The effect of temperature treatment on the degree of social thermoregulation, lying posture, shivering and location within the pen (direct observations).

Proportion of Observations	Temperature Treatment			
	Control	Cold	S.E.M	Significance
Huddling	.002	.010	.0014	P=.01
Touching	.097	.149	.0138	P<.05
Not Touching	.901	.840	.0148	P<.05
Sternal lying	.022	.034	.0032	P<.05
Lateral lying	.050	.041	.0054	ns
Semi-Lateral lying	.337	.283	.0194	P=.07
Shivering	0	.001	.0002	ns
Total lying (all 3 postures)	.409	.359	.0243	ns
<i>Relative frequency of:</i>				
Sternal lying	.052	.108	.0070	P<.001
Lateral lying	.125	.102	.0103	ns
Semi-lateral lying	.823	.800	.0100	P<.05
In area A	.499	.527	.0184	ns
In area B	.501	.473	.0184	ns

in a sternal position compared with older/heavier pigs ($P<0.01$) and those at the control temperature ($P<0.05$). A semi-lateral lying posture tended to be adopted more frequently by pigs at the control temperature than those at the cold temperature ($P=0.07$). Total lying frequency did not differ significantly between the temperature treatments (Table 5.8), however a significant interaction was observed between temperature treatment and stage of growth. Older/heavier pigs were more frequently observed lying in cold conditions; however the converse was true for the younger/lighter pigs ($P<0.01$). Of the total amount of time spent lying, cold pigs were more frequently observed lying in a sternal posture ($P<0.001$) and less frequently observed lying semi-laterally than control pigs ($P<0.05$). Stage of growth also affected the relative frequencies of the different lying postures; younger/lighter pigs were more often observed lying in a sternal position ($P<0.001$) and less often observed in a lateral lying posture ($P<0.001$).

The frequency of shivering behaviour was negligible and not affected by temperature treatment. Although cold pigs were more often observed in area A of the pen and less often in area B than control pigs, the difference was not statistically significant. Respiration rate was higher in pigs at the control temperature than at the lower ambient temperature (54.0 v. 45.5 breaths/minute, S.E.M. 1.78, $P<0.01$), and also in younger/lighter pigs than older/heavier pigs (52.9 v. 46.6, S.E.M. 1.78, $P<0.05$).

Results of the longer-term assessment carried out with the use of 24-h time-lapse video recording are given in Table 5.9. Pigs kept at the low ambient temperature displayed more huddling behaviour ($P<0.05$) and were more often observed touching ($P<0.001$) than pigs at the control temperature, which is in agreement with findings from the short-term observations. In contrast however, there was no effect of temperature treatment on the frequency of sternal lying. Although not significant during the short-term observation, video observations showed that pigs at the low ambient temperature displayed less lateral lying ($P<0.001$) and more semi-lateral lying ($P<0.05$) than pigs at the control temperature. Whilst there were no significant differences in location within the pen during the short-term observations, 24-h observations showed that pigs at the low ambient temperature

TABLE 5.9 The effect of temperature treatment on the degree of social thermoregulation, lying posture, shivering and location within the pen (video observations).

Proportion of Observations	Temperature Treatment			
	Control	Cold	S.E.M	Significance
Huddling	.006	.014	.0022	P<.05
Touching	.405	.546	.0202	P<.001
Not Touching	.588	.440	.0213	P<.001
Sternal lying	.103	.113	.0049	ns
Lateral lying	.263	.154	.0135	P<.001
Semi-Lateral lying	.442	.505	.0152	P<.05
Total lying (all 3 postures)	.807	.772	.0059	P=.001
<i>Relative frequency of:</i>				
Sternal lying	.127	.146	.0059	P<.05
Lateral lying	.326	.199	.0186	P<.001
Semi-lateral lying	.547	.655	.0167	P=.001
In area A	.520	.597	.0216	P<.05
In area B	.480	.403	.0216	P<.05

were more frequently observed in section A of the pen ($P<0.05$), which was away from the drinkers, and less frequently observed in section B ($P<0.05$), which was near the drinkers.

Although there was no significant difference in total lying frequency in the short-term observations, analysis of the video observations found that pigs maintained at a low ambient temperature spent fewer observations lying than pigs at the control temperature (Table 5.9), i.e. cold pigs were more active than control pigs. In both the short- and longer-term observations, cold pigs displayed a higher relative frequency of sternal lying than control pigs ($P<0.001$). Results for the relative frequency of lateral lying differed between the observation periods; there was no significant effect of temperature on lateral lying during the 1-h observation; however, pigs at the low temperature displayed less lateral lying than control pigs during the 24-h observation period ($P<0.001$). Whilst the relative frequency of semi-lateral lying was greater for control pigs than cold pigs during the short 1-h observation period, the reverse was true for the 24-h period: pigs at the low ambient temperature were more frequently observed in a semi-lateral posture than pigs at the control temperature ($P=0.001$).

5.2.3 HEAT-STRESSED FINISHING PIGS

Method

Animals and housing

Pen groups of 10 Large White x Landrace finishing pigs were allocated equally between two controlled environment rooms, each containing four pens. Animals were housed on part-slatted floors, consisting of a solid concrete lying area, with a concrete slatted dunging area.

Liveweight and feed recording

Animals were weighed on the day that the temperature treatment was applied (Day 0), and again seven days later (Day 7). Feed was provided *ad libitum*. Feed intake was monitored from Day 0 to Day 2 collectively, and daily thereafter until Day 7. Water was freely available from two nipple drinkers per pen. As the trial was a crossover design, pigs were at two different stages of growth (79 kg or 85 kg liveweight) when they experienced the different temperature treatments.

Temperature treatments

Predicted upper and lower critical temperatures were calculated using information on expected liveweight, feed intake and floor type (Bruce and Clark, 1978). In room one the control temperature (experienced first) was 21°C and the hot temperature was 25°C, whilst in room 2 the control temperature was 20°C and the hot temperature (experienced first) was 26°C. Animals entered the room on Day -3 and allowed three days to adapt to their new environment. The temperature treatment was applied on Day 0, and returned to the normal commercial setting on the afternoon of Day 7. Pigs were housed in commercial conditions for a further seven days before the entire process was repeated with the crossover temperature treatment. Maximum and minimum temperatures were recorded daily from Day 0 to Day 7. Temperature and air velocity at pig level was recorded daily by hand for each pen from Day 3 to Day 7.

Behavioural observations and respiration rate

These were recorded using the same protocol as described for the previous experiments.

Hygiene scores

Pig and pen hygiene scores were assessed daily on Days 3 to 7 by visual estimation of the percentage of body (pig) or floor (pen) surface area that was soiled as opposed to clean.

Results

Performance data are summarised in Table 5.10. There were no significant effects of temperature treatment on pig liveweight on Day 0 or on Day 7, or on voluntary food intake.

The actual temperature and the calculated thermoneutral range for each pen at each of the different temperature and experimental period combinations is given in Table 5.11. During the control temperature, the individual pen temperature was close to the mid-point of the thermoneutral range for both light and heavy pigs. At the high ambient temperature, individual pen temperatures were midway between the mid-point of the thermoneutral range and the UCT for both light and heavy pigs. Because radiant heaters were used in each pen to achieve the high temperature treatment, pigs would have perceived greater heating than indicated by air temperature alone.

TABLE 5.10 The effect of temperature treatment on liveweight, voluntary food intake and DLWG.

	Temperature Treatment			
	Control	High	S.E.M	Significance
Weight Day 0 (kg)	79.07	79.31	1.037	ns
Weight Day 7 (kg)	85.45	86.09	1.419	ns
DLWG (kg)	.911	.968	.066	ns
Daily Food Intake (MJ ME/pig/day)	29.89	28.84	.889	ns

TABLE 5.11 Comparison of the actual pen temperature and the calculated thermoneutral range.

Temperature treatment	Period	Mean pen temperature	LCT	Mid-point of thermoneutral range	UCT
Control	1. Light	20.95	11.96	21.37	30.78
Control	2. Heavy	20.83	12.79	22.12	31.45
Low	1. Light	25.00	13.37	22.37	31.36
Low	2. Heavy	25.92	12.28	21.67	31.06

The effects of temperature on the degree of social thermoregulation, lying posture and location within the pen are summarised in Table 5.12. Pigs at a high ambient temperature showed a lower frequency of touching than those kept at a control temperature ($P<0.001$). Hot pigs tended to lie more frequently in a sternal posture than control pigs ($P=0.052$), whilst control pigs tended to lie more frequently in a lateral position than hot pigs ($P=0.057$). Semi-lateral lying was not affected by temperature treatment. The total amount of lying behaviour tended to be higher for control pigs than hot pigs (Table 12). Of this, hot pigs were more often observed in a sternal posture ($P<0.05$) than control pigs, whilst control pigs tended to lie more frequently in a lateral posture ($P=0.085$). The relative frequency of semi-lateral lying was unaffected by temperature treatment. Under hot conditions, pigs were more often observed in section B of the pen ($P<0.001$), and less often in section A ($P<0.001$).

Respiration rate was higher in pigs at the high ambient temperature than pigs at the control temperature (31.9 v. 25.1 breaths/minute, S.E.M. 0.87, $P<0.001$).

Wallowing was more frequently displayed by pigs at the high ambient temperature than those at the control temperature (0.083 v. 0.000, S.E.M. 0.0106, $P<0.001$), which was reflected in pig and pen hygiene scores. Pigs maintained at the high ambient temperature had both higher pig and pen hygiene scores, i.e. were dirtier, than pigs at the control temperature (Figure 5.1).

Results of the longer-term assessment carried out with the use of 24-h time-lapse video recording are presented in Table 5.13. In agreement with results from the short-term observations, pigs at the high ambient temperature were less often observed touching ($P<0.001$) and lying in a sternal posture ($P<0.05$) than pigs at the control temperature. Whilst there was a tendency towards an increased frequency of lateral lying by control pigs

TABLE 5.12 The effects of temperature treatment on the degree of social thermoregulation, lying posture and location within the pen in finishing pigs (direct observations).

Proportion of Observations	Temperature Treatment			
	Control	High	S.E.M	P VALUE
Huddling	0	0	–	
Touching	.425	.125	.0193	P<.001
Not Touching	.575	.875	.0193	P<.001
Sternal lying	.112	.147	.0113	P=.052
Lateral lying	.321	.214	.0359	P=.057
Semi-Lateral lying	.369	.364	.0279	ns
Total lying (all 3 postures)	.802	.725	.0277	P=.073
<i>Relative frequency of:</i>				
Sternal lying	.144	.215	.0227	P<.05
Lateral lying	.398	.286	.0421	P=.085
Semi-lateral lying	.459	.499	.0321	ns
In area A	.742	.493	.0097	P<.001
In area B	.257	.507	.0103	P<.001

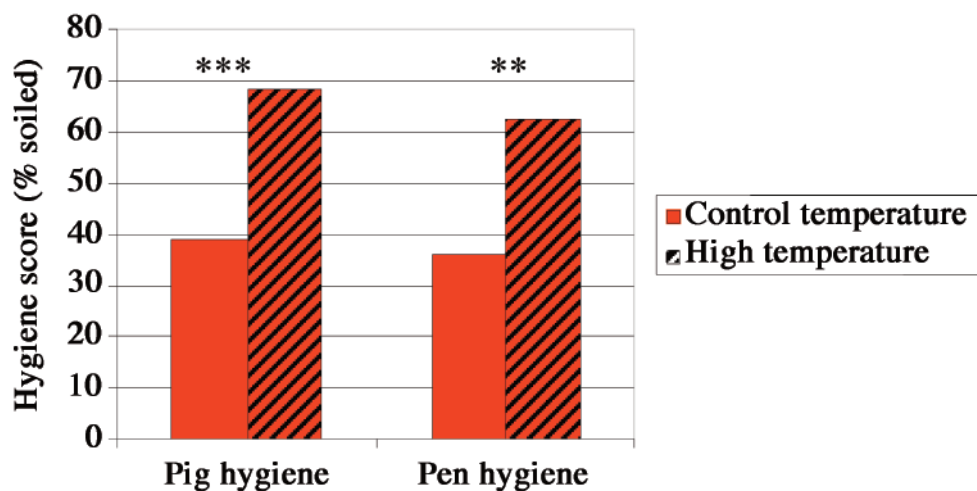


FIGURE 5.1 The effects of temperature treatment on pig and pen hygiene scores.

TABLE 5.13 The effect of temperature on the degree of social thermoregulation, lying posture and location within the pen (video observations).

	Temperature Treatment			
	Control	High	S.E.M	P VALUE
Huddling	0	0	–	
Touching	.474	.326	.0219	P<.001
Not Touching	.526	.674	.0219	P<.001
Sternal lying	.079	.109	.0076	P<.05
Lateral lying	.418	.402	.0195	ns
Semi-Lateral lying	.339	.335	.0130	ns
Total lying (all 3 postures)	.835	.846	.0116	ns
<i>Relative frequency of:</i>				
Sternal lying	.093	.129	.0095	P<.05
Lateral lying	.501	.475	.0190	ns
Semi-lateral lying	.406	.396	.0175	ns
In area A	.770	.493	.0193	P<.001
In area B	.230	.507	.0193	P<.001

during the 1-h observations, the magnitude of the difference was not statistically significant for observations made during the 24-h period. Pigs at the high ambient temperature tended to spend fewer observations lying than control pigs during the short-term observation, however no significant effect of temperature was observed on total lying frequency for the 24-h observation period. The relative frequency of sternal lying was greater for hot pigs than control pigs during both the 1-h and 24-h observations ($P < 0.05$). Similarly, there was no difference between short- and long-term observations in respect of location within the pen.

5.3 REPEATABILITY OF MEASURES FOR ALL STUDIES

For each of the different studies, the directly observed measures were made on five consecutive days; statistical investigation indicated no significant effect of 'day' or 'day x treatment interaction' on these measures.

5.3.1 INTER-OBSERVER RELIABILITY

Three assessors were initially trained using reference pictures and videos as explanation of the methodology. For the cold-stressed weaner pig, inter-observer reliability for the measures was assessed during a simultaneous direct observation session that recorded respiration rate, lying posture and huddling and shivering in different pens of pigs, whilst for heat-stressed finishing pigs, observers assessed respiration rate, lying posture, pig hygiene and panting.

5.3.2 COLD-STRESSED WEANER PIGS

Inter-observer reliability data for cold-stressed weaners are summarised in Table 5.14. Observers 2 and 4 showed good agreement in the assessment of huddling behaviour; however the correlation was weaker between both observers 4 and 1, and 1 and 2 (i.e. observer 1 who had worked less directly on this project differed more compared to the other two observers). Inter-observer reliability for the frequency of sternal lying was poor; correlation was low for observers 2 and 4, and observers 4 and 1, although a weak but significant correlation was observed for observers 1 and 2. Good inter-observer reliability was observed in the assessment of lateral and semi-lateral lying. Mean respiration rates were strongly and significantly correlated for different observers (Table 5.14).

TABLE 5.14 Pearson correlation coefficients (for normally distributed data) and Spearman rank correlation coefficients (for non-normally distributed data) for the frequency of social thermoregulation, different lying postures and respiration rate by three different observers.

	Observers 1 and 2	Observers 2 and 4	Observers 4 and 1
<i>Frequency of:</i>			
Huddling†	.559**	.751***	.556**
Sternal lying	.687***	.210	.069
Lateral lying†	.975 ***	.984***	.964***
Semi-lateral lying	.986***	.984***	.979***
Respiration rate (breaths/min)	.959 ***	.949 ***	.974 ***

Note: † Spearman rank correlation coefficient (r_s).

5.3.3 HEAT-STRESSED FINISHING PIGS

Inter-observer reliability data for heat-stressed finishing are summarised in Table 5.15. A weak but significant correlation was observed between the individual assessors for the frequency of sternal lying. There was good inter-observer agreement in the assessment of lateral and semi-lateral lying postures. Mean respiration rates and pig hygiene scores were consistently similar between observers (Table 5.15).

5.4 DISCUSSION

It is widely accepted that behavioural elements such as lying posture are affected by ambient temperature (Blackshaw and Blackshaw et al., 1994; Beattie et al., 1996; Huynh et al., 2005). In thermoneutral conditions, fattening pigs have been found to spend 90% of the day lying (Ekkel et al., 2003); typical lying postures were lateral (accounting for more than 60% of observations), sternal, or an intermediate of the two, semi-lateral. Since heat exchange by conduction, convection and radiation is proportional to the body surface exposed to the environment, it is unsurprising that pigs housed at high ambient temperatures will spend more time lying laterally in order to transfer as much of their excess body heat to the environment, whilst at a low temperature, pigs will adopt a compact posture with their limbs tucked underneath their body, thus minimising contact with the floor (Close et al., 1981). In view of this knowledge, it is therefore surprising that results from the current series of studies did not find lying posture to be a unanimously reliable indicator of thermal comfort. However, the thermal conductivity of the floor (most previous studies relate to concrete flooring), the space allowance and the degree of disturbance of the pigs will all be influencing factors.

Heat-stressed weaner pigs did follow convention, displaying higher frequencies of lateral lying and lower frequencies of sternal lying than pigs maintained in thermoneutral conditions. Cold-stressed weaner pigs spent a similar number of observations in a lateral

TABLE 5.15 Pearson correlation coefficients (all data normally distributed) for the frequency of different lying postures, respiration rate and assessment of pig hygiene by three different observers.

	Observers 1 and 2	Observers 2 and 3	Observers 3 and 1
<i>Frequency of:</i>			
Sternal lying	.404*	.634***	.433**
Lateral lying	.928***	.922***	.914***
Semi-lateral lying	.907***	.913***	.855***
Pig hygiene (% soiled)	.721***	.909***	.692***
Respiration rate (breaths/min)	.876***	.867***	.862***

pos-ture compared with pigs at the control temperature, but they did however display more sternal lying than their control counterparts, although this was only during the 1-h observation period. In contrast to what was expected in view of the literature, heat-stressed finishing pigs actually spent more observations in a sternal lying posture than pigs at the control temperature, whilst there was no overall effect of temperature on the frequency of lateral lying. Furthermore, assessment of lying posture made during short-term observations did not always adequately reflect longer time assessment. Farm inspections will have to be carried out within a reasonable time period; therefore it is imperative that what the inspector is witnessing is not simply a snapshot of behaviour that is not reflective of the animals as a whole.

Inter-observer reliability was better for some postures than others, but this may be improved upon by more extensive training. In addition to a change in posture from sternal to lateral lying, Geers et al. (1986) also observed that on hot days pigs avoided physical contact with other pen mates. This is in concordance with findings from the present studies on heat-stressed weaner and finishing pigs, whilst in the study with cold-stressed weaner pigs, pigs at the low ambient temperature were more frequently observed in physical contact with one another than those at the control temperature. However, the ability of pigs to separate will depend on space allowance under commercial farm conditions.

For the assessment of huddling behaviour, short-term observations were shown to provide an adequate reflection of longer-term assessment. Correlation coefficients for inter-observer assessment of huddling behaviour were fairly weak, although they were significant, however this may have been improved upon with longer training and had more huddling behaviour been observed at more extreme temperatures than could be achieved in these studies. Shivering and extreme panting behaviour were not observed in any of the studies, however both are recognised physiological adaptations to the thermal environment that are quick and straightforward to assess. Respiration rate showed reliable effects of temperature, being elevated in heat-stressed animals and lower in cold-stressed animals compared with those at a control temperature, and mean respiration rates were strongly and significantly correlated amongst different observers. Despite these promising results, we do not recommend this measure as a candidate for an on-farm monitoring system due to the amount of time required (one minute per pig), although they may be used as an aid to assessing panting during training.

REPEATABILITY OF A LAMENESS SCORE MEASURED ON FARM

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K. Vermeulen, V. Lammens, C.G. van Reenen and F.A.M. Tuytens

6.1 SUMMARY

Lameness is very relevant for pig welfare because of direct painful effects and reduced ability to cope with the environment. The objective of this study was to test the inter-observer variability of two lameness scores. Ten pig farms were visited, in each 20 sows and 20 fattening pigs were tested. Four trained observers were present during each farm visit. Observers scored the gait of the animal according to a four-point scale (from 0 = normal gait to 3 = severely lame) and a continuous scale from 0 to 100%. For sows, prevalence of leg/foot/claw lesions were scored. Video-recordings were made of all animals and 4 observers (different from those present during farm visits) scored the gait from tape according to the four-point scale.

About 80% of the sows and 90 % of the fattening pigs were scored as 0 (normal gait). Lameness problems were not clearly related to leg- or foot lesions. Analysis of the data obtained by direct observations for lameness in sows showed that, if sample size was above 60, all observers but one significantly agreed on the score on the four-point scale. Analysis on the data scored on a scale 0-100% showed that all but one correlation were significant. With regard to the size of the correlations, most correlations between observers were moderate (between 0.4 and 0.7), two were high (above 0.7). All observers showed significant associations between their scores on the four-point scale and the 0-100 % scale.

In fattening pigs, all but one observer pair significantly agreed on the four-point scale, if sample size was above 32. Analysis of the data scored on a scale 0-100% showed that all but one correlation was significant, and that most correlations were moderate (between 0.4 and 0.7). All observers showed significant associations between their scores on the four-point scale and the 0-100 % scale.

In conclusion, for both sows and fattening pigs, lameness can be reliably scored on the four-point scale (live as well as from video tape) and cannot be reliably predicted by scores

of leg or foot lesions. Within observers, the four-point score showed a high association with the percentage score. Since correlations among observers for the percentage score were rather moderate than high, we advise to score lameness on a four-point scale only.

6.2 INTRODUCTION

Lameness is very relevant for pig welfare because of direct painful effects and reduced ability to cope with the environment. A reduction in the freedom of movement can restrict the performance of social behaviour (e.g. evasive behaviour) and increase the risk of falling (Bonde, 2003). Different environmental factors may contribute to causing leg problems such as feed (Jørgensen, 1995), housing system and management (Kroneman et al., 1993a; Barnett et al., 2001; Scott et al., 2006) and lack of physical exercise (Petersen et al., 1998).

The objective of this study was to test the inter-observer variability of two lameness scores as a parameter for monitoring the welfare of sow and fattening pigs on-farm. In addition, it was investigated whether or not the lameness scores correlated with leg/foot/claw-lesion indices.

6.3 METHODS

Inter-observer variability was assessed for sows and fattening pigs separately. Ten pig farms were visited. Per farm, 20 sows and 20 fattening pigs were tested.

Sows: If both group-housed and individually housed sows were present, half of the sows were taken from the group and half of the sows came from individual housing. With regard to group housing, the number of sows tested in one group depended on the total number of groups present (i.e. if one group was available, all sows came from that group; if 4 groups were available, 5 sows were taken from each group).

Gait-scoring took place in the nearest passageway that was suitable (i.e. allowing a clear and unobstructed view of the moving animal). If the pen contained individual feeder stalls, and most sows were lying in these stalls on the moment of testing, all sows but the tested one were temporarily fixed in these stalls and gait scoring took place in the pen. If most sows were out of the feeder stalls, or if no stalls were present, the sow was taken out of the pen individually for gait-scoring. Observations only started after the animal had walked

a certain distance, as most sows tend to be a bit stiff after lying. For sows, prevalence of leg/foot/claw lesions were scored (Bonde, 2003).

Fattening pigs: Animals were selected out of 3-5 pens and taken out individually to the nearest suitable passage way for gait scoring. As in most buildings, the passageway between the pens was too small for a pig to turn around, pigs were taken to the hallway of the building. In case an animal was selected that was not able to walk at all, it was scored while it stayed inside the pen.

6.3.1 GAIT SCORING

From a pool of 7 trained observers (4 from ILVO, 3 from KUL-ZTC), 4 observers (3 from ILVO, 1 from KUL-ZTC) were present during each farm visit. Observers scored the gait of the animal according to:

- a. A four-point scale: 0 = normal gait, 1 = difficulties walking, but still using all legs, swagger of caudal body while walking, shortened stride, 2 = severely lame, minimum weight-bearing on affected limb, 3 = no weight-bearing on affected limb, or not able to walk.
- b. A continuous scale from 0 to 100%: with tags 15% = movements no longer fluent; pig appears stiff; 30% = lameness detected, but still using all legs; 50% = minimum weight-bearing on affected limb while moving; 75% = no weight-bearing on affected limb while standing; minimum weight-bearing while moving; 100% = not able to walk.

The animal was also filmed using a cam-recorder. Four trained observers (2 from ILVO, 2 from KUL-ZTC; these observers were not present during direct observations) scored the gait of the animal from video according to the four-point scale mentioned above. All observers scored the animals in the same order as was done for direct observations.

6.3.2 STATISTICS

As the data were not normally distributed, primarily non-parametrical tests were used for analysis. For analysis of the four-point score, scores (0,1,2,3) were transformed into 3 levels of binary scores: A = 0 vs 1,2,3; B = 0,1 vs 2,3; C = 0,1,2 vs 3. Fisher's exact test was used to test agreement within observer pairs on each level. Spearman's Rank correlation was used to calculate the association between the continuous scores within each observer pair. The association between the four-point score and the percentage score was calculated within observers using a Kruskal-Wallis one-way ANOVA, with the four-point score as the independent variable and the percentage score as the dependent variable.

In case $n < 5$ within one of the four categories, the chi-square approximation did not hold, and a parametric one-way ANOVA on ranks was used to estimate associations.

All statistical analyses described above were performed with Genstat software, version 7.

6.4 RESULTS

6.4.1 DIRECT OBSERVATIONS

Most sows and fattening pigs had a normal gait (see Table 6.1).

Lameness problems were not clearly related to leg- or foot lesions. Nine sows had claws that were too long; three of them had lameness score 1, the other six score 0. One sow had a broken hoof which resulted in score 3. Swellings were more frequent in fattening pigs than in sows; 8 fattening pigs had swellings, but only 3 of them got lameness scores higher than 0. Three sows showed swellings, with 1 receiving a higher score than 0. One fattening pig had an open wound on its leg and had a lameness score 3.

Sows

Analysis of the data for lameness scored on the four-point scale showed that, if sample size was above 60, observers significantly ($P < 0.05$) agreed on all levels. The only exception were observer pairs including observer 7, who only agreed with other observers on score 0 vs score 1,2,3.

Analysis on the data for lameness scored on a scale 0-100% showed that all correlations between observers were significant ($P < 0.05$), except for observer pair 4-7 ($R_s = 0.30$, ns). Two correlations were high (above 0.7), the others were moderate (between 0.4 and 0.7). In line with the results for the four-point scale, observer 7 showed the lowest agreement with other observers.

TABLE 6.1 Percentage of sows and fattening pigs having a lameness score of 0, 1, 2, or 3 according to observer 1.

Type of pig	Lameness score			
	0	1	2	3
Sows (%)	80	15	4	2
Fattening pigs (%)	90	2	5	5

All observers showed significant associations ($P < 0.01$) between their scores on the four-point scale and the 0-100% scale.

Fattening Pigs

Analysis of the data for lameness scored on the four-point scale showed that, if sample size was above 32, observers significantly agreed ($P < 0.05$) on all scores, with the exception of observer pair 4-7.

Analysis of the data for lameness scored on a scale 0-100% showed that all but one correlation were significant. With regard to the size of the correlations, most correlations between observers were moderate, only two were high (above 0.7). All observers showed significant associations ($P < 0.01$) between their scores on the four-point scale and the 0-100 % scale.

6.4.2 VIDEO OBSERVATIONS

Analysis of the data for lameness in sows and fattening pigs, scored from video on the four-point scale, showed that observers significantly agreed on all levels ($P < 0.01$).

6.5 DISCUSSION

In the current study, most sows and fattening pigs had a normal gait. Percentages of severely lame sows and fattening pigs were similar to those found in other studies (Kroneman et al., 1993b; Petersen et al., 2004; Scott et al., 2006). Lameness problems were not clearly related to leg- or foot lesions, confirming results of Kroneman et al. (1993b). On the contrary, Gjein and Larssen (1995) and Leeb et al. (2002) reported that the risk of lameness increased with increasing claw lesion score and with the presence of claw infections.

With regard to direct observations in sows, inter-observer reliability for the four-point scale was high, except for observer pairs including observer 7. Results for fattening pigs were similar. A study by Main et al. (2000), testing a lameness scoring system for finishing pigs on a 0-5 scale, showed that there was a high level of agreement between trained observers but low agreement between untrained observers. Petersen et al. (2004) found a low agreement between trained observers when estimating prevalence of lameness on a 0-1 scale in finishing pigs. They suggested that this might be because the observers scored pens one at a time, whereas lameness might be intermittent. In the current study all

observers scored the pigs at the same time. Therefore, observer 7 who systematically disagreed with other observers, while all other observer pairs showed agreement, could be considered as not well trained yet.

Within observers, the four-point score showed a high association with the percentage score. Correlations among observers for the percentage score were rather moderate (between 0.4 and 0.7) than high (> 0.7). In general, only correlations above 0.7 should be considered as showing a marked relationship (Martin and Bateson, 2001). A more detailed scoring system may lead to a decrease in repeatability due to the confines of subjective scoring (Winckler and Willen, 2001; but see Tuytens et al. in press). As the percentage scoring system did not seem to provide more detailed information than the four-point scale, we suggest to score lameness on a four-point scale only.

Also from videotape, lameness can be reliably scored on the four-point scale, with the advantage that the tape can be reviewed.

6.6 CONCLUSION

In conclusion, for both sows and fattening pigs, lameness can be reliably scored on the four-point scale, live as well as from video tape. Within observers, the four-point score showed a high association with the percentage score. Since correlations among observers for the percentage score were rather moderate than high, we advise to score lameness on a four-point scale only.

REPEATABILITY OF A LAMENESS SCORE AT SLAUGHTER

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K. Vermeulen, C.G. van Reenen and F.A.M. Tuytens

7.1 SUMMARY

According to Grandin (1996), poor condition of animals arriving at the plant, such as cripples is one of the five basic causes of animal welfare problems in slaughter plants. The objective of this study was to test inter-observer variability of a lameness score as a parameter for monitoring the welfare of fattening pigs at slaughter. Two Belgian and two Spanish slaughterhouses were visited. During direct observations, the fraction of lame pigs in a total number of 173 groups of pigs was scored at two events: 1) during unloading and 2) during movement to lairage. Three observers out of a pool of nine observers were present at each location. Video-recordings were made in slaughterhouse 1 and 2, and 4 observers scored the fraction of lame pigs/group in 79 groups during unloading and 3 observers scored 59 groups during movement to lairage.

With regard to direct observations at unloading, 5 out of 11 observer pairs did not agree on the presence/absence of groups with lame pigs and consequently, the associated Spearman's Rank Correlations on the fraction of lame pigs/group were not significant. Those correlations that were significant, were low. In general, it was difficult to score lameness at unloading, especially if pigs were unloaded from the third or second tier; as they would slide or rush down group-wise from the ramp, this did not allow a clear and unobstructed view of every individual pig.

In lairage, all observer pairs agreed on the presence or absence of groups with lame pigs. As pigs moved slower and slid less than at unloading since the surface was horizontal, it was easier to score lameness. However, since Spearman's Rank correlations were only moderate, it is apparently difficult to spot all lame individuals. A clear and unobstructed view of every moving animal is often not possible when pigs are moved group-wise.

Lameness scored from videotape resulted in all 6 observer-pairs agreeing on the number of groups with lame pigs at unloading, and 2 out of 3 observer pairs agreeing on the number of groups with lame pigs in lairage. Associated Spearman's rank correlations for

the fraction of lame pigs in a group were significant but moderate. Thus, lameness can be scored from videotape as well, but this requires quite some pre-editing of the tape in order to artificially define distinguishable groups, and involves a risk of artificially reducing inter-observer variation.

We conclude that scoring lameness of fattening pigs at slaughter is a reliable welfare parameter, if it is scored in lairage and not during unloading.

7.2 INTRODUCTION

Lameness is very relevant for pig welfare because of direct painful effects and reduced ability to cope with the environment. According to Grandin (1996), poor condition of animals arriving at the plant, such as cripples is one of the five basic causes of animal welfare problems in slaughter plants. The objective of this study was to test inter-observer variability of a lameness score as a parameter for monitoring the welfare of fattening pigs at slaughter.

7.3 METHODS

Two Belgian and two Spanish slaughterhouses were visited. In total 24 lorries were included and 173 groups of pigs were scored for lameness (see Table 7.1).

Lameness was scored at two events: 1) during unloading (over the whole length of the unloading ramp) and 2) during movement to lairage, in the passageway from the point where the pigs left the ramp, for a length of 5-7 meters (the exact length was agreed upon by the observers before scoring started). Lameness was scored by direct observation of gait and by observation of gait from video-recordings made in slaughterhouse 1 and 2. The number of (slightly or severely) lame pigs per group was counted.

Table 7.1 Number of truckloads and groups studied in 4 slaughterhouses.

Slaughterhouse	Nr. of lorries	Nr. of groups
1	11	56
2	7	51
3	2	28
4	4	38

Direct observations: the experimental unit, i.e. subgroup of a truckload, was determined arbitrarily before unloading by a handler standing in the lorry, marking each group with a different colour code. By default, group size was 10; if group size was smaller (because it was the last animals on a tier), this was recorded by the handler. The experimental unit during unloading was similar to the one during movement to lairage. For estimating inter-observer repeatability, at least 3 observers at unloading and 3 observers in lairage (at each location: 1 observer from KUL-ZTC, 1 from CLO-DVL, 1 from IRTA Monells) counted the number of (slightly or severely) lame animals.

Video-recordings: as the colour codes were not easy to identify from video, it was decided to determine arbitrarily new experimental units on video, with each new unit being announced by a title slide. The experimental unit during unloading was thus not similar to the one during movement to lairage. Number of animals in a unit varied from 5 to 40. Data from both sites were analysed separately. Number of groups studied at unloading were 79 (48 from slaughterhouse 1 and 31 from slaughterhouse 2). For estimating inter-observer repeatability, 2 observers from ILVO, and 2 observers from IRTA Monells counted the number of lame pigs at unloading. Number of groups studied in lairage were 59 (29 from slaughterhouse 1 and 30 from slaughterhouse 2). For estimating inter-observer repeatability, 2 observers from ILVO, and 2 observers from KUL-ZTC counted the number of lame pigs in lairage.

7.3.1 Statistics

As the data were not normally distributed, non-parametrical tests were used for analysis.

As a preliminary test, Fisher's exact test was used to test agreement within observer pairs on absence/presence of groups with one or more lame pigs. Next, Spearman's rank correlation was used to calculate the association between the fractions of lame pigs / group within each observer pair.

All statistical analyses described above were performed with Genstat software, version 7.

7.4 RESULTS AND DISCUSSION

7.4.1 Direct Observations

For lameness at unloading, 5 out of 11 observer pairs did not agree on the presence/absence of groups with lame pigs and consequently, the associated Spearman's rank Correlations were not significant. Those correlations that were significant, were low.

In general, it was difficult to score lameness at unloading, especially if pigs were unloaded from the third or second tier. As they would slide or rush down group-wise from the ramp, this did not allow a clear and unobstructed view of every individual pig, and not every pig was seen while walking.

In lairage, all observer pairs agreed on the presence or absence of groups with lame pigs. As pigs moved slower and slid less than at unloading since the lairage surface was horizontal, it was easier to score lameness. However, since Spearman's Rank correlations were only moderate, it is apparently difficult to spot all lame individuals. A clear and unobstructed view of every moving animal is often not possible when pigs are moved group-wise.

7.4.2 Video Observations

Results from analyses of recordings made at unloading shows that all observers agreed on the number of groups with lame pigs, and that correlations on the fraction of lame pigs/group were significant but mostly moderate. Results from analyses of recordings made in lairage show that two out of three observer pairs agreed significantly and one showed a trend on the number of groups with lame pigs, and that correlations on the fraction of lame pigs/group were significant (two were moderate, one was high).

Thus, inter-observer reliability at unloading seems to be higher when scoring from videotape. The recorded images may have artificially reduced inter-observer variation because 1) visibility was somewhat lower than during live observations, 2) group size for video-recordings was larger, and 3) all observers saw the pigs from the same invariable angle. However, in order to appropriately score lameness, it is best to observe a pig from the front, the side and the back, which can be done as they pass the observer during live observations.

7.5 CONCLUSIONS

Scoring lameness of fattening pigs at unloading is not recommended because pigs often slide or rush down group-wise from the ramp. As a result, it is not easy to distinguish lame from non-lame animals. In lairage, lameness can be scored although the moderate Spearman's rank correlations show that a clear and unobstructed view of every moving animal is often not possible when pigs are moved group-wise. Lameness can be scored from videotape as well, but this requires quite some pre-editing of the tape in order to artificially define distinguishable groups, and involves a risk of artificially reducing inter-observer variation.

REPEATABILITY OF A SLIPPING SCORE AT SLAUGHTER

N.A. Geverink, A. Dalmau, A. Velarde, C.G. van Reenen and F.A.M. Tuytens

8.1 SUMMARY

Good animal welfare and calm handling at the slaughterhouse are impossible if animals slip or fall on the floor. The objective of this study was to test inter-observer variability of a slipping/falling score as a parameter for monitoring the welfare of fattening pigs at slaughter. Two Belgian and two Spanish slaughterhouses were visited. The fraction of pigs slipping and falling in a total number of 173 groups of about 10 pigs each was scored at two events: 1) during unloading and 2) during movement to lairage. Three observers out of a pool of nine observers were present at each location. Video recordings were made in slaughterhouse 1 and 2, and 4 observers scored the fraction of slipping and falling pigs/group in 79 groups during unloading.

In general, slipping and falling were observed mainly at unloading and incidentally in lairage, probably because pigs hardly slip or fall on horizontal surfaces. The percentage of pigs slipping and falling at unloading depended on the lorry tier from which they were unloaded; the higher the tier, the steeper the ramp, the more pigs slipped and fell. During direct observations, 8 out of 9 observer pairs significantly agreed on the number of groups with presence or absence of slipping pigs. Spearman rank correlations on the percentage of pigs/group slipping were significant for all observer pairs and $r_s > 0.7$ in 8 out of 11 cases. Eight out of 11 observer pairs significantly agreed on the number of groups with presence or absence of falling pigs at unloading. The same pairs showed significant Spearman rank correlations on the percentage of pigs/group falling, but most correlations were moderate ($r_s < 0.7$), probably due to the lower incidence of pigs falling than slipping. The three pairs that did not agree all included the same observer. If an observer systematically disagrees with other observers, while all other observer pairs show agreement, this observer should be considered as not well trained yet. Inter-observer reliability for video observations were in the same range as those for direct observations.

Due to the low numbers of pigs slipping and falling in lairage, the inter-observer reliability on the recordings of slipping in lairage was low, and no reliability testing on the data of falling could be done. Thus, slipping and falling should be observed at unloading, for pigs

from all tiers. A slipping/falling score seems to be a reliable parameter for monitoring the welfare of fattening pigs at slaughter.

8.2 INTRODUCTION

Good animal welfare and calm handling at the slaughterhouse are impossible if animals slip or fall on the floor (Grandin, 2003). The Council Directive 93/119/EC states that unloading equipment in slaughterhouses must have non-slip flooring to prevent slipping and falling. Grandin (2000) mentions the percentage of pigs that slip or fall during handling as one of the five major critical control points for monitoring welfare at slaughter plants. The objective of this study was to test inter-observer variability of a slipping score and a falling score as parameters for monitoring the welfare of fattening pigs at slaughter.

8.3 METHODS

Two Belgian and two Spanish slaughterhouses were visited (see Table 8.1). The type of unloading ramp present in each slaughterhouse is listed in Table 8.1. Crossover bridges attached to the vehicles were always made of metal.

Slipping and falling were scored at two events: 1) during unloading (over the whole length of the unloading ramp) and 2) during movement to lairage, in the passageway from the point where the pigs left the ramp, for a length of 5–7 meters (the exact length was agreed upon by the observers before scoring started). Scoring during moving to the place of stunning was abandoned as this location was too crowded with pigs.

The number of animals within a subgroup slipping and/or falling was scored by direct observation and by observation from video recordings. Video recordings were made in slaughterhouse 1 and 2. ‘Slipping’ was defined as: loss of balance without body touching the floor (Grandin, 1996). ‘Falling’ was defined as: loss of balance with body (i.e. other

TABLE 8.1 Number of lorries and groups studied during direct observations in four slaughterhouses.

Slaughterhouse	Country	Type of unloading ramp	Nr. of lorries	Nr. of subgroups
1	Belgium	Metal, adjustable	11	56
2	Belgium	Rubber, adjustable	7	51
3	Spain	Concrete, not adjustable	2	28
4	Spain	Metal, adjustable	4	38

part than legs) touches the floor. It was registered from which lorry tier (lower, middle, top) a subgroup was unloaded.

Direct observations: The experimental unit, being subgroups of a lorry, was determined arbitrarily before unloading by a handler standing in the lorry. To enable the observers to distinguish the subgroups, the handler marked each group with a different colour code. By default, the group size was 10; if group size was smaller (e.g. because it were the last animals on a tier), this was recorded by the handler. The experimental unit during unloading was similar to the one during movement to lairage. For number of subgroups studied, see Table 8.1. For estimating inter-observer repeatability, 3 or 4 observers at unloading and 3 observers in lairage (at each location: 1 observer from KUL-ZTC, 1 from ILVO, 1 from IRTA Monells) counted the number of pigs slipping and falling.

Video recordings: as the colour codes were not easy to identify from video, it was decided to determine arbitrarily new experimental units on video, with each new unit being announced by a title slide. Because during direct observations, pigs were hardly observed to slip or fall in lairage, only recordings made at unloading were studied. Number of subgroups studied at unloading were 79 (48 from slaughterhouse 1 and 31 from slaughterhouse 2). For estimating inter-observer repeatability, 2 observers from ILVO, and 2 observers from IRTA Monells counted the number of pigs slipping and falling within each group.

8.3.1 Statistics

As the data were not normally distributed, non-parametrical tests were used for analysis.

As a preliminary test, Fisher's exact test was used to test agreement within observer pairs on absence/presence of subgroups with pigs slipping or falling. Next, Spearman's rank correlation was used to calculate the association between the percentages of pigs slipping/falling per subgroup within observer pairs. All statistical analyses were performed with Genstat software, version 7.

8.4 RESULTS AND DISCUSSION

In general, slipping and falling were mainly observed at unloading and incidentally in lairage; pigs hardly slipped or fell at horizontal surfaces (see Table 8.2).

TABLE 8.2 Percentage of pigs recorded as slipping or falling in 4 visited slaughterhouses.

Slaughterhouse	% pigs slipping at unloading ^a	% pigs falling at unloading ^a	% pigs slipping in lairage ^b	% pigs falling in lairage ^b
1	21.6	3.6	2.4	.2
2	16.3	4.5	2.4	0
3	22.6	13.6	1.1	0
4	63.8	8.4	0	0

Notes: ^a as scored by observer 1 during direct observations; ^b as scored by observer 6 in slaughterhouse 1 and 2, and by observer 8 in slaughterhouse 3 and 4 during direct observations.

8.4.1 Unloading

The percentage of pigs slipping and falling at unloading depended on the tier from which they were unloaded; the higher the tier, the steeper the ramp, the more pigs slipped and fell (Table 8.3).

During direct observations, observers significantly agreed on the number of subgroups with presence or absence of slipping pigs, except for observer pair 1–5. Spearman rank correlations on the fraction of pigs/subgroup slipping were high, except for two observer pairs including observer 5, who showed moderate correlations (around 0.3).

Observers significantly agreed on the number of subgroups with presence or absence of falling pigs at unloading, except for pairs including observer 4. Spearman rank correlations on the fraction of pigs/subgroup falling were significant but most were moderate, one was high.

Results from video observations confirmed the results found during direct observations. For slipping, 4 out of 6 observer pairs significantly agreed on the number of groups with presence or absence of slipping pigs at unloading and for falling, all observer pairs agreed. All Spearman rank correlations on the fraction of pigs/group slipping or falling were significant. All but one correlation for slipping were high, all correlations for falling were moderate.

8.4.2 Lairage

The inter-observer reliability for direct observations of slipping in lairage was low; only one pair of observers agreed on the number of subgroups containing pigs slipping. A Spearman correlation coefficient for the fraction of pigs/subgroup falling could not be calculated due to too many zero's in the data set.

Due to the low number of pigs observed as falling in lairage (0 to 3 in total depending on the observer), no reliability testing on these data could be done.

TABLE 8.3 Percentage of pigs from each tier, recorded as slipping or falling at unloading by observer 1 during direct observations.

Lorry deck	n (subgroups)	% pigs slipping	% pigs falling
1 (bottom)	81	15.6	2.7
2 (middle)	61	36.9	8.1
3 (top)	31	42.8	11.9

8.5 CONCLUSIONS

Slipping and falling should be observed at unloading, since this is the location where it is mainly observed, notably when pigs are unloaded from the middle or top tier of a lorry. In lairage, on horizontal surfaces, pigs will hardly slip or fall.

With regard to direct observations, inter-observer reliability for number of subgroups containing pigs slipping, and for the fraction of pigs/subgroup slipping was high for all but two observer pairs. Inter-observer reliability for number of subgroups containing pigs falling was high except for observer pairs with observer 4. Reliability for the fraction of pigs/subgroup falling was only moderate, probably due to the lower incidence of pigs falling than slipping. Results for interobserver reliability when slipping and falling were scored from videotape were similar to those for direct observations.

If an observer systematically disagrees with other observers, while all other observer pairs show agreement, this observer should be considered as not well trained yet.

STANDARDISATION OF HEALTH SCORING IN PIGS

K. Scott, J.H. Guy, V. Hautekiet, L. Van Steenberghe, R. D'Eath and S.A. Edwards

9.1 SUMMARY

Much of the available scientific literature on health conditions in pigs relates to prevalence and/or severity; very few of these studies have provided detailed methodologies on how clinical symptoms were assessed. Even fewer studies have investigated validation, repeatability and inter- and intra-observer reliability, all of which are important considerations when attempting to develop an on-farm welfare assessment tool. Documented methodologies, in addition to practical experiences, were reviewed and discussed, and a protocol was formulated for on-farm health assessment in pigs as an indicator of welfare status. The protocol covers six different health domains:

1. respiratory problems (weaners and finishers)
 - coughing and sneezing, pumping, twisted snouts;
2. enteric problems (sows, weaners and finishers)
 - rectal prolapse, scouring, solid faeces (constipation), hygiene of pigs
3. neurological problems (sows, weaners and finishers);
4. reproductive problems (sows)
 - metritis, mastitis, uterine prolapse;
5. general debility (sows, weaners and finishers)
 - body condition, condition of the skin/coat, posture/demeanour;
6. others (sows, piglets, weaners and finishers)
 - lameness, splay leg, ruptures and hernias and local infections.

A 0–2 severity scale was agreed upon for most domains, where a score of 0 was indicative of acceptable welfare, a score of 1 was indicative some compromise of welfare, and a score of two was indicative of a serious and unacceptable welfare problem. These scores can be applied at the level of the individual for sows, or at pen level for growing pigs.

9.2 INTRODUCTION

The objective of this review is to provide standardisation for measurement of the following health parameters, both on-farm and at the abattoir:

1. respiratory problems (sows, weaners and finishers)
2. enteric problems (sows, weaners and finishers)
3. neurological problems (sows, weaners and finishers)
4. reproductive problems (sows)
5. general debility (sows, weaners and finishers)
6. others (sows, weaners and finishers)

The aim is not to review the literature on the symptoms of individual diseases, but rather to review the indicators of general disease groups (e.g. respiratory, neurological etc.).

9.2.1 RESPIRATORY PROBLEMS

Coughing, sneezing, laboured breathing ('pumping') and twisted snouts are common indicators of a variety of respiratory problems. Whilst all of these indicators have been used in the scientific literature to monitor incidences of respiratory conditions, few studies have given detailed methodologies or reported on elements of validation and inter- and intra-observer reliability.

Coughing and Sneezing

Many studies have monitored incidences and severity of coughing as an indicator of a respiratory problem using differing methodologies. Thacker et al. (2006) used a simple classification of 0 = no coughing or 1 = coughing in their study, whilst Done et al. (2005) used a more subjective scale to assess coughing and also laboured breathing, where 0 = not observed, 1 = noticeable, 2 = obvious, and 3 = profound. Geers et al. (1986), investigating the relationship between transport conditions and the occurrence of coughing in growing pigs, forced the pigs to stand up during the journey, and recorded a pen as coughing if one or more pigs in that pen were observed coughing.

In some studies, the prevalence of coughing has been related to the severity of lung damage at slaughter. Halloy et al. (2004) induced bronchopneumonia by administering an *E. coli* endotoxin combined with *Pasteurella multocida* in the trachea of piglets. The cough frequency was individually counted for a 30 minute period by one observer who was able to simultaneously observe a maximum of ten previously-identified animals. A cumulative cough count (CCC) was calculated by addition of the daily cough counts for the duration

of the experiment. The CCC significantly increased from 1–14 days post-infection with *E.coli* and the cough changes were found to be proportional to the intensity of lung inflammation. The study concluded that coughing could be a potential indicator for the intensity and evolution of respiratory disease, and that it was also a good predictor for the magnitude of lung lesions at slaughter.

Maes et al. (1999) formulated a coughing index in their study. Pigs were observed in the morning, 10–20 seconds after they had been stirred. Twenty percent of pigs in a pen were randomly selected and examined during a three minute period, with the number of pigs that coughed once or more during this observation period recorded. The study examined the effects of vaccination against *M. hyopneumoniae*, and whilst they found that coughing was not specific for enzootic pneumonia, an overall clinical score expressed as a coughing index was useful to predict the prevalence of pneumonia in slaughter pigs.

Some studies have calculated the prevalence of coughing within a pen or house. Geers et al. (1989) forced pigs to stand up and subsequently observed them for five minutes. Pigs that were observed coughing were expressed as a proportion of animals in the whole house. Morés et al. (2001) assessed coughing at four different stages. At each stage, three counts of two minutes were made and the percentage of coughing was calculated by the average of the three counts in relation to batch size. Regression analyses were carried out on the data, and the study concluded that the quantification of coughing and sneezing could be used to estimate pneumonia and atrophic rhinitis indices respectively in growing-finishing pigs.

Escobar et al. (2002) recorded coughing when pigs exhibited a dry, non-productive cough that lasted three seconds or more during the time when they were being cleaned out (pneumonic coughing), and differentiated this from the sneezing and infrequent coughing that occurred when a pig put its snout into the feeder. Control pigs did not exhibit pneumonic coughing and did not have any lung lesions at slaughter.

No information on inter-observer reliability in scoring by any of these methods has been reported.

Twisted Snouts

Twisted snouts are characteristic of atrophic rhinitis and can vary in severity from a slight deformity of the snout to severe nasal distortion. Whilst the latter is easy to detect on-farm, there is a lack of documented scoring systems for assessing twisted snouts in the live pig. Most studies have assessed the degree of erosion of turbinate bones on the nasal cavity post-slaughter (D’Allaire et al., 1988; Collins et al., 1989).

9.2.2 ENTERIC PROBLEMS

Rectal Prolapse

Rectal prolapse, the extrusion of a section of the rectum through the anus, is relatively common on pig units and is associated with a number of factors resulting in an increase in intra-abdominal pressure including straining associated with enteritis and diarrhoea, pigs gorging on liquid feeding and the feeding of flatulent diets (Straw et al., 2006). Rectal prolapses can occur in pigs of various ages and are frequently sporadic in nature. Whilst there is an abundance of scientific literature on studies investigating the prevalence and cause of the condition, there is a lack of studies which have qualitatively assessed the severity of rectal prolapse.

Faecal Consistency

The consistency of faeces may vary according to the diet that is offered, however scouring may be considered to occur when there is a change to a more fluid consistency than normal, especially when associated with signs of either large- or small-intestine disease (Straw et al., 2006). The use of faecal consistency scales has been well documented, but the exact scale has varied greatly between studies. Scott (unpublished data) used a 1–5 scale when assessing faecal consistency in finishing pigs at a pen level, where 1 = thin watery manure, 2 = liquid dairy like manure, 3 = a weak and shapeless heap of dung, 4 = a soft cylindrical turd, and 5 = a firm, dry and stackable cylindrical turd. Owusu-Asiedu et al. (2003) used a four-point faecal consistency score system (0 = normal; 1 = soft faeces; 2 = mild diarrhoea; and 3 = severe diarrhoea). Taras et al. (2006) assessed faecal consistency daily, using a scale from 1 to 4 (firm to liquid) to investigate the effects of probiotic diet supplementation. Diarrhoea was defined as liquid consistency over a minimum of two days. Whilst they found that there were no overall treatment differences in body weight gain, feed intake or feed efficiency in piglets (weaned at 28 d), the overall incidence of diarrhoea was reduced from d 28–56 in pigs that received the probiotic supplement in their diet. Wellock (personal communication) used a four-point scale (1 = firm, 2 = soft, spreads slightly, 3 = very soft, spreads readily, 4 = watery like consistency) with half-point increments for increased accuracy for assessing faecal consistency at a pen level.

Vente-Spreeuwenberg et al. (2003), investigating the interrelationships between gut morphology and faeces consistency in newly weaned pigs, quantified faecal consistency using a scale ranging from 0–3: 0 = normally shaped faeces, 1 = shapeless (loose) faeces, 2 = thick, liquid (soft) faeces, and 3 = thin, liquid faeces. They reported a negative correlation between villus height and the excretion of more-liquid faeces (r Pearson = -0.14, $P < 0.01$), and found that piglets without diarrhoea tended to have deeper crypts than piglets with diarrhoea ($P < 0.10$). They concluded that the relatively simple measure of faecal consistency could reflect the more complex measure of small intestinal villus height.

In contrast to diarrhoea, no use of a scoring scale for increased solidity of faeces resulting from constipation has been found in the literature.

Colour of Faeces

The colour of scour can aid diagnosis of a health condition. Porcine Intestinal Adenomatosis (PIA) is associated with loose dark tarry-coloured faeces that have an offensive smell. Gastro-oesophageal ulceration is associated with dark-coloured faeces that are often hard and pelleted. Coccidiosis often results in a watery yellow-grey scour with an offensive odour, although some infected pigs may have 'sheep pellet' faeces, and watery yellow faeces are often indicative of Salmonella. Whilst associations have been made in the literature between colour and consistency of faeces and enteric conditions, these tend to be in relation to identifying one specific disease/condition, and not as indicators of general enteric disease.

Pig Hygiene

Faecal material can be a source of infectious agents, and therefore minimising contact between pigs and their excrement is important in terms of reducing possible disease risks. It is also important in relation to carcass contamination. Morgan et al. (1987) reported a strong correlation between the proportion of animals with Salmonella spp. in their faeces and the proportion of contaminated carcasses at the end of the line. Scott et al. (2006) assessed the hygiene score of finishing pigs by visual estimation of the body surface area which was clean as opposed to soiled with faeces, reporting significantly lower levels of hygiene in straw-bedded pigs than in fully-slatted pigs.

9.2.3 NEUROLOGICAL PROBLEMS

Muscles Tremors and Paddling

Muscle tremors and paddling movements can be symptoms of a variety of neurological problems (Straw et al., 2006), without being specific to any particular single condition and as such, they are useful symptoms to consider when assessing pigs for neurological problems. However, there is a lack of scientific literature pertaining to qualitative assessment of tremors and paddling as general indicators of neurological problems.

9.2.4 REPRODUCTIVE PROBLEMS

Mastitis and Metritis

Whilst mastitis can have clinical implications for the lactating sow, it is also a common cause of failure to thrive in litters of piglets, and as a result it can be used as an indicator of both piglet and sow welfare. Mastitis can be difficult to diagnose in the early stages (physical examination is necessary but can be difficult to carry out), although it is more apparent in severe cases. Österlundh et al. (2002) examined each mammary gland for signs of inflammation, such as a change in consistency and discolouration, and used an arbitrary scoring scale: none, mild, moderate and severe. Mahan et al. (2000) used a 0–3 score for the assessment of mastitis-metritis-agalactia. A score of 0 indicated that the udder reflected the normal state of post-farrowing conditions with visual evidence of an ample quantity of milk being supplied to the nursing litter and/or little or no abnormal quantity of discharge from the vagina. A score of 3 reflected a severe hardness of the udder and an indication ofagalactia (failure to produce milk) and/or a copious amount of discharge from the vagina.

9.2.5 GENERAL DEBILITY

Body Condition

The best measure of general debility is body condition. Body condition scoring in sows has been discussed in detail in another chapter of this book. However, there is a lack of documented scoring systems for assessing body condition in growing pigs.

Conditions of the Skin and Coat

Poor skin and coat condition is also a characteristic symptom of general debility, but also arises from specific diseases. Some of these diseases are restricted to the skin (for example, ear necrosis), whilst other skin conditions are symptomatic of more general pathophysiological conditions such as PDNS. Ivers et al. (1993), investigating the effects of supplemental niacin on sow reproduction and sow and litter performance, assessed the condition of the skin and coat since niacin deficiency is associated with dermatitis and a rough hair-coat. A score of 1 represented normal appearing hair and skin, a score of 2 represented a mild dermatitis or a rough hair-coat, and a score of 3 represented a severe dermatitis or an extremely rough hair-coat. Inflammation and/or discolouration of the skin can be clinical symptoms of a variety of different diseases; however, there is a lack of

scientific literature on the qualitative assessment of skin and coat characteristics as general indicators of health problems.

9.2.6 OTHERS

Lameness, lesions and wounds on the body can be serious welfare problems. However they will not be considered further within this review as they have been dealt with in detail in other chapters of this book.

There has been much research conducted in an attempt to identify the aetiology of splay leg (Straw et al., 2006), however there is a lack of information on qualitatively assessing the severity of the condition.

9.3 GENERAL DISCUSSION

Because of the limited documentation of scoring methodologies in the literature, much reliance is placed on practical experience when assessing different health parameters. None of the methodologies reviewed, with the exception of sow body condition, had information on repeatability and inter- and intra-observer reliability, and very few contained information on validation. Six major health domains were identified (respiratory, enteric, neurological, reproductive, general debility and others), and for each parameter, the authors sought to include indicators of the disease symptoms specific for each domain that assessors could qualitatively score on-farm. It is important that any protocol should not be construed as a diagnostic tool to identify individual health conditions, which is the responsibility of a veterinarian, but rather it should be used to highlight the presence of health problems affecting the welfare of animals.

Whilst each condition would need to be assessed according to its own individual scale, it was agreed that all should be scored using a 0–2 severity scale. The exception to this would be for conditions such as a prolapse, where they are either absent (score 0) or present (score 2). The qualifying description for each point on the scale is specific to the individual condition, however for most conditions, a score of 0 is indicative of acceptable welfare, a score of 1 indicates that there is some compromise of welfare, and a score of 2 indicates a serious and unacceptable welfare problem. Farms can then be classified by the proportion of animals or pens falling into each of these categories. It is hoped that the 0–2 scale will simplify matters for both the assessor on the farm, and also for the farmer, who at a glance, will be able to identify in which specific systems the welfare level on his farm is unacceptable.

HEALTH STATUS IN PIGS MEASURED AT SLAUGHTER

V. Hautekiet, L. Van Steenberghe, A. Dalmau and A. Velarde

10.1 SUMMARY

There are two ways for monitoring the health status of animals, on-farm or in the slaughter line by means of slaughter checks. Slaughter checks are a good measure to indicate disease problems on the farm. The data have intrinsic value to producers, veterinarians or others seeking to improve the health and productivity of swine herds. Inspection for gross lesions in slaughtered pigs is useful both for detecting and quantifying diseases in herds. Monitoring the prevalence of lesions supports assessment of disease spread within a herd. For some diseases, evaluation of the extent or severity of disease provides supplementary information which can aid assessment of the severity of disease or specificity of the lesions. Data considered most useful for on-farm decision making concerns white spots on livers, nasal turbinate atrophy, lesions indicative of sarcoptic mange and enzootic pneumonia (Mercy, 1990; Davies et al., 1992).

Severity scoring and disease prevalence estimates must be accurate and repeatable to provide reliable information on emerging disease and to detect changes in the prevalence of disease following the implementation of control programs. However, it must be kept in mind that the time required for resolution of many gross lesions is much shorter than the life of growing pigs. Therefore, disease events in early life are generally unlikely to be reflected at slaughter. So it should be remembered that the pigs inspected are not a random sample from the reference population but represents the largest (oldest) animals from that population. Moreover, the routine market group is biased by exclusion of dead and culled stock and animals retained for breeding.

In the abattoir, slaughter checks can be taken for each carcass. This gives us an idea of the health status of the pigs and there can be feedback to the farmer f.e. when there are a lot of white spots this indicates an *Ascaris suum* problem on farm. The farmer can be made aware of the problem.

This report is based on literature and own experiences regarding slaughter checks.

10.2 INTRODUCTION

There are two ways for monitoring the health status of animals, on-farm or in the slaughter line by means of slaughter checks. Slaughter checks are a good measure to indicate disease problems on the farm. The data have intrinsic value to producers, veterinarians or others seeking to improve the health and productivity of swine herds. Inspection for gross lesions in slaughtered pigs is useful both for detecting and quantifying diseases in herds. Monitoring the prevalence of lesions supports assessment of disease spread within a herd. For some diseases, evaluation of the extent or severity of disease provides supplementary information which can aid assessment of the severity of disease or specificity of the lesions. Data considered most useful for on-farm decision making concerns white spots on livers, nasal turbinate atrophy, lesions indicative of sarcoptic mange and enzootic pneumonia (Mercy, 1990; Davies et al., 1992).

Severity scoring and disease prevalence estimates must be accurate and repeatable to provide reliable information on emerging disease and to detect changes in the prevalence of disease following the implementation of control programs. However, it must be kept in mind that the time required for resolution of many gross lesions is much shorter than the life of growing pigs. Therefore, disease events in early life are generally unlikely to be reflected at slaughter. So it should be remembered that the pigs inspected are not a random sample from the reference population but represents the largest (oldest) animals from that population. Moreover, the routine market group is biased by exclusion of dead and culled stock and animals retained for breeding. Hence, the method is focusing on fattening pigs with health related lesions of tissues and organs at time of slaughter.

10.3 TYPE OF SLAUGHTER CHECKS

The following lesions are scored and severity scores are reported where appropriate.

10.3.1 Pleurisy

- Definition: inflammation of the pleurae, which can lead to adhesions of the lungs with the pleura.
- The population to which pleuritic lesions at slaughter should be related consists of pigs within the last 8–12 weeks of production.
- Type of scoring: pleurisy is scored according to the severity of the lesions:
 - grade 0: no pleurisy;
 - grade 1: <25% adhesion of lungs with pleura.

- grade 2: 25–50%;
- grade 3: >50%.

Simplified the scoring 0/1 can also be used (0= pleurisy absent, 1= pleurisy present).

10.3.2 Liver

- Definition: livers were examined for the presence of ‘white spots’, indicative for the trans-hepatic migration of the larvae of *Ascaris suum* (Christensen and Cullinane, 1990).
- Time of resolution: Since white spot lesions resolve after 40 days after inoculation with ascarid eggs, presence of milk spots at slaughter indicates a recent uptake of eggs and larval migration.

Liver disorders that show up in slaughtered animals are an indication that they were exposed to a worm infection in the last 4–6 weeks of the finishing period.

So the absence of white spots on the liver in slaughtered stock may not indicate that younger pigs or sows are free of parasitism.

Type of scoring

Livers are scored according to the number of white spots (Christensen and Cullinane, 1990):

- grade 0: no white spots on the liver;
- grade 1: < 10 white spots on the liver;
- grade 2: > 10 white spots on the liver¹

Also the intestinal presence of adult ascarids is an indicator of infestation. (Pointon et al., 1997).

10.3.3 Heart (Pericarditis)

- Definition: pericarditis is an indicator of polyserositis infections, possibly resulting from severe *A. pleuropneumoniae* infections, other primary polyserositis agents or secondary pneumonic infections.
- Type of scoring:
 - 0 = absent
 - 1 = present

10.3.4 Papular Dermatitis (Mange)

- Definition: Sarcoptic mange is caused by an infestation with the mite *Sarcoptes scabiei* var. *suis*.

The common hypersensitive form of sarcoptic mange in growing pigs is characterized by lesions of papular dermatitis (thickening or wrinkling and/or reddening of the skin, red spots on the skin).

- Type of scoring: each carcass is graded, based on the severity and distribution of typical lesions of papular dermatitis.

The grading system of Cargill and Dobson can be used:

- 0 = no signs of mange;
- 1 = mild lesions predominantly on buttocks, neck and ears;
- 2 = lesions widespread over body in moderate density;
- 3 = severe lesions widespread over body with areas of dense hypersensitivity papules, crusts on skin.

Score 2 and 3 are highly specific for the presence of the mite *Sarcoptes scabiei* var. *Suis*) (Straw. et al., 1999).

Surveillance of lesions at slaughter provides a simple mechanism for evaluating control programs. Hereby the timing and frequency of the treatment is important.

10.3.5 Arthritis

- Definition: inflammation of the stifle, elbow, tarsus, carpus, shoulder and/or hip joint.
- Type of scoring: absent or present + location.

10.3.6 Abscesses

- Definition: A circumscribed collection of pus, in any part of the body, formed by the disintegration and stretching of the tissues, usually due to injury, toxicities or infection from bacteria. Also abscesses in the neck occur due to non-hygienic injections.
- Type of scoring: absent or present + location.

Abscesses in the carcass and/or lungs are commonly associated with infections secondary to tail biting or other cutaneous wounds.

10.3.7 Ileitis (*Proliferative Enteropathy*)

- Definition: the terminal ileum is palpated to detect mucosal thickening as a result of *Lawsonia intracellularis* infection.
- Time of resolution: 4–6 weeks
- Type of scoring: Classification of lesions is based on gross thickening of the ileum and edema and congestion of the mesentery and serosa. It can be confirmed by histological examination (Christensen and Cullinane, 1990).

The terminal ileum is palpated and lesions in the ileum are graded according to the following criteria:

0= no abnormality detected;

1= mucosal thickening palpable from the serosal surface, suspicious for PIA;

2= severe thickening of the ileum wall, giving the appearance of hose-pipe gut – oedema and congestion of the serosa may be present.

10.3.8 *Progressive Atrophic Rhinitis*

- Definition: the degree of turbinate atrophy at the level between the upper first and second premolars. These progressive lesions are caused by toxigenic *Pasteurella multocida* and can be observed at slaughter. Animals with atrophic rhinitis have a distorted snout or atrophy of the turbinate bones can be seen.
- Time of resolution: 4–5 months.
- Type of scoring: snouts are scored for severity from grade 0 to 5. Snouts can be sectioned at the level of the upper second premolar tooth.

Photos of this scoring system are available.

The detection of AR is not routinely carried out in most abattoirs. Obviously distorted snouts are registered but it is difficult to look for atrophy of the turbinate bones in a longitudinally dissected carcass.

10.3.9 *Lungs*

- Definition: pneumonia, lungs with inflammatory processes on the surface, consolidation of the lung.
- Time of resolution: 8–16 weeks (Pointon et al., 1992).
- Type of scoring: The percentage of the lung surface affected is multiplied by the relative weight of each lobe (Maes, 1998). The apical and cardial lobes each represent 20% of the lung surface. The caudal or diaphragmatic lobes represent 60 % of the lung surface. The accessory lobes are not taken into consideration. Lesions of pneumonia under a certain form can indicate infection with *Mycoplasma*.

10.3.10 Fissures

Fissures on the lung are a sign of healed pneumonia lesions and can be used as detection for enzootic pneumonia (Maes, 1998).

- Type of scoring: absent (0) or present (1)

10.4 TYPE OF RECORDING

The frequency and timing of repeated inspections of a herd are highly variable and will be affected by many factors, including the health status and performance of the herd, possible seasonality of disease monitored, cost of inspection, herd size and the specific purpose for collecting data. Owing to seasonal fluctuations reported for several diseases (Straw et al., 1999), inspections should be performed quarterly to obtain a reliable profile of lesion prevalence in a herd. Additional checks can be strategically timed to allow monitoring of the efficacy of disease preventive measures. Less frequent checks may miss peaks of disease but may be useful diagnostically to identify causes of disease epidemics. Inspections also can be done, according to the disease history of the grower-finisher herd, to diagnostically investigate suspected problems and to determine what control measures need implementing.

It's highly recommended to record the slaughter checks with a hand held computer. This small computer can be connected with a normal computer by a docking station. In this way, data can be transferred easily to EXCEL® for Windows. Programs are available to automatically analyze the data. Advantages of using a hand held computer are: possible to note down very fast any pathological lesion, hands are free for palpation and analyzing the data can be done real fast. There is almost no chance to make any mathematical error, papers don't become dirty and there is the possibility for unambiguous scoring throughout different slaughterhouses.

10.5 CONCLUSIONS

The observation of slaughter checks is a proven method for detecting health and welfare related problems at farm level. The results can be used for advising on housing and management aspects in order to improve pig's health and welfare. However, the sampling

and observation method have to be standardized, taking into account circumstantial factors enabling straightforward comparison within and between farms.

DEAD ON ARRIVAL IN PIGS

V. Hautekiet, L. Van Steenberghe, A. Dalmau and A. Velarde

11.1 SUMMARY

Transportation is considered as a major stressor for farm animals, especially for pigs, and might have detrimental effects on the health, well-being, performance and ultimately on product quality (Stephens and Perry, 1990). Pigs are often stressed during loading beyond the limits of adaptation. The stress and excitement associated with handling and transport can lead to serious health problems and even death.

Mortality rates in slaughter pigs during transport or lairage are very different among EU countries. In different European countries mortality during transportation ranges from 0.01% to 1% (Allen, 1979; Warriss, 1998; Wajda and Denaburski, 2003). The combined effect of genotype and temperature probably explains this variation.

Mortality rate during transport increases in the case of breeds more susceptible to stress (Murray and Johnson, 1998; Gispert et al., 2000) and transported at higher temperatures as also in the case of pigs fed directly before transportation or transported in overcrowded trucks (Guardia et al., 1996; Wajda and Denaburski, 2003). Part of the death losses is related to rough, unmotivated and otherwise inadequate treatment by people who have to handle and transport the pigs (van Logtestijn et al., 1982). Stress can be reduced by using the hydraulic lift, not using electric prodders, minimizing the steepness of the loading bridge, etc. (van Putten and Elshof, 1978). So it is obvious that good facilities and good handling of stock is very important in reducing stress and thereby death losses during loading and in transit (Gorski, 2000).

When a pig arrives dead at the abattoir, death can be verified by testing the cornea reflex and heartbeat. The veterinarian responsible for ante-mortem inspection should register the number of dead animals arriving at the abattoir and the possible reason of death.

The number of deaths in transit and at lairage can be registered as a percentage of total number of pigs at the abattoir.

11.2 INTRODUCTION

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The number of deaths in transit and at lairage can be registered as a percentage of total number of pigs at the abattoir.

11.3 POSSIBLE CAUSES OF TRANSPORT LOSSES

Two factors are particularly important in determining mortality rates in transported pigs. The first is genotype, the second is ambient temperature (Warriss, 1998).

11.3.1 Porcine Stress Syndrome/Malignant Hyperthermia

Most cases of transport losses are attributed to the Malignant Hyperthermia Syndrome (or Porcine Stress Syndrome), which is frequently associated with stress-deaths (Robertson, 1987). This syndrome is genetically determined by the halothane gene, an autosomal recessive gene (van Logtestijn et al., 1982) named the ryanodine receptor gene (ryr-1). A DNA test for Porcine Stress Syndrome can be performed typing this skeletal ryanodine receptor gene (ryr-1). DNA samples can be isolated from blood (Pérez et al., 2002).

Stressful conditions such as transportation can trigger Malignant Hyperthermia Syndrome, ultimately leading to death (Fabrega et al., 2002). So, breeds susceptible to stress, such as the Piétrain and Belgian Landrace or genotypes containing genes from these breeds, are much more likely to die in transit (Lister et al., 1981; Grandin, 2002).

Stress susceptible pigs have an abnormality in their muscle metabolism, which makes the muscle overreactive to stressful stimuli such as high temperatures. The muscle is prone to excessive metabolism (muscular anaerobic glycolysis) and pigs develop hyperthermia and lethal blood potassium levels (Robertson, 1987; Gregory, 1998).

Porcine Stress Syndrome is manifested by muscle weakening, shivers, hyperthermia, excess of acid metabolic lactates in blood and may lead to cardiac and circulatory failure, in some cases resulting in death (Elliott et al., 2001), frequently rapid (Robertson, 1987).

The risk of deaths during transport can be minimized by careful selection of the breeding stock (Murray, 2000) and so improving the stress resistance of the breeds used (Fabiansson et al., 1979).

11.3.2 Heat Stress

When pigs are stress-susceptible or have been previously stressed (at loading) and are subjected to extremes of temperature and humidity, the return to a normal physiological state will be delayed, sometimes resulting in death by heat stress.

There is a rise in death losses during transport with increasing ambient temperatures. Transport losses are higher during the summer months than in the winter months due to a higher temperature and also a higher water vapour pressure in the air (Guisse and Penny, 1989; van Logtestijn et al., 1982)

Pigs are susceptible to high temperatures probably because of their limited thermoregulatory abilities. As they are not able to eliminate heat through their skin because they do not have functioning sweat glands, they lose temperature only by an increased breathing rate, panting or by wallowing to achieve evaporative cooling, the latter is not possible at transport. (Guardia et al., 1996; Warriss, 1998; Wajda and Denaburski, 2003).

Improvements to lower the mortality rates due to heat stress include optimal ventilation in vehicles, transportation during cooler parts of the day, improve the stress resistance of the breeds used (Smith and Allen, 1976; Warriss, 1995).

11.3.3 Fasting Level

The feeding regime prior to transport is linked to transport deaths. The pigs should not be transported too soon after feeding. Increased mortality is probably due to the fact that a full stomach causes a narrowing of the artery diameter, thus slowing blood circulation, what may result in failure of the whole cardiovascular system (Warriss et al., 1996).

Deaths in transit of pigs fed within two to six hours of transport were significantly higher than those who were fasted longer (Lohr, 1970). Warriss (1985) also reported a slight increase in mortality during transport in recently-fed pigs.

Overfilled intestines lead to more stress at the time of transport. In addition pigs are extremely susceptible to motion sickness, which can lead to vomiting and even death through choking (Warriss et al., 1996).

11.3.4 Overcrowding of Trucks

Overloading of trucks is a major cause of increased stress and death losses, probably to be explained by a combined effect of increased heat production and reduced capacity of heat loss (Robertson, 1987; Grandin, 2002). The loading density for pigs around 100 kg should not exceed 0.42 m² per pig (von Borell and Schaffer, 2005).

11.3.4 Other Factors

In general, it is accepted that the duration of the journey is an aspect of transport that can affect the welfare and meat quality of pigs (Bradshaw et al., 1996), the duration of the trip seems to be a risk for pig's mortality.

Slatted floors showed a significant relationship with the number of deaths in transit. One suggestion is that pigs taken off slatted floors may have increased difficulty in negotiating corridors, doors and ramps and are therefore exposed to further stress during loading (Robertson, 1987).

STANDARDISATION OF THE MEASURE ‘ACUTE PHASE PROTEIN’

A. Dalmau and A. Velarde

12.1 SUMMARY

The acute phase response (APR) in both humans and animals is defined as a non-specific reaction to tissue damage such as infection, inflammation, neoplasia and immunological disease. One of these effects corresponds to changes in the concentration of some plasma proteins, mainly synthesised in the liver, which are called acute phase proteins (APPs). Some of these proteins increase their serum levels (positive APPs) while other decrease (negative APPs). The positive APPs have been used in veterinary medicine to study the APR to inflammation and infection and can be used as markers of animal health and welfare. Positive APPs can be divided in major or moderate APPs. Major APPs are of higher interest to assess health and animal welfare of pigs than moderate APPs. Some recognised major APPs in pigs are haptoglobin (HP), PigMAP, C-reactive protein and serum amyloid A. To assess welfare, only HP and pig-MAP has been used. At slaughter, samples could be taken from blood after sticking, or from meat juice of the diaphragm. Different techniques exist to analyse each APP, although the ELISA technique described by Hiss et al. (2003) for HP and ELISA technique used by Piñeiro et al. (2003) or radial immunodiffusion (Mancini, 1995) for pig-MAP are best options. The main problem to consider APPs valid to assess animal welfare is the lack of standard basal values on healthy animals at different ages, states and farm conditions. In our opinion more information is needed about specific problems of animal welfare and their effect on APP. Therefore, the measure has a punctuation of 2 to be a candidate for the final monitoring system.

12.2 INTRODUCTION

The acute phase response (APR) in both humans and animals is defined as a non-specific reaction to tissue damage such as infection, inflammation, neoplasia and immunological

disease. The APR is a very complex reaction, involving local and systemic effects. One of these effects corresponds to changes in the concentration of some plasma proteins, mainly synthesised in the liver, which are called acute phase proteins (APP). Synthesis of APPs takes place in the liver after serum peaks of proinflammatory cytokines released by macrophages, one of the animal body's defence mechanisms against external agents. Some of these proteins increase their serum levels (positive APPs) while other decrease (negative APPs). The positive APPs have been used in veterinary medicine to study the APR to inflammation and infection and can be used as markers of animal health and welfare. However, positive APPs are divided in major and moderate APP. For instance, C-reactive protein (CRP) is a major APP, that increases over 200 times from a low, virtually negligible, normal level. Moderate APP's increase their concentration only 2–3 times during the response. Therefore, major APPs are of higher interest to assess health and animal welfare of pigs than moderate APPs. Other recognised major APP in pigs are haptoglobin, Pig-MAP and serum amyloid A (described as a major APP in pigs experimentally infected with *Actinobacillus pleuropneumoniae*).

Haptoglobin (HP) is an alfa-globulin with a molecular weight of approximately 125 kDa. It is the most widely used APP in pigs mainly due to the availability of methods for its quantification. C-reactive protein (CRP) has a molecular size of approximately 115 Kda. It is named C-reactive protein due to its ability to bind pneumococcal C-polysaccharide. Porcine HP and CRP were identified as major APP with significantly raised concentration after 24 hours, a peak by 48 hours and a return to normal levels within 6 days. The molecular weight of the native form of serum amyloid A (SAA) is estimated approximately 180 kDa as SAA normally is found in a complex with lipoproteins and Pig-MAP is an alfa2-glycoprotein.

12.3 ANALYSIS AND SAMPLING PROCEDURE

Some assays for APP are based on biochemical properties of some proteins. However, immunochemical assays are the most general method used, with the advantage of it high specificity and sensibility. The most common sample used for measurement of APP is the blood serum or plasma. However, saliva or meat juice can also be used, with the advantage that the collection of these fluids is non-invasive. Meat juice can be collected by freezing and thawing meat samples from the diaphragm collected at slaughter Regula et al. (2003).

12.3.1 Haptoglobin (HP)

A wide range of methods has been used for the quantification of pig haptoglobin, including biochemical assays based in the property of binding haemoglobin and immunochemical method like immunoprecipitation in gel techniques, nephelometry or ELISA. Saco et al.

(2003) determined haptoglobin for animal welfare purposes, using their capacity to bind haemoglobin. The radial immunodiffusion technique (Mancini, 1965) was also used for animal welfare purposes in studies of Segalés et al. (2004), Lampreave (1994) and Chapinal et al. (2003). Nephelometry was used by Fleisher et al. (2003) or Lipperheide (1998). Finally, Hiss et al. (2003) presented an ELISA method with a high correlation with the nephelometric method. In opinion of the authors, ELISA can analyze a much broader range of concentrations and needs less antiserum than the nephelometric method. This method was used to assess animal welfare by Geers et al. (2003), Gymnich et al. (2003), Regula et al. (2003) and Schmitz et al. (2003). Therefore, if results obtained in different laboratories and by different methods are going to be compared, a standardisation of the methodology is needed.

Haemolitical serum samples may interfere the quantification of HP, not only in the biochemical method but also in ELISA. However, the ELISA method described by Hiss et al. (2003) has the advantage that can be applicable to haemolytic samples and can be used in whole blood or blood serum. In the same study, these authors reported a good correlation between blood serum and meat juice with the ELISA system used. Therefore, meat juice samples might provide a matrix in which the Hp status of the animals is reflected and which can thus be used for endpoint controls at slaughter. Hiss et al. (2003) refused to use saliva samples due to the low sensitivity observed.

12.3.2 C-reactive Protein (CRP)

Three different techniques have been used to measure CRP in serum. Lampreave et al. (1994), for instance, used immunoelectrophoresis and observed an increase of 5–7 times in CRP using turpentine injection. Fleisher et al. (2003) used turbidimetry and reported significant relationships between C-reactive and haptoglobin in serum of lactating sows and growth performance of piglets. Finally, Petersen et al. (2003) used an ELISA technique, calculating the CRP concentration in porcine plasma and serum samples as units with the concentration of a commercial standard (Tridelta Ltd, Ireland). The same assay was used to measure CRP in the saliva of pigs by Moya et al. (2003). Saliva was collected by allowing the pig to chew a cotton bud. Subsequently, saliva was extracted from the cotton bud by centrifugation. Nevertheless, CRP could not be consistently detected in the saliva.

12.3.3 Serum Amyloid A (SAA)

The determination of SAA assays for veterinary diagnosis has been less widespread as that of Hp assays, probably because of the difficulty of measuring serum SAA levels. However, quantitative assays including indirect ELISA, noncompetitive enzyme immunoassay and the latex agglutination test have been used. According to Heegaard (1998), SAA increased their serum levels two days after infection with *Actinobacillus pleuropneumoniae*, although according to Gruys et al. (2005) SAA increases within four hours and the maximum is reached within 24 to 48 hours after initiation. SAA could not be consistently detected in the saliva using an ELISA test (Moya et al., 2003).

12.3.4 Pig-MAP

Segalés et al. (2004) used radial immunodiffusion (Mancini, 1995) to measure pig-MAP in the serum of pigs of farms with postweaning multisystemic wasting syndrome (PMWS), with an intra- and inter-assay coefficient of variation lower than 5%. Saco et al. (2003) used the same technique after diluting the serum samples 1/20 in saline solution to measure serum pig-MAP in pigs before transport, just after transport and after stunning for slaughter. According to authors, differences were observed 20-21 h after the beginning of transport and a significant correlation was found between pig-MAP and haptoglobin. Lampreave (1994) determined pig-MAP in serum by sodium dodecyl sulphate-polyacrylamide gel electrophoresis, obtaining an increase at least 15-fold after a turpentine injection. According to Ruiz de la Torre et al. (2003) a circadian rhythm exists in serum pig-MAP, with variations of about 25% during the day. Piñeiro et al., (2003a) concluded that stressors impair pig performance and that effects can be detected through the variation of serum concentration of pig-MAP and haptoglobin. The same authors (Piñeiro et al., 2003b) measured serum pig-MAP at farm, slaughterhouse arrival and slaughtering, (Piñeiro et al., 2003c) in gestating sows and boars.

12.4 REFERENCE AND NORMAL VALUES

12.4.1 HP

Some values obtained at farm in different stages and ages are given in Table 12.1. At slaughter, Geers et al. (2003), found an haptoglobin value in blood samples of 1.10 mg/ml with a within farm variability of 0.68.

12.4.2 CRP

According to Petersen et al. (2003), pigs free of disease have from 0,20 to 0,29 mg/ml CRP in serum and pigs with disease from 1.09 to 1.49, although more studies are needed for this APP and SAA.

12.4.3 Pig-MAP

According to Segalés et al. (2004), the concentration of pig-MAP in healthy pigs is of 0.4–0.8 mg/ml and can increase up to 6–8 mg/ml in acute inflammation. In Table 12.2 is given some values of pig MAP obtained at serum samples by different authors. No data has been found on saliva or meat juice samples.

TABLE 12.1 Values obtained by different authors of serum HP (mg/ml).

Item	HP value	Reference
Healthy suckling piglets – 2 weeks	.23±.23 SD	Hiss et al., 2003
Healthy weaned piglets – 4 weeks	.69±.42 SD	
Healthy fattening pigs – 6 months	.68±.39 SD	
Healthy pigs – 3 weeks (Farm with PMWS)	.78±.73 SD	Segalés et al., 2004
Healthy pigs – 7 weeks (Farm with PMWS)	1.10±.95 SD	
Healthy pigs – 12 weeks (Farm with PMWS)	1.90±.46 SD	
Healthy pigs – 28 weeks (Farm with PMWS)	1.59±.73 SD	
Healthy pigs	.10±.18 SD	Regula et al., poster
Healthy pigs low space	1.44±.07 SE	Geers et al., 2003
Healthy pigs medium space	1.19±.22 SE	
Healthy pigs high space	1.58±.11 SE	
Pigs with <i>Lawsonia intracellularis</i> presence	1.52±.05 SE	
Pigs with <i>Lawsonia intracellularis</i> absence	1.35±.06 SE	
Pigs with lung lesions	2.90±.60 SE	
Pigs without lung lesions	1.43±.15 SE	
Pigs with presence of abscesses	1.76±.19 SE	
Pigs with absence of abscesses	1.46±.05 SE	
Fasting pigs	1.46±.04 SE	
No fasting pigs	1.82±.23 SE	
Healthy pigs – 4 weeks	.59±.07 SE	Piñeiro et al., 2003d
Healthy pigs – 8 weeks	.69±.10 SE	
Healthy pigs – 12 weeks	1.36±.09 SE	
Healthy pigs – 16 weeks	1.00±.08 SE	
Healthy pigs – 20 weeks	.63±.06 SE	
Healthy gestating sows	1.29±.09 SE	Piñeiro et al., 2003c
Healthy boars	.73±.04 SE	
Healthy sows, 110 day of gestation	1.82±.92 SD	Gymnich et al., 2003
Healthy sows, 1st day of lactation	2.21±.80 SD	
Healthy sows, 3rd day of lactation	2.20±1.08 SD	
Healthy pigs at farm	.56±.09 SE	Piñeiro et al., 2003b
Healthy pigs at slaughterhouse arrival	.75±.09 SE	
Healthy pigs at slaughtering	1.07±.09 SE	
*Meat juice in healthy pigs	.10±.18 SE	Regula et al., 2003
Healthy piglets at farm	.22–.37	Piñeiro et al., 2003a
The same piglets 12 days later	.10–.43	
The same pigs one month later	1.26–1.94	
Healthy pigs in farm with PMWS	1.06±.73 SE	Segalés et al., 2003
No healthy pigs in farm with PMWS	2.52±.88 SE	

Notes: *Samples obtained from meat juice.

12.5 DISCUSSION

The use of major APP, mainly HP, but also CRP, SAA and pig-MAP, has been used to assess animal health and animal welfare on farm and at slaughter. APP levels in slaughter pigs are affected by the transport and the stock density. Under experimental conditions, when the factor studied (i.e. transport duration) is the only source of variability between animals, APP could be a good welfare indicator. Nevertheless, when animals from different farms, with different healthy status are compared, these factors of variability increase, and make difficult the interpretation of the results. For instance, after a long transport (36 h), the concentration of pig-MAP in pigs injected with a tranquilizer was 0.66±0.07 mg/ml and

TABLE 12.2 Values obtained by different authors of serum pig-MAP (mg/ml).

Item	Pig-Map value	Reference
Healthy pigs – 3 weeks (Farm with PMWS)	.86±.44 SD	Segalés et al., 2004
Healthy pigs – 7 weeks (Farm with PMWS)	.84±.52 SD	
Healthy pigs – 12 weeks (Farm with PMWS)	1.04±.48 SD	
Healthy pigs – 28 weeks (Farm with PMWS)	1.59±1.42 SD	
Healthy pigs – 4 weeks	1.05±.06 SE	Piñeiro et al., 2003d
Healthy pigs – 8 weeks	.96±.10 SE	
Healthy pigs – 12 weeks	1.59±.11 SE	
Healthy pigs – 16 weeks	1.12±.09 SE	
Healthy pigs – 20 weeks	.75±.04 SE	Piñeiro et al., 2003c
Healthy gestating sows	.96±.08 SE	
Healthy boars	1.24±.03 SE	
Healthy pigs at farm after long transport	.60±.07 SD	Piñeiro et al., 2003b
Healthy pigs at slaughterhouse arrival after l.tr.	.81±.07 SD	
Healthy pigs at slaughtering after long transport	1.09±.07 SD	
Healthy piglets at farm	.74–1.20	Piñeiro et al., 2003a
The same piglets 12 days later	.75–1.02	
The same pigs one month later	.69–1.37	
Healthy pigs in farm with PMWS	.76±.34 SE	Segalés et al., 2003
No healthy pigs in farm with PMWS	3.82±1.53 SE	

in pigs without tranquilizer 0.81±0.07 mg/ml (Piñeiro et al., 2003b). Nevertheless, a healthy pig in a farm with PMWS is around 0.76±0.34 mg/ml (Segalés et al., 2003) and a healthy gestating sow around 0.96±0.08 (Piñeiro et al., 2003c).

Values higher than 2 mg/ml of serum pig-MAP or HP are a clear indicator of healthy problems. In this case, the use of APP (mainly HP and pig MAP) has to be considered to assess animal welfare problems related with health. Other animal welfare problems have a lower release of APP and, in consequence, are more difficult to assess. In our opinion, to consider the use of APP to monitor animal welfare, more studies are needed to found reference values and some correction factors considering special cases (i.e. farms with PMWS).

Nowadays, serum and meat juice samples are usefulness to assess APP in animals, although a the concentration measured is lower than in blood, serum or plasma. Different techniques exist to analyse each APP, although the ELISA technique described by Hiss et al. (2003) for HP and ELISA technique used by Piñeiro et al. (2003) or radial immunodiffusion (Mancini, 1995) for pig-MAP could be the best options. Samples could be taken from blood during sticking at slaughter or from jugular vein at farm. In addition, samples from meat juice can be taken from the diaphragm if HP is analysed.

12.6 CONCLUSIONS

The main problem to consider APP as valid measure to assess animal welfare is the lack of basal values on healthy animals in different ages, states and farm conditions. In our opinion, more information is needed about specific problems of animal welfare and their effect on APP levels. Therefore, the measure has a punctuation of 2 to be a candidate for the final monitoring system.

According to the existing literature, two main APP have been used to assess animal welfare: HP and pig-MAP. Little information exists about other APP as CRP and SAA.

STANDARDISATION OF THE MEASURE ‘MEAT QUALITY’ TO ASSESS THE WELFARE OF PIGS AT SLAUGHTER

A. Dalmau, A. Velarde and M. Gispert

13.1 SUMMARY

Transport, lairage and slaughter conditions are of great importance for final meat quality, because ante mortem short-term or long-term stressors change the normal muscle metabolism and affect fresh meat colour, waterholding capacity, shelf-life, and technological yields. Stress before slaughter induces undesirable effects on the end quality of meat such as pale, soft, exudative (PSE) meat and dark firm dry (DFD) meat. PSE and DFD incidence is a relevant indicator of welfare during transport, lairage and slaughter. To identify these meat quality defects, different parameters are used: pH, electrical conductivity, colour, and drip loss. Guardia et al. (2004), using the Tecpro Pork Quality Meter (PQM) classified carcasses showing PQM values greater than $6 \mu\text{s}$ as PSE and those greater than 4 but lower or equal to $6 \mu\text{s}$ as prone to PSE. The measurement of the meat colour can also help to assess meat quality problems. Two different systems can be used to assess meat colour, a measure to assess a visual colour and a measure to assess an instrumental colour. The visual colour is assessed by subjective colour scales as the Japanese colour scale (Nakai et al., 1975). To measure the instrumental colour (objective measure) several types of instruments (colorimeters and spectrophotometers) are available. To further complicate this issue, each instrument offers a variety of options that allow researchers to choose, as for example the colour systems (hunter, CIE, and tristimulus). The CIE colour system is recommended and consisted in L^* , a^* and b^* values (CIE, 1976), where L^* is the lightness, a^* coordinate measures red-greenness and b^* coordinate measures yellow-blueness. According to Warner et al. (1997) and Channon et al. (2003b), carcasses can be classified as PSE when L^* value > 50 , and according to Simek et al. (2004) when $L^* > 55$. Finally, the formation of lactic acid and the resultant drop in pH in the post-mortem period are responsible for a destruction of protein and a loss of muscle to bind water. This protein destruction increases as higher is the drop in pH during the first hours after slaughtering. Therefore, the short-term stress affects it directly, increasing

the drip losses of the meat. The two reference methods to assess meat quality and animal welfare assessing drip loss could be considered the Honikel method (1987) and the Rassmussen and Anderson method (1996). According to Warner et al. (1997), Channon et al. (2003b) and Simek et al. (2004) carcasses can be classified as PSE when drip loss > 5%. In general, muscle selected to take all measures are Longissimus dorsi or Semimembranosus and a clear definition of the location of the sample taken is needed due to local differences in all the variables mentioned between muscles. At least, duplicate measures are needed for all the variables.

13.2 INTRODUCTION

Stress conditions during transport, lairage and at slaughter influence negatively meat quality. Both, pale, soft and exudative (PSE) meat and dark, firm and dry (DFD) are related to poor welfare conditions (Tarrant, 1989). At slaughter, the supply of oxygen to the muscle ceases, and any subsequent metabolic process is anaerobic. Therefore, the energy (ATP) is generated through breakdown of glycogen by glycolysis. Under these conditions, the breakdown of glycogen/glucose results in an accumulation of lactic acid, that could not be removed by the blood system and induces the progressive acidification of the muscle (Warriss, 2000). The drop in the muscle pH causes a destruction of muscle protein and the conversion of the muscle into meat. The final pH is inversely proportional to the concentration of lactic acid.

Ante mortem short-term or long-term stressors impair the normal muscle metabolism and affect fresh meat colour, waterholding capacity, shelf-life, and technological yields. Stress induces the mobilization of glycogen, and the accumulation of acid lactic. If the stress is around the time of slaughter, the presence of high concentration of acid lactic increases the acidification rate within the first hour after slaughter, and reduces de pH value. The affected meat becomes pale, soft, and fluid may drip from the surface (PSE meat). PSE meat is commonly defined as having a pH at 45 min post mortem of < 6 (Warriss, 2000). PSE usually occurs in pigs that are genetically sensitive to stress when subjected to acute stressors immediately prior to slaughter (Oliver et al., 1988), though it can occur also in normal pigs subjected to stressful conditions before slaughter.

On the other hand, if the animal is glycogen depleted before slaughter, less lactic acid will be formed after slaughter and the meat will not acidify normally. DFD is often defined as having an ultimate pH measured after 24 h of >6 (Warriss, 2000). In this case the meat will be very dry and dark in colour (DFD). The glycogen deficiency is associated with long-term stress conditions, i.e. low environmental temperatures, fighting when mixing or long fasting periods, when associated to long transports or long lairage times. In addition, prolonged rough handling causes muscle fatigue and reduces the muscle glycogen concentration at slaughter, producing DFD meat (Gispert et al., 2000).

PSE and DFD incidence is a relevant indicator of welfare during transport, lairage and slaughter. To identify these meat quality defects, different parameters are used: pH, electrical conductivity, colour, and drip loss.

13.2.1 pH

The measures of pH can be taken at different times, from 30 min after slaughter (Santos et al., 1997) to 24 h. Nevertheless, the great majority of authors agree to take measures of pH at 45 min and 24 h after slaughter. (Oliver et al., 1993; Barton Gade and Christensen, 1998; Fisher et al., 2000; Fortina et al., 2005; Correa et al., 2006; Mojas-Rojas et al., 2006).

The pH at 45 min (pH45) is used to assess PSE meat. Smith and Wilson (1978), Froystein (1981), Chadwick and Kempster (1983) and Oliver et al., (1988), defined meat as PSE when $\text{pH}_{45} < 6.0$ and Kallweit (1981) when $\text{pH}_{45} < 5.8$. However, the criteria to classify the meat as clearly PSE included also other parameters, as meat colour (colour evaluation), temperature of the carcass, and drip loss (Channon et al., 2003b; Simek et al., 2004; Mota-Rojas et al., 2006).

The pH at 24 h (pH24) alone can be used to assess DFD meat. A pH24 greater than 6.0 is related to DFD meat (Warriss, 2000). According to Guàrdia et al. (2005) a pH24 greater than 6.2 is related to a serious DFD problem.

The acidification rate and pH drop differ between muscles of the same animal. Therefore, to measure pH, a standardisation of the muscle and the area is needed. The muscle Semimembranosus and Longissimus dorsi are the more representative (Santos et al., 1997; Barton Grade and Christensen, 1998; Oliver et al., 2003; Fortina et al., 2005; Millet et al., 2005; Mojas-Rojas et al., 2006). The measure in the Longissimus dorsi can be carried out at the level of the last rib (Brown et al., 1998; Oliver et al., 1993; Josell et al., 2003; Foury et al., 2005), at the level of the 10th and 11th ribs (Hamilton et al., 2003; Mota-Rojas et al., 2006), between the 12th and 13th rib (Simek et al., 2004) or at the level of the 13th rib (can be the last one, but some pigs have 14 ribs; Millet et al., 2005). The vertebrae can be also taken as a reference point, and the pH can be measure either between the 13th and 14th thoracic vertebrae (Otto et al., 2006), at the last thoracic vertebrae (Lindahl et al., 2006), between the 4th and 5th thoracic vertebrae or between the 5th and 6th lumbar vertebrae (Channon et al., 2003a). Other muscles used are Biceps femoris (Santos et al., 1997; Barton Gade and Christensen, 1998; Channon et al., 2003a), Adductor (Santos et al., 1997) and Semispinalis capitis (Santos et al., 1997; Barton Gade and Christensen, 1998), although Biceps femoris and Semispinalis capitis are mainly used for pH at 24 h.

Optimal values of pH at 45 min are > 6.1 and at 24 h postslaughtering 5.6-5.9. Two to three measures are taken to obtain a mean value. The pH should be adequate to the temperature, as it affects the measure. The carcass is about 37–39°C at 45 m and 4°C at 24h after slaughter.

13.2.2 Electrical Conductivity

The electrical conductivity determines meat quality on the different cell membrane permeability and relative distribution of electrolytes. In fact, when the cell membrane permeability is altered, there is an accumulation of liquid and mineral salts in the intercellular space and the conductivity increases. A high electrical conductivity is associated with paler and wetter meat, and, therefore, with PSE meat. The electrical conductivity is given a measure of the waterholding capacity of the meat, with the advantage that can be obtained faster and before that the techniques based on drip loss.

The electrical conductivity is measured with an instrument inside a scale, for instance, the Pork Quality Meter used to measure from 0.0 to 20.0 microsiemens (μs). Nevertheless, the use of electrical conductivity to assess meat quality is contradictory. According to Pliquett and Pliquett (1998) the measurement is highly dependent on the system used. For instance, in a study carried out by Lee et al. (2000) two instruments for measuring conductivity at 24 h post mortem were used. The results obtained with the UWEC (University of Wisconsin-Madison) were highly correlated with drip loss ($r = 0.81$) but not those using the NWK LT K21 (NWK-Thien GmbH, Landsberg, Germany) ($r = 0.45$). The electrical conductivity should be measured, when the waterholding capacity of the muscle is stabilised.

Although the waterholding capacity is stabilised around two hours after slaughtering, in some animals the stabilisation can take more time. Therefore, it is recommended to standardise the measure at 24 h after slaughter. Similar to the pH value the measurements of conductivity at 48 and 72 h did not yield additional information. Two to three measures are necessary by muscle, due to the high variation observed by local effects. Conductivity alone has been used to assess PSE meat. Fàbrega et al. (2004), using the Tecpro Pork Quality Meter (PQM) defined PSE as meat with PQM values greater than 4 μs , while Guardia et al. (2004) classified carcasses showing PQM values greater than 6 μs as PSE and those greater than 4 but lower or equal to 6 μs as prone to PSE.

13.2.3 Meat Colour

Short-term stress induces pale meat (PSE meat) and long-term stress induces dark meat (DFD meat). In both cases, a change in the normal colour of the meat is detected. Therefore, the measurement of the meat colour can help to assess meat quality problems and, in consequence, the cause in terms of animal welfare.

There are three sources of colour variation in meat:

1. The content of pigment is a determining factor and is intrinsic to the muscle, being dependent on primary production factors such as species, age of animal and nutritional regimen.

2. The preslaughter conditions and the slaughter process itself affect colour by influencing the rate of pH decline and the ultimate pH, being, linked to animal welfare.
3. During storage, distribution and display, the processes of oxygenation and oxidation impact colour.

Two different systems can be used to describe meat colour, a measure of the visual colour and a instrumental method. The visual colour is measured subjectively according to references colour scales such as the Japanese colour scale (Nakai et al., 1975). In this case a score is given to the meat in accordance with a scale of different colours (from 1 to 6). Reference scales make the subjective description easier. An optimal range for meat would be around 3–4, but values lower than 3 or higher than 4 would be considered PSE and DFD meat, respectively. As this is a subjective measure is useful to use the mean scores of two observers.

To measure the instrumental colour (objective measure) several types of equipments (colorimeters and spectrophotometers) are available. To further complicate this issue, each instrument offers a variety of options that allow researchers to choose from several (1) colour systems (hunter, CIE, and tristimulus); (2) Illuminants (A, C, D65, and Ultralume); (3) observers angle (2° and 10°); and (4) aperture sizes (0.64–3.2 cm). The recommended parameters are a light source of D65 with the illumination/viewing system as 45/0 or 0/45 or diffuse 8 (d/8). The Commission Internationale de l'Eclairage (CIE) has specified a colour space referred as CIELAB (CIE, 1976). In this system, the tristimulus values are used to calculate three coordinates: L^* is the lightness component, a^* measures red-greenness, and the b^* coordinate yellow-blueness.

L^* , a^* and b^* value can be conveniently measures using portable tristimulus colour analysers such as the Minolta Chroma Meter (Minolta (UK) Limited). The samples need to be thick enough to prevent light passing through them. This means a minimum depth of at least 1 cm, and preferably 2.5 cm (Warriss, 2000). An L^* value of 45–53 is considered a normal range. According to Warner et al. (1997) and Channon et al. (2003b), meat can be classified as PSE when L^* value > 50, and according to Simek et al. (2004) when L^* > 55.

Both, the visual and instrumental colour is measured after 24 h post mortem, when the waterholding capacity of the muscles is entirely stabilised and no more pigments are losing with the exudate. As in the other parameters, the muscle, and the location within the muscle must be clearly specified due to the intrinsic differences between muscles. Colour measures are normally taken in the m. Longissimus dorsi. Sampling should be a cross-section taken perpendicular to the long axis of the muscle. If storage is to occur prior to exposing a surface for measurement of colour, the sample should be refrigerated at no higher temperature than 4°C. Storage conditions such as temperature, light and overlap or packaging must be specified. Blooming time is important and is dependent upon such factors as temperature. Some authors recommend that blooming be allowed for at least 1 h (time of blooming must be exact because can affect the colour of the meat by process of oxygenation and oxidation) at a maximum temperature of 4°C. Surface drying must be

avoided by use of an oxygen-permeable film or by control of humidity. Subsequent measurement may be made with or without the film in place depending upon the instrumentation. Nevertheless, according to Brewer et al. (2001), L^* value (instrumental colour) is unaffected by the bloom time, being the best predictor of visual pink colour intensity. Therefore, using the L^* value, a blooming fixed at 5 minutes could be enough. It is recommended to take duplicate measurements on different sites of the exposed surface. It must be recognized that in some muscles differences of considerable magnitude exist between lateral and medial sites on the cross-section of the muscle.

13.2.4 Waterholding Capacity

Waterholding Capacity (WHC) is the ability of the meat to retrain its water during cutting, heating, grinding, and pressing. The formation of lactic acid and the resultant drop in pH in the post-mortem period are responsible of the destruction of protein and a loss of muscle to bind water. This protein destruction increases as higher is the drop in pH during the first hours after slaughter. Therefore, the short-term stress affects directly the WHC. For the different phenomena of WHC, Hamm (1986) proposed the following terminology:

- Drip Loss (DL): Formation of exudates from meat (except thawing loss) without application of external forces.
- Thawing loss (TL): Formation of exudates from meat or meat systems after freezing and thawing without application of external forces.
- Cooking loss (CL): Release of fluid after heating of meat or meat systems either without or with application of external forces (e.g. centrifugation or pressing).
- Expressible juice (EJ): Release of juice from unheated meat or meat systems (also after freezing and thawing) during application of external forces such as pressing (e.g. filterpaper press method), centrifugation methods, or suction methods (e.g. capillary volumeter method).

So far, several groups have proposed different methodology to determine Waterholding Capacity. Additionally, there is a high diversity in procedures, for example concerning sample size or the force applied to the meat so that it is difficult to compare results from different methodology (see Table 13.1).

The two reference methods to assess drip loss are the Honikel method (1987) and the Rassmussen and Anderson method (1996).

According to Honikel (1987) the best method for measuring drip loss must conserve the integrity of muscle before the initial sampling takes place and that no external force other than gravity is applied when measuring drip. Orientation of the fibres with respect to the cut is also important. Surface evaporation has to be prevented and the method of supporting the meat piece should minimize the state of tension (suspended from above) and/or compression (supported from below). A bascule with sufficient accuracy (± 0.05 g), appropriate closable containers with net bottoms or sealable plastic bags with net casings and a room (cabinet or refrigerator) with controllable and near constant temperature are

TABLE 13.1 Methods developed to study drip loss in meat samples.

Authors	Method	Force Applied	Meat Sample
Grau and Hamm (1953)	Filter paper press method	External pressure method	.30 g
Hamm (1972)	Press method (using filter paper between two plates)	External pressure method	.30 g
Kauffman et al. (1986)	Filter paper method	External pressure method	.30 g
Honikel (1987)	The bag method	Gravimetric method	80–120
Lunström and Malmfors (1985); Honikel and Hamm (1994)	The tray method	Gravimetric method	–
Rasmussen and Anderson (1996)	EZ-DripLoss method: a method working with drip loss containers	Gravimetric method	10 g
Walukonis et al. (2002)	Method using absorptive material early post-mortem	Absorptive material method	–
Boutton et al (1971, 1972)	Centrifugation method	Centrifugal force	3–4 g

required. It is recommended to store the meat at +1 to +4°C. Meat samples are cut from the carcass 24 h after slaughter on m. longissimus dorsi and immediately weighted. The samples are then placed in the container, which is closed after filling in order to avoid evaporation into the environment. After the required storage time at the temperature under investigation (+1 to +4°C) samples are again weighed (48 h after slaughter). A weight of about 80 g is recommended. For commercial cuts a sufficient description of location in the carcass and cut should be given due to differences observed between different muscles in the same animal. To avoid/minimize loss of drip before first weighting, sampling must be immediate, minimum previous manipulation must be employed and strict temperature control is necessary. At least two samples of neighbouring positions and similar weight and shape should be used. Triplicates are recommended. At the end of experiments samples should be taken off the containers, mopped dry gently and weighed immediately. Calculation should be related to initial weight and presented as % drip loss.

Nevertheless, Honikel method (1987) is not the unique method that can be used, according to Rasmussen and Anderson (1996) the EZ-Drip Loss method is easier to use under abattoir conditions and easier to perform in a reproducible way. In addition it has a higher sensitivity. Furthermore, it is possible to detect local PSE spots using the EZ-Drip Loss method (Christensen, 2003). Nevertheless, it needs more time than Honikel (1987) technique (72 h after slaughtering) and space is needed in the slaughterhouse to clean the containers used and to store the samples more time. Sample collection rules are the same than for Honikel method (1987), except that only a 10 g sample is needed.

According to Warner et al. (1997), Channon et al. (2003b) and Simek et al. (2004) carcasses can be classified as PSE when drip loss > 5%.

13.2.5 Assessing PSE or DFD Meat

The pH at 24 h can be used to assess DFD meat and, in consequence, long-term stress in pigs. It is commonly defined as having a pH₂₄ greater than 6. The pH at 45 min can be used to assess PSE meat and in consequence short-term stress in pigs. It is commonly defined as having a pH₄₅ lower than 6. For assessing PSE, some authors have proposed a combination of parameters. Mota-Rojas et al. (2006) classified meat as clearly PSE when included pale colour (subjective colour evaluation), temperature of the carcass higher than 40°C, and a pH₄₅ < 5.5. According to Warner et al. (1997) carcasses can be classified as PSE when pH₄₅ was <6, L* value > 50 and drip loss > 5%. Channon et al. (2003b) classified PSE meat when pH₄₅<5.6, L* value > 50 and drip loss > 5% and according to Simek et al. (2004) when pH₁ < 5.6, L* > 55; drip > 5. The three last authors based on results obtained by Warner et al. (1997). In addition, conductivity and colour was used for Fàbrega et al. (2004) to assess PSE meat, considering loins showing PQM values > 6 μm and L* values > 53 as PSE.

13.3 CONCLUSIONS

Animal welfare problems related with short-term stress (including lairage conditions and driving to the stunner) and long-term stress (including farm handling, mixing, loading and transport) can affect meat quality, essentially affecting the water holding capacity of the meat, colour and tenderness. These problems are defined as PSE and DFD meats and can be assessed by measuring pH at 45 min and 24 h, drip loss, meat colour and conductivity at 24 h after slaughter.

To assess DFD meat pH 24 h can be used and to assess PSE pH at 45 min. Electrical conductivity at 24h can be also used to determine PSE meat.

Meat quality parameters measured in the slaughter line can be informative for pig's welfare during transport, handling and slaughter.

INTER-OBSERVER VARIABILITY OF STUNNING EFFECTIVENESS SCORING

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14.1 SUMMARY

The objective of the study was to assess the inter-observer variability of the measures to score stunning effectiveness at slaughter. The stunning effectiveness includes successful stunning (immediate loss of consciousness) and duration of the unconsciousness until animal death due to exsanguination. The signs of recognition of an ineffective stunning or recovery of consciousness are: corneal reflex (blinking response to touching the eyeball), rhythmic breathing (full cycle of inspiration and expiration occurring usually through the nose), vocalisation, attempts to raise the head, and righting reflex (attempt to recover the normal body position). Evaluation of inter-observer variability was scored from video clips and by direct observation at slaughterhouses. Corneal reflex was scored just after stunning to assess loss of consciousness and just before sticking, to assess recovery to consciousness. Sensibility to pain, rhythmic breathing, righting reflex and vocalisation were observed continuously from the end of the application of the stunning until 30 s after sticking. Any pig showing vocalisation or righting reflex was observed neither in the video clips nor by direct observation. Therefore, the repeatability of these measures was not assessed. Rhythmic breathing was only presented in the pigs recorded with a percentage of 7%. Corneal reflex was the parameter with the higher incidence (more than the 20% of the pigs). This reflex is generally the last reflex to disappear during loss of consciousness and the first one to reappear as consciousness. The absence of this parameter indicates that the animal is unconscious, but the presence does not distinguish accurately between consciousness and unconsciousness. The resumption rhythmic breathing indicates that the animal is already or close to becoming conscious, and the presence of righting reflex and vocalisation indicate that the consciousness has fully returned.

When scoring corneal reflex, the repeatability between observers was good (Spearman's rank correlation higher than 0.7). When scoring rhythmic breathing, the inter observer repeatability was medium (Spearman's rank correlation of 0.67). Although the righting reflex and vocalisation could not be assessed in this study, they are clear indicators of

onset to consciousness in pigs (EFSA, 2004) and, therefore, can not be excluded from the final proposal. It is suggested to include corneal reflex, righting reflex and vocalisations in the scoring system for assessing stunning effectiveness in pigs.

14.2 INTRODUCTION

The stunning effectiveness includes succesful stunning (immediate loss of conciousness) and duration of the unconsciousness until animal death due to exsanguination. The signs of recognition of an ineffective stunning or recovery of consciousness include: 1) corneal reflex, 2) response to painful stimulus, 3) rhythmic breathing, 4) vocalisation, 5) attempts to raise the head and 6) righting reflex. The objective of the work was to assess the interobserver variability of the different measures to evaluate stunning effectiveness in pigs.

14.3 METHODS

Four commercial abattoirs, two equipped with an electrically stunning system and two with CO₂, were visited in Spain and Belgium to assess the presence of signs of consciousness after stunning in pigs. Corneal reflex was assessed by touching the cornea with a blunt object (i.e. a pen). If the animal showed blinking response, the reflex was considered positive. If the eye didn't blinked or closed slowly, the reflex was considered negative. Sensibility to pain was assessed by a nose prick with a needle. If withdrawal of the head was observed, the response to the noxious stimuli was considered positive. Rhythmic breathing was assessed by observation of the respiratory movements of the flanks. Attempts to raise the head and righting reflex were assessed as a single parameter named righting reflex, and defined as voluntary movements of the animal to recover the normal body position. Vocalisation was defined as squealing. Corneal reflex and sensibility to pain, were assessed either immediately after stunning to evaluate succesful stunning or just before sticking, to evaluate recovery to consciousness. Rhythmic breathing, righting reflex and vocalisation were assessed along the slaughter line until the death of the animal. Thus, it was assessed animals incorrectly stunned and animals that might recover because delay in the sticking procedure or incorrect sticking. The evaluation of constrict pupil was rejected during preliminary observations, due to the difficulty to be assessed by different observers at the same time. The animals were assessed individually.

Evaluation of inter-observer variability was scored 1) from video clips and 2) by direct observation at slaughterhouses.

To evaluate inter-observer variability four sets of videos clips were recorded. The first one, with 20 records was used to train the observers. The second set, with 100 records, was assessed by 7 observers from IRTA to score corneal reflex and sensibility to pain. The third set, with 140 records, was assessed by 18 observers (2 from K.U. Leuven, 2 from ILVO, 8 from UAB and 6 from IRTA) to score also corneal reflex and sensibility to pain. The fourth set, with 37 records, was assessed by 18 observers to score rhythmic breathing, righting reflex and vocalization. The observers from K.U. Leuven, ILVO and one observer from IRTA scored the video clips alone on a computer. The rest of observers of IRTA and UAB scored the video clips in two separate sessions with a projector.

Direct evaluation at slaughterhouses was carried out by 5 observers in the two abattoirs of Belgium and 6 observers in the two abattoirs of Spain. During the evaluation, corneal reflex, sensibility to pain, rhythmic breathing, righting reflex and vocalisation from a total of 425 pigs, in Belgium and 420 pigs in Spain were scored.

A general model (PROC GENMOD) of the Statistical Analysis System (SAS; software SAS Institute Inc., Cary, NC; 1999–2001) for repeated measures and binomial distribution was used to study differences between observers. In addition, Spearman's Rank correlation was used to calculate the association between observer pairs. The significance level was fixed at $P < 0.05$.

14.4 RESULTS

14.4.1 Corneal Reflex

In the videos clips, the 23% of the animals showed corneal reflex in the second set of videos clips ($n=140$) and the 34% in the third one ($n=100$). In the Belgian abattoirs, the 19.2% and 19.6% of the animals showed corneal reflex in the electrical and CO₂ stunning systems, respectively. In Spanish abattoirs, the 19.3% and 32.0% of the animals showed corneal reflex in the electrical and CO₂ stunning systems, respectively.

According to the GENMOD procedure of SAS, no differences were found between observers in the second (chi-square = 24.18; d.f. = 17; $P = 0.1146$) and third set of video clips (chi-square = 9.86; d.f. = 6; $P = 0.1306$). When direct evaluation was carried out, no differences were found between observers in the abattoirs of Belgium (chi-square = 8.19; d.f. = 4; $P = 0.0847$), but an observer effect was found in the results of Spain (chi-square = 29.97; d.f. = 5; $P < 0.0001$). The mean Spearman's rank correlation between paired observers was 0.83 for the second set ($n=140$), 0.85 for the third set ($n=100$), 0.80 for the

direct observations in Spain, and 0.76 for the direct observations in Belgium. In general, from the 174 Spearman correlations studied between observers when video records were used for the assessment, it was found that in 32 cases the correlation was higher than 0.90 and in 5 cases lower than 0.70. The correlations for the direct observations are shown in Tables 14.1 and 14.2.

14.4.2 Sensibility to Pain

Any pig did not show sensibility to pain, neither in the video clips nor by direct observation. Therefore, the repeatability of this parameter could not be assessed.

14.4.3 Righting Reflex

Any pig did not show righting reflex, neither in the video clips nor by direct observation. Therefore, the repeatability of this parameter could not be assessed.

14.4.4 Vocalisation

Any pig did not show vocalisation, neither in the video clips nor by direct observation. Therefore, the repeatability of this parameter could not be assessed.

TABLE 14.1 Spearman's rank correlation between pairs of observers of corneal reflex assessment in Spain.

3a	A	B	C	D	E
A					
B	.74				
C	.75	.87			
D	.69**	.82	.80		
E	.75	.82	.85	.81	
F	.77	.85	.89*	.80	.82

Notes: * correlations higher than 0.90; ** correlations lower or equal than 0.70.

TABLE 14.2 Spearman's rank correlation between pairs of observers of corneal reflex assessment in Belgium.

3b	A	B	C	D
A				
B	.77			
C	.76	.83		
D	.70**	.71	.74	
E	.71	.71	.75	.89*

Notes: * correlations higher than 0.90; ** correlations lower or equal than 0.70.

14.4.5 Rhythmic Breathing

The 7% of the animals video recorded showed rhythmic breathing and only 1 of the 845 animals assessed in the four slaughterhouses visited, showed this indicator of onset to consciousness. Therefore, the repeatability of this parameter was only assessed in the video clips.

According to the GENMOD procedure of SAS, no differences were found between observers in the video clip (chi-square = 17.18; d.f. = 15; P = 0.3082). The mean Spearman's Rank correlation between paired observers was 0.67. In general, from the 153 Spearman correlations studied between observers, it was found that in only 2 cases the correlation was higher than 0.90 and in 83 cases lower than 0.70.

14.5 DISCUSSION

According to the results of the study, the only parameter scored that showed a high correlation (> 0.7) was the corneal reflex. This reflex was also the parameter with the highest incidence in slaughter pigs after stunning (around 20% of animals). The corneal reflex is generally the last reflex to disappear during loss of consciousness and the first one to reappear as consciousness. However, as it has been observed also in unconscious animals, the presence of this reflex does not distinguish accurately between consciousness and unconsciousness. However, when it is absent, it is likely that the animal is unconscious (Anil, 1991; Gregory, 1998).

The rhythmic breathing has medium correlation between observers (mean Spearman's rank correlation between paired observers = 0.67). The incidence of pigs that showed this parameter is also low. The resumption of this reflex indicates that the brain stem has resumed some normal function and the animal is already or close to becoming conscious.

Finally, any of the animals assessed did not show response to painful stimulus, righting reflex, or vocalisation. The response to painful stimuli like a nose prick with a hypodermic needle is a useful parameter to determine the perception of a noxious stimulus. However, absence of response can occur in conscious animals due to the analgesia induced by the stunning methods. On the other hand, if an animal is attempting to recover the normal body position (righting reflex), or vocalise it is likely that consciousness has fully returned. The absence of animals showing these behaviours prevented acquisition of training material and the assessment of inter observer repeatability. Nevertheless, righting reflex and vocalisation are valid parameters to assess fully consciousness in pigs (EFSA, 2004), and can not be excluded from the final proposal.

Regarding the corneal reflex, the correlation between observers was higher when video clips were scored than by direct evaluation at slaughterhouse. Two reasons are suggested to explain it. Firstly, in the video clips, all observers are scoring the animal from the same point of view. At slaughter, each observer was scoring the reflex from different position. Secondly, with the video records, the observer could stop the image and make a review, being impossible in direct observations. In this respect, it was found a better correlation between observers when they used a computer than when a general session with a projector was made and there was not possible to freeze the image.

14.6 CONCLUSIONS

Corneal reflex, with a high inter observer repeatability, and rhythmic breathing with a medium inter observer repeatability are reliable parameters to assess stunning effectiveness in pigs. As no incidence of pigs showing righting reflex and vocalisations, no inter observer repeatability with these two parameters has been carried out. However, both parameters are indicative of fully consciousness and could not be discard in a monitoring scheme. Furthermore, both parameters are easy to score.

REPEATABILITY OF ABNORMAL BEHAVIOUR

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15.1 SUMMARY

Abnormal behaviours are considered as good indicators for the assessment of welfare compared to health or impaired performance, as they represent the first level of response of an animal to an aversive or stressful environment. Even if they are part of the natural behavioural repertoire, they can be considered as abnormal if animals perform them according to an invariant sequence (stereotypies for sows), too frequently (as in the case of aggressive behaviour or belly-nosing) or if they are not performed at all (social behaviour, investigation).

Negative social behaviours are common after mixing of pigs. However, a few days after mixing, such behaviours should be less frequent. After this period, a high level of negative behaviours is therefore a sign that the relationship between pigs is not stabilized.

For these criteria to be included in a welfare assessment tool, we aim to evaluate the repeatability of the recording of abnormal behaviour by different observers. The study was conducted at group level in case of piglets or pigs, and individually for sows.

In a first study, we observed the behaviour of nine groups of weaned piglets and eleven groups of growing pigs during two hours (61 scans, two minutes interval). The observations began five minutes after we had made the pigs stand up. The result indicated that a period starting at least 20 minutes after the beginning of the observation gives a good representation of the activity of the animals during these two hours. Then we tested this method for repeatability with three pairs, involving three observers, on 83 pens of pigs and 60 pens of piglets.

Negative social behaviour showed low Spearman coefficients between observers. Nevertheless, both observers considered the behaviour as a social behaviour. Inter-observer correlations concerning investigation towards pen fittings or straw/toy were higher, particularly in growing pigs (≥ 0.78). Results on belly nosing showed low Spearman correlations, which could be due to a low occurrence of such behaviour. Considering that

a welfare assessment tool should detect obvious signs of poor welfare and therefore a high level of abnormal behaviour, it is recommended to observe belly nosing (for piglets), negative social behaviour (including belly nosing for growing pigs) and positive social behaviour, respectively.

For the stereotyped behaviour of sows, we defined the following procedure: a group of sows was made to stand up. Then each sow was observed during 15 sec, its behaviour was defined as stereotyped, non-stereotyped or doubt of stereotypy. Then the next sow was observed.

Three observers tested the reliability on 143 gestating sows at various parities. The method used in this study to measure stereotyped behaviour in sows showed good repeatability between observers (Kappa coefficients above 0.80). The observations need to start at least 10 minutes after the sows have been made to stand up, and 30 minutes after a meal, when sows are fed simultaneously, to avoid a period where sows can be hyperactive.

15.2 GENERAL INTRODUCTION

Abnormal behaviours are considered as good indicators for the assessment of welfare compared to health or impaired performance, as they represent the first level of response of an animal to an aversive or stressful environment. Even if they are part of the natural behavioural repertoire, they can be considered as abnormal if animals perform them according to an invariant sequence (stereotypies for sows), too frequently (as in the case of aggressive behaviour or belly nosing) or if they are not performed at all (social behaviour, investigation).

15.3 ABNORMAL BEHAVIOUR IN PIGS AND PIGLETS

15.3.1 INTRODUCTION

Negative social negative behaviours are common and necessary after mixing of pigs, in order to establish a hierarchy amongst the group. However, a few days after mixing, such behaviours should be less frequent. After this period, a high level of negative behaviours is therefore a sign that the relationship between pigs is not stabilized. This result may be due to limited space allowance or inadequate access to food.

In weaned piglets, belly nosing is the main abnormal behaviour in relation with very early weaning (Gonyou et al., 1998), whereas it is rarely seen in older animals.

For these criteria to be included in a welfare assessment tool, we aim to develop an on-farm method to record the behaviour of groups of animals and to evaluate its repeatability by different observers.

15.3.2 METHODS

A preliminary study was conducted, with two hours observation of eleven batches of growing pigs and nine batches of piglets, in order to define a shorter period of observation that could reflect the whole period. Scans began five minutes after entering the room, with an interval of two minutes between two observations. The list of behaviours recorded was the following:

Active behaviours

- Negative social behaviour: aggressive behaviour including biting, suckling and moving firmly the flank of the animal (belly nosing*) or social behaviour with a response from the disturbed animal.
- Positive social behaviour: sniffing, nosing, licking, moving gently a part of the animal.
- Investigation of the pen: sniffing, nosing, licking all features of the pen.
- Play/investigation towards straw or other material.
- Belly nosing (piglets).
- Other active behaviours.

Non-active behaviours:

- Resting.

The shorter periods consisted of five consecutive scans (scan1 – scan5; scan2-scan6, scan N-scan N+4). We compared the frequency of the main behaviours in each of these periods to the frequency of the main behaviours observed during the remaining observations of the two-hour period with a Mantel-Haenzel chi-square in order to take into account all batches of observations. One statistical analysis was made for both pigs and piglets. The comparisons were done successively for each short period (observations done in the scan 0 – scan 8 period versus observations done during the scan 10 – scan 61 period; then observations done in the scan 2 – scan 10 period versus observations done during the scan 0 and the scan 12 – scan 61 period , and so on . The result of these analyses is presented in table 1. Results concerning the first periods are not presented because the activity of the animals was too different from the activity observed in the remaining period and chi-square test were therefore significant. Soon after entering the room, the behaviour of

animals is more linked to the disturbance generated by the observer and does not reflect the spontaneous activity of the group.

The result indicates that a period starting at least 20 minutes after the beginning of the observation (Scan 10 – scan 14) gives a good representation of the activity of the animals during these two hours (Table 15.1). Results were the same for piglets.

The study on repeatability was conducted on 83 pens differing in their size (group size from 8 to 40 pigs) or their type of floor (fully slatted floor, partially slatted floor, straw) for growing pigs and 60 pens on fully slatted floor for piglets. Live weights were 12 kg and 70–90 kg in piglets and growing pigs respectively.

Three observers tested the reliability. A preliminary training period consisted of viewing videos on behavioural activities and of observation on living pigs for all observers simultaneously in order to harmonize the way to interpret all the behaviours. In order to synchronize the observers as much as possible, a procedure was imposed to collect the information: the way to scan the pen was the same and the recordings began at the same time for each pen and each scan. The observers worked in pairs, because there was not room for more than two people to look at a pen of animals simultaneously.

Observations took place in the morning, because animals are in general more active. Animals were made stand up when the observers entered the room. The number of animal per pen was recorded. Behaviour of all animals in a group was recorded 20 to 25 minutes later, five times at a two-minute interval between two scans, from the corridor (outside the pen). A detailed ethogram was used but the analyses was carried out on regrouped activities as follows: negative social behaviour (aggressive behaviour including biting, suckling and moving firmly the flank of the animal or social behaviour with a response from the disturbed animal), positive social behaviour (sniffing, nosing, licking, moving gently a part of the animal), investigation of the pen (sniffing, nosing, licking all features of the pen), play/investigation towards straw or other material, belly nosing, other active behaviours and resting. As belly nosing appeared sometimes in growing pigs but generally

TABLE 15.1 Mantel-Haenzel chi-squares statistics for the comparison of the frequency of the main behavioural activities of growing pigs (investigative behaviours on pen fittings, investigative behaviour on toys or straw, non-feeding oral activity, social positive behaviour, social negative behaviour) between the shorter period (5 successive scans) and the rest of the two-hour period.

Short period	Rest of the 2-hour period	Mantel-Haenzel chi-squares Test
Scan 7 – scan 11	scan 0 – scan 6 and scan 12 – scan 60	*
Scan 8 – scan 12	scan 0 – scan 7 and scan 13 – scan 60	**
Scan 9 – scan 13	scan 0 – scan 8 and scan 14 – scan 60	*
Scan 10 – scan 14	scan 0 – scan 9 and scan 15 – scan 60	ns
Scan 11 – scan 15	scan 0 – scan 10 and scan 16 – scan 60	ns
Scan 12 – scan 16	scan 0 – scan 11 and scan 17 – scan 60	ns
Scan 13 – scan 17	scan 0 – scan 12 and scan 18 – scan 60	ns
Scan 14 – scan 18	scan 0 – scan 13 and scan 19 – scan 60	ns

Notes: ns non-significant; * $p < 0.05$; ** $p < 0.01$.

at a low level, it was considered as a negative behaviour only if it was associated with a reaction from the manipulated pig.

Statistical Analysis

Each activity was expressed a percentage of the total number of active behaviours. Spearman correlations were calculated between observers of each pair. As the synchronicity of recordings between observers was not strictly achieved, correlations were considered as valuable when the value exceeded at least 0.65. This is also the reason why we used Spearman correlation analysis, instead of Kappa coefficients which are used for synchronised recordings, and as done for the analysis of the abnormal behaviour in sows. The effect of observer was tested by using a Wilcoxon test for each pair and each activity.

15.3.3 RESULTS

Results on negative social behaviour showed better Spearman correlation coefficients for piglets than for pigs (respectively above 0.61 and under 0.62), illustrated in Tables 15.2 and 15.3. Even though the way to collect the information was standardized, a slight difference in the observation speed between observers may explain this result because of the short duration of these behaviours. As a pig begins to sniff or nose another animal before biting it, one observer may have recorded an event considered as a positive behaviour whereas the other one recorded a bite. In addition, groups of piglets did not exceed 15 animals, which could have improved the synchronicity of observations. Nevertheless both observers considered the behaviour as a social behaviour. Indeed, correlation coefficients were around 0.75 concerning the social behaviour (negative plus positive) for piglets and growing pigs except for one pair of observers.

Results on belly nosing showed low Spearman correlations coefficients, which could be due to a low occurrence of such behaviour.

Investigations towards pen fittings or straw/toy for growing pigs were well correlated between each observer in all pairs, but the correlation was less good for piglets.

We noticed an effect of the observer for some behaviour and for pairs 1–2 and 2–3, but no observer effect was observed within pair 1–3.

TABLE 15.2 Spearman correlation coefficients and observer effect for behavioural observations on piglets

	Spearman correlation			Wilcoxon test		
	Pair 1–2	Pair 1–3	Pair 2–3	Pair 1–2	Pair 1–3	Pair 2–3
Negative social behaviour	.66	.70	.61	ns	ns	ns
Positive social behaviour	.66	.55	.47	***	ns	***
Belly nosing	.57	.46	.67	***	ns	**
All social behaviour	.75	.63	.74	***	ns	***
Investigation of the pen	.87	.78	.78	ns	ns	***
Play/ Investigation of straw or toys	.51	1	.59	ns	ns	ns

Notes: ns non-significant; * p<0.05; ** p<0.01; *** p <0.001.

TABLE 15.3 Spearman correlation coefficients and observer effect for behavioural observations on growing pigs

	Spearman correlation			Wilcoxon test		
	Pair 1–2	Pair 1–3	Pair 2–3	Pair 1–2	Pair 1–3	Pair 2–3
Negative social behaviour	.38	.65	.54	*	ns	ns
Positive social behaviour	.66	.62	.66	ns	ns	***
Belly nosing				ns	ns	ns
All social behaviour	.79	.80	.76	**	ns	***
Investigation of the pen	.78	.85	.82	ns	ns	***
Play/ Investigation of straw or toys	.95	.93	.96	***	*	*

Notes: ns non-significant; * p<0.05; ** p<0.01; *** p <0.001.

15.3.4 DISCUSSION/CONCLUSION

Our results show that a short 10-min period gives a good evaluation of the behaviour of a group recorded during two hours. No validation has been made to assess the repeatability over a longer period (a week for instance). Therefore observations must be made avoiding atypical times including the feeding period, mixing of animals, excessive temperatures, or recent interventions of the farmer. The measure should ideally be recorded when the pigs are active, preferably in the morning.

Our results present good Spearman correlations for the main behaviours that can be included in an on-farm welfare assessment. The more detailed the observations we want to record, the less significant are the correlations. Nevertheless, in the case of social behaviour, our method allows the recording of negative behaviours, even if their frequency is low, and thus to identify risk of impaired welfare. The recording of positive social behaviour may allow the building of a criterion based on the relative proportion of negative to positive behaviour that can be used in the welfare assessment tool.

In our opinion, the observer effect does not mean that different assessors might rank farms differently, making the reliability of the measure questionable. The observer effect obtained for some behaviour in this work illustrates the importance of the training period. We noticed this observer effect in pairs involving Observer 2. That can be explained by the way behaviour was scored. Observers 1 and 3 attributed behaviour to an animal even if they did not see it completely but the posture of the animal appeared characteristic of this behaviour.

In contrast, Observer 2 did not score the animal if he did not see it clearly. This observer scored fewer active behaviours but this had no consequence on the correlations. In the final use of this method, we advise to record only animals that are clearly visible.

15.4 ABNORMAL BEHAVIOUR IN SOWS

15.4.1 INTRODUCTION

From the abnormal behaviours reported in sows, stereotyped behaviours are considered as good indicators for the assessment of welfare as they represent the first level of response of an animal to an aversive or stressful environment compared to health or impaired performance. They consist of a succession of motor acts, some of which arise from the natural behaviour. They can be considered as abnormal if animals perform them according to an invariant sequence (Odberg, 1978). Stereotypies are in general related with feeding frustration in gestating sows but a barren environment may enhance their expression (Terlouw et al., 1999). The level of stereotyped behaviour increases over time in sows and its expression varies from one animal to another. Such abnormal behaviour concerns mainly gestating sows and is rarely reported in lactating sows.

For this indicator to be included in a welfare assessment tool, we aim to develop an on-farm method to record the stereotyped behaviour of gestating sows group-housed or in stalls.

15.4.2 METHODS

The study on repeatability was conducted on 143 gestating sows at various parities. They were either housed in groups on a fully slatted floor or on straw, or in stalls on a fully slatted floor.

Three observers tested the reliability. A preliminary training period consisted of viewing videos on stereotyped activities and of observation on living sows for all observers simultaneously in order to harmonize the way to interpret all the behaviours. The stereotyped behaviour was defined as a sequence of invariant motor acts, repeated frequently and having no obvious goal or function. We considered the main following motor acts:

- sham chewing;

- tongue rolling;
- teeth grinding;
- bar, trough, drinker biting;
- floor licking.

Other behaviours such as straw or stone chewing may be considered as stereotyped behaviour if performed repeatedly and following a specific sequence.

Observations took place in the morning, because animals are in general more active. A group of 8 sows were made stand up. The behaviour of all these sows was then recorded simultaneously by three observers. Once the observation was finished, a second one was carried out.

The observations were conducted over three days. On the third day, the observation took place 30 minutes after the end of the feeding period, sooner than on the two previous days. All sows were recorded during 15 sec and then 1 min. The scoring method was the following:

- at the end of the 15 sec period: a first score was defined (note 1, three levels :stereotyped/ non stereotyped/ doubt of stereotypy)
- at the end of the 1min period: a second score was defined (note 2, two levels :stereotyped/ non stereotyped)
- a final score was defined (note 3): note 3 was equal to note 2 if there was a doubt after the 15 sec period, otherwise it was equal to note 1.

Statistical Analysis

Two analyses were conducted on the three notes. The agreement between observers was tested by a Kappa test. We used a chi-square test to analyse the effect of the period of recording.

TABLE 15.4 Kappa coefficient for each note on the behaviour of sows (283 observations).

	Pair 1–2	Pair 1–3	Pair 2–3
Note 1	.64	.70	.65
Note 2	.85	.83	.84
Note 3	.79	.80	.82

TABLE 15.5 Mean values of Kappa coefficient for the note 3 according to the day of observation (day 1, day 2, day 3).

	Number of sows	Kappa value
Day 1	97	.84
Day 2	89	.76
Day 3	96	.69

15.4.3 RESULTS

The analysis of concordance is illustrated in Table 15.4. We considered that agreement between observers was good or very good if the coefficient values exceeded at least 0.60 and 0.80 respectively.

Table 15.4 indicates that the kappa coefficient exceeds 0.80 for note 2 and note 3. Comparison between the first and the second evaluation on the same sows presented higher Kappa coefficient in the second evaluation, suggesting a better concordance between observers (Table 15.5). The coefficient values were higher for the note 2, but results of note 3 can be considered as good. This result suggested that even if a 1 min-period gave better coefficients, the method based on the two steps of observation (15 sec and 1 min more if doubt) gave similar results.

When the observations were carried out soon after the feeding period (Day 3), observers were less concordant (Table 15.5). At this moment the sows showed hyperactivity with a high frequency of oral behaviour. In this case, the sequence characterizing the stereotyped behaviour was more difficult to identify according to the observers.

The coefficients calculated for each period of observation were higher in the second evaluation whatever the note and the pairs (Table 15.6).

The number of sows presenting stereotyped behaviour was higher at the first evaluation compared to second one (Table 15.7) as well as the frequency of score ‘doubt’.

TABLE 15.6 Kappa coefficient for each note at each evaluation of the behaviour of sows.

	First evaluation			Second evaluation		
	Pair 1-2	Pair 1-3	Pair 2-3	Pair 1-2	Pair 1-3	Pair 2-3
Note 1	.58	.65	.60	.72	.76	.72
Note 2	.81	.81	.80	.90	.86	.89
Note 3	.75	.78	.82	.85	.82	.84

TABLE 15.7 Comparison of the measures obtained at the two evaluations made on the same animals (283 observations * 3 observers).

	Evaluation 1	Evaluation 2	Chi square test
Note 1			
Stereotyped	132	117	
Non stereotyped	224	260	**
Doubt	73	43	
Note 2			
Stereotyped	180	144	*
Non stereotyped	249	273	
Note 3			
Stereotyped	169	134	*
Non stereotyped	260	283	

Notes: * p<0.05; ** p<0.01.

15.4.4 DISCUSSION/CONCLUSION

The method used in this study to measure stereotyped behaviour in sows appears robust for the repeatability between observers. The observations need to start at least 10 minutes after the sows have been made stand up, and 30 minutes after a meal, when sows are fed simultaneously. Sows can be hyperactive soon after feeding, and this increase in motor activity may be confounded with stereotypies while the sequence is not observed. This may lead to different evaluations between different assessors, even if they are well trained.

Our hypothesis was to consider that if a sow is motivated to perform stereotyped behaviour, this behaviour would be expressed every time the sow is disturbed. We did not validate this in this work. We saw a higher frequency of stereotyped behaviour at the first evaluation than at the second one. This suggests that the second evaluation shows up the sows that clearly exhibit stereotyped behaviour, which could more representative of this problem in a farm.

Further investigations on validity of this measurement over longer time are needed. During the training work in a welfare assessment, we suggest that at least the assessors could train on the same sows, in the morning and in the afternoon, to check the repeatability over the day. This would be helpful in interpreting results for farms where simultaneous feeding systems are not used. According to our assumption, if a sow is motivated to perform stereotyped behaviour, this behaviour would be expressed every time the sow is disturbed, all day long. Nevertheless it may not be the case in special environments (ie high temperatures), and therefore we recommend that observations should take place in the morning.

VALIDATION OF MEASURES FOR POSITIVE EMOTIONS

M.B.M. Bracke, P. Lenskens and H.A.M. Spoolder

16.1 SUMMARY

Work was conducted to identify behaviours indicative of positive emotions and to develop a more feasible novel object test (NOT) for application in on-farm welfare auditing. In total eight small experiments were conducted.

Two studies were conducted comparing the full behavioural repertoire, of pigs in both conventional and organic housing, and in both background conditions and after the provision of three different novel objects (branches, rubber hose cross and plastic ball). Piglets held under enriched conditions do not seem to show overt signs of presumed positive emotions while barren kept pigs responded stronger to a novel object. There was no interaction between attractiveness of the toy and the level of enrichment of the home pen, on play behaviour with the toy.

In the subsequent experiments a more feasible novel object test (NOT) using a piece of rope to elicit play behaviour and a so-called modified AMI-sensor was developed and tested in six small experiments.

Firstly, in a pilot experiment the animal-material interaction (AMI) with the rope was recorded every 10 min. for 140 min. A peak in AMI was reached at the second 10 min reading and the level of AMI progressively declined thereafter.

Secondly, the NOT responses of conventionally housed pigs were compared with organic housing growing pigs and weaned pigs. It was found that compared to conventional housing, organic growers had higher AMI values throughout. Organic weaners had higher responses initially and a more rapid decline. The main conclusion from the experiments comparing organic and conventional housing was that even under rather variable conditions and using a rather limited number of observations the NOT was able to detect significant differences between organic and conventional housing systems.

Thirdly, the effects of the provision of short chopped straw were tested. It was found that straw significantly decreased AMI to the novel rope over time, whereas controls showed an initial increase without significant subsequent decrease. These results indicate that the NOT can detect relatively small differences in enrichment (as evidenced by the provision of short chopped straw).

Fourthly, in two experiments the effects of the provision of a jerrycan (canister) were tested. In accordance with our expectation no major effects were detected. In addition, it was shown that in these highly controlled and frequently repeated conditions a small effect (which was significant using a Sign test) could be detected, indicating that the NOT is a sensitive test that is able to detect even small differences in environmental enrichment.

The test has potential for being developed into a reasonably valid, highly reliable and highly feasible test for measuring positive emotions in pigs under on-farm welfare-auditing conditions.

16.2 GENERAL INTRODUCTION

Underlying the work is the general and pragmatic assumption that various aspects of play behaviour (i.e. object, social and locomotor play) most typically indicate positive welfare. Play indicates ‘having fun’ (Spinka et al., 2001). Ultimate validation would require confirming this assumption, but this was not considered feasible within the present scope of the project. It was realised that full validation of the measure would not be possible. For that reason, the ‘validity’ testing in this project focussed on obtaining one or more animal-based measures derived from play behaviour and examine how these measures reflected the level of (resource-based) environmental enrichment provided to the pigs.

Play behaviour is known to be affected by enrichment. Barren housed pigs were less active, showed less explorative and play behaviour and spent more time on oral activities directed at pen mates than pigs from enriched housing (Bolhuis, 2004; Bolhuis et al., 2005; Bracke et al., 2006).

In another study conducted at ASG in Lelystad (NL) ‘enrichment materials for pigs’ a model (called RICHPIG) has been constructed to assess the value of enrichment materials for pigs based on available scientific information collected in a database. With the model the value of enrichment materials, which consisted mainly of different aspects of object play (also called animal-material interactions, AMI), can be expressed with a score on a scale from 0 to 10 (Bracke et al., 2007).

The present paper adds to this modelling approach (which uses both resource- and animal-based measures) by aiming to measure the animal’s responsiveness. The advantage of such

a purely animal-based measure could be that certain types of enrichment may not be detectable during the audit. For example, when substrate is absent in the pens but the farmer is claiming to have provided edible substrate in the morning before the visit, it may be relevant to be able to verify the claim with an animal-based measure that indicates the level to which the pigs' needs to explore and root have actually been satisfied. Similarly, it is conceivable that stockmanship may result in different levels of enrichment as perceived by the animals when physically similar amounts of enrichment have been provided. Animal-based measures may be useful to ultimately help solve this kind of problem. Before this can be done, however, an animal-based measure must first be identified, validated and operationalised for feasible on-farm use during an audit.

A novel object test (NOT) could be a suitable candidate measure for auditing positive emotions in pigs (and perhaps also in other species) as this is an animal-based measure that requires relatively little time to measure and appears to be (negatively) related to the level of environmental enrichment.

The primary objective of the study was to identify parameters indicating positive emotional states in pigs, which would be suitable for standardised on-farm measurement. To this end a series of brief studies were carried out and a novel object test (NOT) using a piece of rope was developed that would require a limited amount of recording time. First, two small studies were done to describe the behavioural responses from barren and enriched (organic) pigs to toys of different complexity. Thereafter, seven small experiments were done applying the NOT with the main aims to (a) describe the process of the pigs' interaction with the novel rope in time (one small pilot experiment), (b) detect differences between conventional and organic pigs (one experiment comparing weaners and another comparing growers) , (c) detect differences in moderately enriched conditions, using fine chopped straw (one experiment) and to (d) test the sensitivity of the NOT in conditions marginally enriched with a jerrycan (two repeated, but slightly modified, experiments). In addition, the experiments were evaluated (e) to examine whether the potential covariates 'group size' and 'weight/age' had an effect, and (f) to evaluate differences between farms housing pigs under intensive conditions. These objectives will be addressed in the following sections in the order they were listed here, where the last two objectives will be discussed as subsections of the 'General discussion', which will address issues applying across experiments.

16.3 BEHAVIOURAL RESPONSES TO TOYS

16.3.1 Introduction

On the basis of our experience and the literature we assumed that a good housing system (with space and straw) will provide good welfare, and that play behaviour is an indicator of positive emotions and will be performed esp. when other needs have been met.

Since play behaviour is mostly seen in young animals we first observed piglets on our experimental organic farm with presumed good housing conditions, where the conditions to perform play behaviour were considerably enhanced. The behaviour of these organic pigs was compared with regular type housing that was also present on the same premises. Observations focused on presumed behavioural indicators of positive emotions such as play, curling/wagging of the tail, exploring, body posture and vocalizations in both organic and regular/conventionally housed pigs. The piglets were observed first without and subsequently with the presence of a novel object. Initially only one type of novel object (branches) was tested. In an attempt to improve variability between housing systems and to explore the wider range of behavioural responses, a second study was conducted in which two (presumably less attractive) novel objects (rubber hose cross and plastic ball) were compared in the two housing systems. The aim was to identify interactions between toy type and housing system, as this would enable us to select the toy most suited to differentiate between housing systems (i.e. between different levels of environmental enrichment and assumed positive emotions).

The first phase of the project, therefore, consisted of two studies with the following hypotheses:

Study 1:

1. Piglets held under positive (organic) housing conditions will show more signs of presumed positive emotions, like play behaviour, than piglets held under barren conditions.
2. Piglets held in a barren environment will become hyper-excitable. They will react more strongly to a novel object compared to piglets in an enriched environment.

Study 2:

3. Less attractive toys will elicit more play in barren compared to organic conditions than do more attractive toys (i.e. we expected an interaction between the level of attractiveness of the toy and the level of enrichment of the home pen).

16.3.2 Methods

For Study 1, the behaviours of 256 piglets, from 7 till 10 weeks of age, were compared under 2 different housing conditions. One group of piglets was housed under conditions which maximized the performance of play- and species-specific behaviours. They were housed in groups of 15 animals per pen according to Dutch organic standards in fully enriched environments with ample straw and an outdoor access (0.6 m²/animal indoor and 0.4 m²/animal outdoor). The outdoor area was not soil, but had a partly slatted concrete floor. The second group of piglets was housed under conditions which minimized play and species-specific behaviours. They were conventionally housed under barren conditions: no straw, 10 animals per pen, 0.4 m² per animal and no outdoor access. As enrichment the conventionally housed pigs had a chain in the pen.

Per system 16 pens were observed for 2 consecutive hours using direct observations (with the observer present in the unit). The first observation hour the behaviour of the animals under their normal housing conditions was observed. In the second hour play behaviour was evoked by introducing a novel object: branches of oak without leaves.

Per pen 8 piglets were randomly selected. Every 4 minutes all 8 piglets were individually observed (scan sampled), whereby, in sequence, each piglet was observed continuously for 30 seconds (focal animal sampled). The outdoor area was accessible during the observations, but the observer could not observe the pigs there from within the unit. Individual pigs could be identified by a number sprayed on their backs with a standard colour stock marker. Behaviour observations were scored using a handheld computer (The Observer, Noldus, Wageningen).

Study 2 was a separate experiment in the same two housing systems. This time a total of 514 animals were observed between 30 and 90 minutes after they were offered with one of two different types of toys with differing levels of enrichment value: a cross made of two plastic pipes, suspended on a chain approximately 60 cm above the floor, and a hard ball which could be freely pushed around on the floor. The number of pens per treatment was 16 (16 pens * 2 housing systems (regular/organic) * 2 toy types (cross/ball) * 8 selected pigs per pen = 514 animals). On average the organic pigs were housed in groups of 15.2 animals/pen, whereas the regular pigs were housed in groups of 10.5 animals per pen.

16.3.3 Results

The first study did not confirm our hypothesis that piglets housed under positive conditions would show more signs of presumed positive emotions, like play behaviour, compared to those housed under barren conditions, except for the fact that organic pigs interacted more with straw (which was not present in the conventional pens; see below).

During the first hour of observations (without novel object), there were no significant differences in play behaviour between the two housing systems; in both systems 0.6%

locomotor play, and respectively 0.27% and 0.24% social play for the organic and conventional piglets ($P>0.05$). The conventionally housed piglets had, in contrast to the organic piglets, a metal chain in their pen. They played for 0.85% of their time with this chain. By contract, the organic piglets spent a great deal of their time (12.1%) nosing the substrate (straw; which was not present in the conventional pens).

There was no significant difference in the amount of belly nosing (0.003% vs. 1.82%; $P>0.05$), but the organic piglets manipulated the ears of other piglets less then the conventional piglets (0.09% vs. 0.86%; $P<0.05$) and were also nosing the pen less (0.5% vs. 2.5%; $P<0.001$).

Furthermore there was a significant difference in resting behaviour. The organic piglets rested more with the eyes closed (57% vs. 33%; $P<0.01$), while the conventional piglets rested more with the eyes open (14% vs. 26%; $P<0.001$). In total the organic piglets rested more. It seems that they were less disturbed by their pen mates.

When presented with the novel object, the conventionally housed piglets played significantly more with the branches than the organic piglets (56.1% vs. 43.1%; $P<0.05$). There was no difference in overall activity level between the two systems (71.6% vs. 81.8% for organic vs. conventional respectively; $P>0.05$).

Study 2 found differences in object-directed behaviour between the two housing systems, but also between the two objects. The organic animals played less with the toys (as in Study 1), and the cross was more attractive then the ball. However, there was no interaction between type of toy and housing system (see Table 16.1). Finally, the organic pigs tended to lose interest more quickly in either toy, compared to the conventional animals ($P=0.063$). In organic pigs the proportion of manipulation decreased by 84 and 59% between the 2nd and 3rd half hour following introduction for ball and cross respectively, and in the conventional system these figures were 55 and 32%.

16.3.4 Discussion

The two housing systems used in our experiment represent two extremes on the (Dutch) scale of housing conditions, potentially resulting in considerable differences in the expression of positive emotions. Both studies showed a higher level of interaction with the toy by the conventional pigs, and a steeper decline in interest compared to conventionally, barren housed animals. This may indicate a rebound effect in deprived animals, indicating that animal-material interactions (AMI) with a novel object may inversely reflect positive emotions covarying with the level of environmental enrichment.

TABLE 16.1 Effects of providing a ball or a plastic cross made of two plastic pipes on behaviour.

	Ball		Cross		Toy	Significance	
	Organic	Convent	Organic	Convent		Housing	Toy*Housing
Play Object	0.06	0.09	0.17	0.32	<0.001	<0.05	0.128

These findings were in accordance with earlier work done by Stolba and Wood-Gush (1981) who had shown that over an 80 min observation period the pigs' interaction with a novel object (car tyre) decreased with increasing environmental complexity (comparing pigs in a semi-natural environment, furnished (family) pen, open-fronted straw pen and Danish partly slatted pen). They found that pigs in more intensive systems were more interested in the car tyre immediately after introduction and that their interest was maintained for a longer period of time.

To use this rebound effect as a measure of positive emotions in pigs we wanted to maximise the discriminatory value of the test. The difference in time spent playing with the branches between organic and conventional piglets in Study 1 was approximately 13%. In the second study the two toys, which were overall less attractive than the branches, differed 3% (ball) and 15% (cross). The results of the two studies are not directly comparable, however. One of the main differences between the two studies is the timing of the observations (Study 1 compared the behaviour in the hour immediately following novel object introduction, while Study 2 compared behaviour between 30 and 90 minutes following introduction; a difference that may well explain the elevated levels of the interaction with the branches in Figure 16.1). However, it seems that a toy needs to have a certain level of attractiveness in order to elicit a differential behavioural response between pigs from different housing systems (Figure 16.1). Rubber hose cross showed a somewhat higher level of differentiation than branches. By comparison, the levels of play with the enrichment materials provided in the pens (a chain and straw for conventional and organic pigs respectively) showed the next highest level of differentiation (namely 11.25%).

A ball loose on the floor (which may get soiled, is not biteable and not flexible) does not appear to be a suitable enrichment device and does not appear suitable to differentiate between the two housing systems.

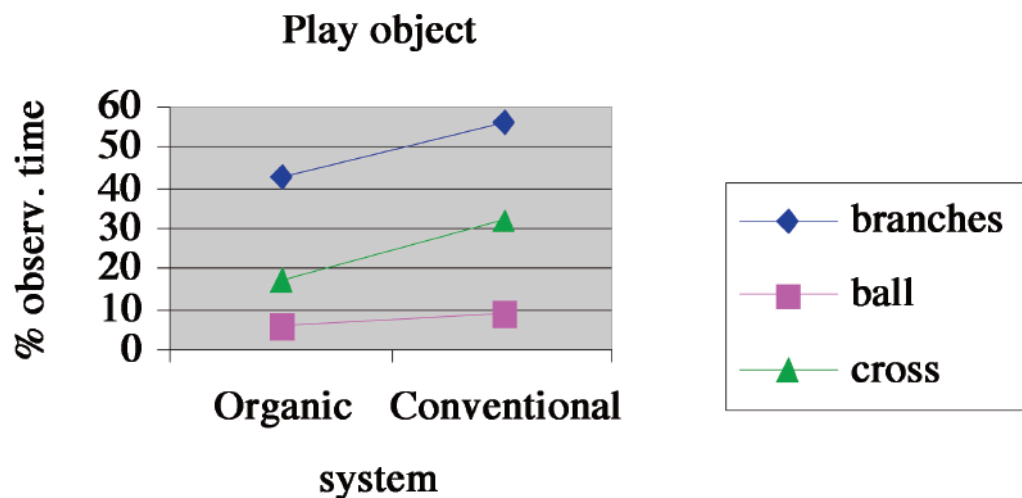


FIGURE 16.1 Differences in object play between pigs from two different housing systems, and three different novel objects.

It can be concluded that:

1. Piglets held under enriched, organic housing conditions do not seem to show overt signs of presumed positive emotions, like play behaviour, compared to piglets held under barren conditions, except for the differences in object-directed behaviour (straw and chain).
2. Barren kept pigs will respond stronger to a novel object (higher level of interaction and longer attention span).
3. But we could not demonstrate an interaction between attractiveness of the toy and the level of enrichment of the home pen, on play behaviour with the toy. In other words we found no support for the hypothesis that less attractive toys would elicit enhanced play in barren compared to organic conditions than do more attractive toys.

16.4 THE REACTION TO A NOVEL OBJECT OVER TIME

16.4.1 Introduction

This part of the project started with the selection of a piece of rope as the object to be used in the NOT (novel object test). This material was not only considered suitable on the basis of the previous findings (flexible like the cross, somewhat destructible like the branches, unlikely to get out of sight or soiled as the ball did), it also met the further requirement that it could be controlled/fixed to the pen wall and to the recording device (AMI sensor) that would substantially increase the feasibility of the test.

As part of the pilot work developing a feasible novel object test (NOT) measurements were taken to ‘describe’ the process of animal-material interaction frequency (AMI) with the rope over time. The animal-material interactions (AMI) with the rope were registered at pen level over predetermined periods (14 periods of 10 minutes) using a prototype so-called AMI-sensor (modified after Zonderland et al., 2001).

16.4.2 Methods

Measurements were taken on finishing pigs every 10 minutes for a period of 140 minutes in 4 pens (of which 2 pens contained 8 pigs per pen and 2 pens contained 5 pigs per pen). The observations were done in one unit containing crossbred slaughter pigs. All pens were 3.05 m deep and 2.65 m wide. They had a partly solid, concave floor (1.2 m deep), extending from 0.4 m from the front wall to 1.45 m from the back wall, with concrete slatted floors in the front and the back of the pen. All pens had a dry feeder containing a

drinking nipple and a chain hanging on the pen wall dividing neighbouring pens. No further enrichment was provided.

16.4.3 Results

Even though no statistics are possible on this small dataset, a pattern observed in all 4 pens could be taken to indicate a trend (approaching a P value of 0.06 in a Sign Test). The test showed that there is a peak (of over 15 interactions per minute) at $t=20$ min in all 4 pens and a somewhat asymptotic decline towards about AMI = 2 interactions per minute at $t=140$ min (see Figure 16.2).

In addition (and much more tentatively), the 2 pens with a larger group size (8 pigs per pen) had higher values than the 2 pens with 5 pigs per pen during the first four observations ($t=10$ to $t=40$ min), but had lower values at $t=50$ and $t=60$ min. The rate of decline, therefore, was higher in the two larger groups than in the two smaller groups. This latter observation presented a very preliminary first indication that there might be a confounding effect of group size.

16.4.4 Discussion

The main conclusion of this first pilot study in Phase 2 is that the AMI sensor was able to register the levels of interaction with the rope over time, showing a peak in AMI at $t=20$

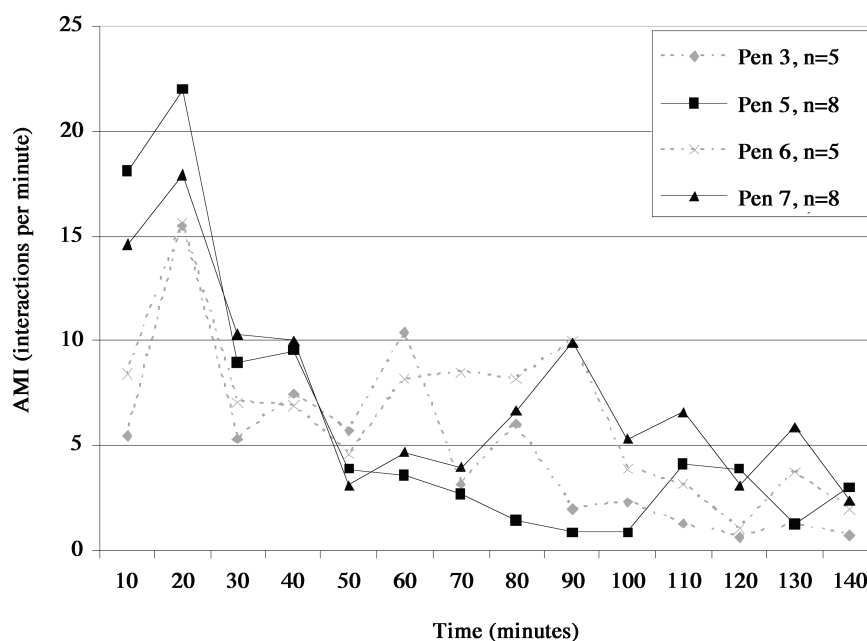


FIGURE 16.2 Level of AMI (interactions per pen per minute) for 4 different pens with finish-ing pigs over a 140 min period after introduction of a novel piece of rope.

min after introduction and a tendency to show reduced levels after 100 min. Furthermore, there may (perhaps) be differences in the rate of decline between group sizes.

16.5 EFFECTS OF ORGANIC HOUSING

16.5.1 Introduction

The novel object test (NOT) was applied at the experimental farm in Raalte (NL; similar to the studies in Phase 1) to determine whether the test could detect relatively large enrichment differences between organic and conventional pigs housed on one farm.

16.5.2 Materials and Methods

The main differences between the organic and conventional housing was that organic pigs had ample straw (0.5 kg and 1 kg per pen daily for weaners and growers respectively), more space and access to an outdoor area (in total about 2.61 m²/grower and 1.0 m²/weaner), whereas conventional pigs had less space (in total about 0.9 m²/grower and 0.3 m²/weaner), no straw and no outdoor access. For organic pigs the outdoor area consisted of a roofed-yard with a partly slatted concrete floor. Organic piglets had been weaned at 6 weeks of age and were not tail docked. Conventional pigs were weaned at 4 weeks and had docked tails.

Both organic and conventional pigs reached a weight of about 23 kg at about 10 weeks of age, at which time both types of pig were moved to the growing accommodation where growth rates averaged about 800 g. per pig per day.

The impact of housing was studied in two separate experiments, one comparing growers and one comparing weaners, in units that had been balanced as much as possible for age.

For growers in total 14 conventional pens from 3 units were compared with 12 organic pens from 2 units. For weaners 15 conventional pens from 2 units were compared with 14 organic pens from 2 units. The number of pigs per pen was variable. The median numbers of conventional and organic growers was 9 and 16 pigs per pen respectively (ranges: 6–9 and 10–32 respectively). The median numbers of conventional and organic weaners was 9 and 12 pigs per pen respectively (ranges: 5–11 and 5–16 respectively). Conventional weaners were 57 days of age, whereas organic weaners were 64 days of age. Conventional and organic growers had median ages of 135 and 133 days respectively (ranges: 112–161 and 101–143 days of age respectively).

Conventional growers had been provided with either some chopped straw or some sawdust in the morning (as part of routine management practice), whereas all conventional weaners had access to a chain in the pen. In addition, sawdust had been provided in one unit of conventional weaners but not in the second unit.

The novel object test consisted of the introduction of a small piece of white, nylon rope (3 mm diameter) at the front gate of the pen, opposite the feeder. The animal-material interactions (AMI) with the rope were registered at pen level over predetermined periods (8 periods of 15 minutes followed by two periods of 30 min each) using a prototype so-called AMI-sensor (modified after Zonderland et al., 2001).

Statistics: A Split plot ANOVA (on observations within pens within units) was done on log transformed data using Genstat 8 (Anonymous, 1993). Since this analysis assumes a constant covariance between observations the dataset was condensed to 3 data points per pen (each consisting of the average AMI for the first, second and third half an hour respectively). The measures taken after 90 min were ignored in the Split plot analysis, also because a feasible test should preferably take a limited period of time to record. The covariates 'age' and 'number of pigs per pen' were added on a trial and error basis where relevant (e.g. since for weaners the factor 'age' differed only by 1 week and was fixed to 'farm type' (i.e. organic or conventional), it was not analysed for that category of pigs).

In order to show the 'full' dataset the (not transformed) mean values and their standard errors were graphically represented, and an ANOVA was done on the intercepts (with the y-axis) and slopes of the log-transformed curves (see Oude Voshaar, 1995).

16.5.3 Results

The error bar graphs comparing both organic and conventionally housed weaners and growers are shown in Figures 16.3 and 16.4.

The Split plot analysis for weaners showed a significant effect of 'time' and a significant 'time'- 'farm type' interaction when no covariates were included in the analysis (both $p < 0.01$). AMI was significantly higher in the first half hour compared to the second and third half an hour (means 3.08a, 1.98 b and 1.37b respectively). Table 16.2 shows that organic weaners had elevated AMI levels in the first half hour both compared to the second and third half an hour and compared to conventional weaners at all three half hour periods.

The Split plot analysis for growers showed a significant effect of 'farm type' when no covariates were included in the analysis ($p < 0.05$). Including only 'age' as a covariate did not show an effect. Including 'number of pigs per pen' as a covariate, however, eliminated the effect of 'farm type' and showed a trend effect of the covariate ($p < 0.1$) at the unit stratum, where the 'number of pigs' was positively related to AMI. Noteworthy was also that with this covariate in the model the predicted means for organic growers were lower (but not significantly lower) than for conventional growers (3.07 and 5.26 respectively, p

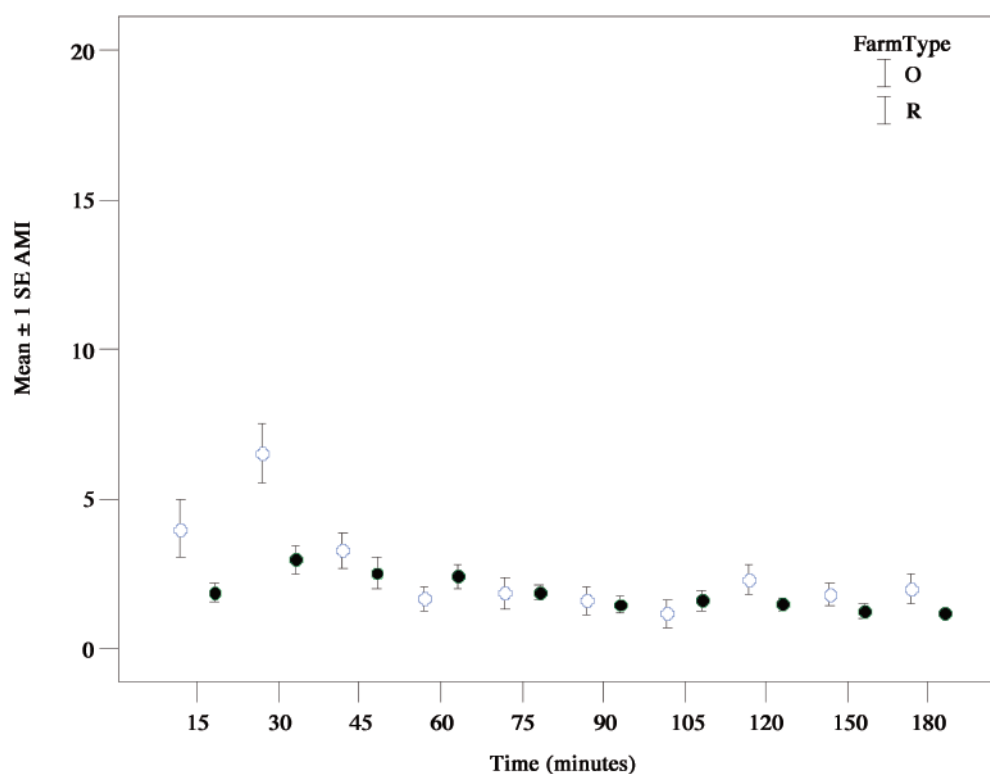


FIGURE 16.3 Means and standard error (SE) bars of animal-material interactions per minute (AMI) in organic (O, open data points) and conventional (R, regular, solid data points) weaned pigs at 10 time intervals after introduction of a novel rope.

Notes: At each time point O is represented by the first and R by the second bar.

TABLE 16.2 Animal-material interaction (AMI) levels for organic and conventionally housed weaned pigs during the first, second and third half an hour after introduction of the novel object.

Time (min)	Organic	Conventional
30	4.15a	2.26b
60	1.97b	1.99b
90	1.25b	1.49b

= 0.41). Including both ‘age’ and ‘number of pigs’ as covariates eliminated the finding of all trends and significant effects.

When no covariates were included no effect of slope was found, but the organic ‘farm type’ showed a trend ($p = 0.1$) for having a higher intercept than conventionally housed pigs (which reflected the elevated levels in organic pens). This effect was maintained when ‘age’ was included as covariate. Including the ‘number of pigs per pen’ as covariate showed no effect on intercept, but resulted in a significant effect of both this covariate and ‘farm type’ on slope (both $p = 0.05$; organic pigs showing a negative slope while regular pigs showing a positive slope; the number of pigs being positively related to AMI). Including both ‘age’ and ‘number of (growing) pigs per pen’ as covariates eliminated all findings of trends and significant effects on slope and intercept.

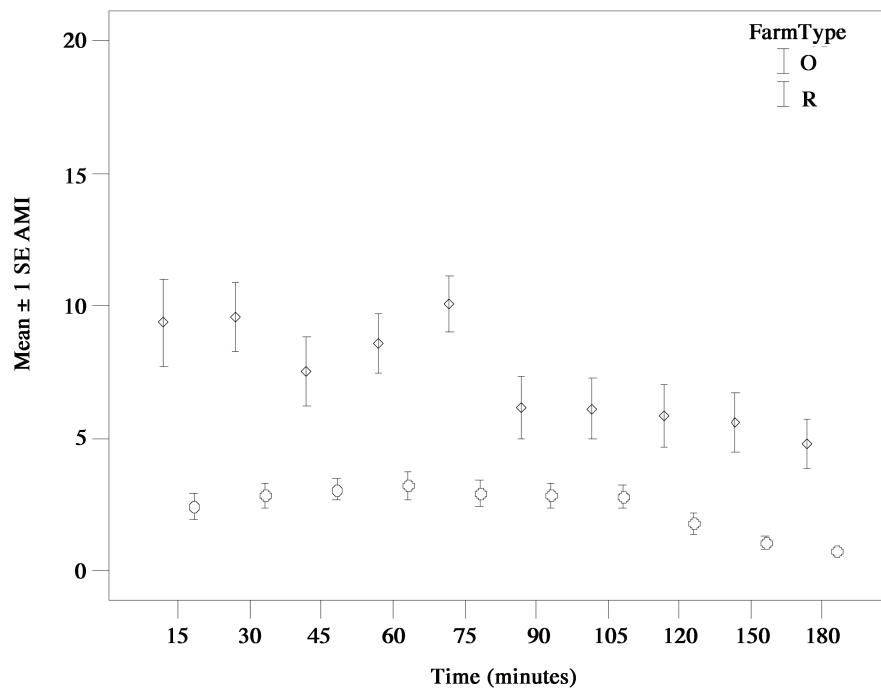


FIGURE 16.4 Means and standard error (SE) bars of animal-material (novel rope) interactions per minute (AMI) over time in organic (O, diamond-shaped data points) and conventional (R regular, round data points) growing pigs.

Notes: At each time point O is represented by the first and R by the second bar.

16.5.4 Discussion

Elevated animal-material interaction (AMI) levels were found in organic pigs (but for weaners during the first half hour only) compared to conventionally housed pigs in response to a novel rope. This appears to be in contrast to earlier findings (see the results of the first experiment reported above) where organic pigs showed reduced levels of novel object exploration. Various factors may explain the difference. Firstly, the present study used a thin nylon rope whereas the work in Phase 1 included much larger objects (plastic ball, branches and rubber hose cross). Secondly, sampling methods differed. The previous work involved focal animal sampling using an ethogram expressing AMI at the individual pig level (interactions per focal pig), while for pragmatic (feasibility) reasons the present study used a sensor-derived AMI value that was expressed at the pen level (interactions per pen). Expressing AMI as frequency per pig per minute (rather than as frequency per pen per minute), however, did not alter the main findings of the present study. Thirdly, the experimental set-up differed. The previous experiments (in Phase 1) were balanced more for group size by excluding the larger pens (above 18 pigs per pen) on the organic farm from the comparison, while the present study had included these pens (with up to 32 pigs per pen) in order to examine possible effects of group size. The potentially confounding effect of group size was confirmed in the finding that elevated AMI levels in organic growers compared to conventional growers were eliminated (and were even reversed) by adding the covariate ‘number of pigs per pen’ into the analysis. However, since the present

study was observational with respect to the covariate 'number of pigs per pen' this finding would have to be confirmed experimentally before a definite conclusion can be drawn.

With respect to the elevated AMI levels in the more enriched (organic) conditions, the results of the present study, therefore, were not in accordance with previous work (experiment 1; Stolba and Wood-Gush, 1981). These previous studies however, had not only shown that pigs in more enriched systems were less interested in a novel object (branches/hose cross/ball; car tyre) immediately after introduction, but also that their interest was maintained for a shorter period of time. The latter finding (an increased decline in enriched conditions) was confirmed in the present study. Organic weaners showed a progressive decline in AMI from the first to second half an hour, and organic growers showed reduced AMI over time as indicated from the analysis of the slopes of the regression coefficients, at least when the number of pigs per pen was included as covariate.

The apparent differences between the novel object responses of weaners and growers is not easily explained but may be related to an effect of age, housing and time of day (weaner testing had started in the morning at 11.15 am, while grower testing had started in the afternoon at 3.15 pm, but there did not appear to be a difference between morning and afternoon recordings in the studies conducted in experiment 1). The more rapid decline in AMI in enriched pigs in response to the novel rope could indicate enhanced welfare, but, in this study, it could also be a direct effect of the (initially) elevated AMI levels. The elevated AMI levels in enriched pigs appear to contradict the hypothesis of a rebound effect of positive emotions in barren housed pigs. In the present study the conventionally housed pigs had received some sawdust or short chopped straw in the morning as part of the routine management practice on the farm. This material may have reduced responding to the novel object.

Further validity testing appears to be required and should preferably focus on applying the NOT under more controlled conditions, as the comparison between organic and conventional housing suffered from too many explanatory variables. In addition, with respect to the further development of the NOT it may be noted that the measures taken beyond 90 min did not appear to have added value (may even have acted contraproductive in the analyses of intercepts and slopes of the regression lines) in detecting differences between the housing systems. Together with condensing the measures (taking 1 rather than 2 measures per half hour), this may provide scope for improving the feasibility of the NOT for on-farm welfare assessment.

The main conclusion from these two small experiments was that even under rather variable conditions and with a rather limited number of observations the novel object test (NOT) was able to detect significant differences between organic and conventional housing systems, which differed considerably in the level of environmental enrichment provided to the pigs. The absolute level of animal-material interaction (AMI) and esp. the rate of decline over time could be relevant parameters to assess the level of enrichment and/or the level of positive emotions in pigs.

16.6 EFFECTS OF FINE CHOPPED STRAW

16.6.1 Introduction

The previous work compared organic and conventional systems that differed considerably in the level of environmental enrichment (straw and space). For use in a welfare index, however, the novel object test (NOT) must also be sensitive enough to detect relatively small differences in enrichment. A relatively small difference could, for example, consist of a handful of fine chopped straw given to pigs otherwise kept in a similar environment.

The welfare benefits of fine short chopped straw are questionable. Straw is mentioned in the EC Directive as a 'good' material. Some experts regard sufficient and good quality straw as the gold standard (see the inventory of expert opinion reported in Bracke, 2006). However, less favourable effects of fine chopped straw were reported by Day et al. (2001), who found reduced interest and even increased tail biting in pens with fine chopped straw (80% of strands ≤ 4 cm) compared to pens with longer (coarse chopped and full length) straw. In their study tail biting was even higher in pens with fine chopped straw than in control pens without straw.

The objective of this experiment was to test the sensitivity of the novel object test as a measure of positive emotions differentiating between different levels of enrichment using fine chopped straw provided to fattening pigs.

16.6.2 Methods

On a commercial farm 2 units with 8 pens each were used (age of the pigs in these units was 190 and 150 days). Each pen contained between 3 and 11 crossbred fattening pigs (average: 7.3 pigs/pen). All pens were 2.15 m wide and 3.5 m deep, and contained a dry pellet feeder and a drinking nipple. Half of the pens were provided with half a handful of finely chopped straw (strands of 2–4 cm in length) per pig per pen, both the day before, in the morning a few hours before the start of the test, at the start of the test and at $t=30$ min. Since the number of pigs per pen differed, treatments were randomly assigned but balanced as much as possible for the number of pigs per pen. In each pen a novel object (nylon rope, 3 mm. diameter) was hung, suspended 30 cm above the floor from a horizontal bar at 1.5 m. The interactions with the rope were counted 'online', using a so-called AMI sensor (modified after Zonderland et al., 2001). The interaction rate per minute was calculated for the first, second and third half an hour (by accident the last measurement was taken at 80, instead of 90 minutes) after the object had been provided to the pigs.

Statistics: A Split plot ANOVA (on observations within pens within units) was done using Genstat 8 (ref) on log transformed data.

16.6.3 Results

Figure 16.5 shows the error bar graph of the effects of straw compared to no straw over time.

There was a near trend effect of the provision of straw (straw, no straw means were 4.61 and 6.15 respectively, $p=0.13$). There was a significant decline over time (first, second or third half an hour means were 6.86a, 5.24ab and 4.20b respectively; $p=0.027$, where means with different superscripts differed significantly). Also, a significant time-treatment interaction was found ($p=0.009$, see Table 16.3). In straw pens there was a significant decrease of AMI over time, whereas in control pens there was an initial increase and no significant decrease over time. No effect of the number of pigs per pen, or unit (age of the pigs) was found.

16.6.4 Discussion

The novel nylon rope elicited a considerable amount of attention in pens with and without chopped straw. The main difference between straw pens and controls as detected by the novel object test (NOT) was not the absolute level of animal-material interaction (AMI), but the higher rate of decline in enriched pens. This is in line with the previous experiment where the NOT was applied in organic and conventionally housed pigs.

As in the case of organic weaners, the decline became evident already between the first and second half an hour after introduction of the rope, again, providing scope for improving the feasibility of the test.

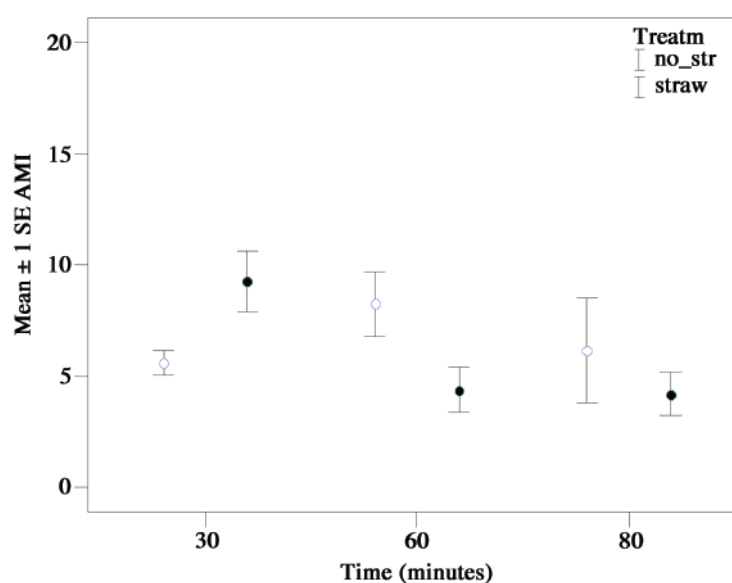


FIGURE 16.5 Means and standard error (SE) bars of animal-material (novel rope) interactions per minute (AMI) over time in pens with and without novel short chopped straw (solid and open data points respectively).

TABLE 16.3 AMI levels for pens with and without straw during the first, second and third half an hour of the novel object test (NOT).

Time (min)	No straw	Straw
30	5.77ab	8.16a
60	7.78a	3.52b
80	5.18ab	3.40b

The main finding is in line with the view that the novel straw elicited positive emotions which reduced the interest in the novel rope. An alternative explanation, however, may be that the straw induced activity (without positive emotions, perhaps even inducing negative emotions like frustration and fear) which increased preliminary attention for the rope thereafter rapidly declining as the enhanced activity had ‘exhausted’ (satiated or frustrated) the pigs. More detailed ethological studies would be required to resolve this issue. However, it should be emphasised that in this experiment only a limited number of observations were made (in 16 pens only) with a variable number of pigs per pen.

The main conclusion was that a small amount of newly provided fine chopped straw just before and during the first half hour of the novel object test (NOT) resulted in a more rapid decrease in animal-material interaction (AMI) compared to the no-straw situation, indicating that the provision of straw may (but does not have to) have been accompanied by positive emotions.

16.7 EFFECTS OF A JERRYCAN

16.7.1 Introduction

Having shown that the novel object test (NOT) can detect relatively large differences in enrichment (organic versus conventionally housed pigs and pigs enriched with and without novel fine chopped straw), the NOT was in need of further sensitivity testing, together with an examination of potentially confounding factors such as age and group size.

The selected stimulus for the last experiment(s) was a jerrycan (canister) that had been in the barn (unit) for longer and that had been provided to the pigs the day before testing. The jerrycan was expected to be of limited enriching value as pigs have been believed to more rapidly lose interest in enrichment materials that have been in the barn for longer and that have adopted the barn smell (Stubbe, 2000). Also, jerrycans do not have the properties which stimulate AMI such as novelty, chewability, ingestibility and destructibility (see Zonderland et al. 2001; van der Weerd et al., 2003). Based on RICH-PIG and expert opinion (Bracke et al., 2007) the prediction was made that the jerrycan is a very modest enrichment device, that should hardly affect the interaction with the novel object (rope).

The objective of this experiment was to test the sensitivity of the novel object test as a measure of positive emotions: The test would be highly sensitive if it could differentiate between pens of fattening pigs with and without jerrycans (as this was presumed to be a very modest/minimal level of environmental enrichment). (Note: This part of the work has also been published in Bracke and Spoolder, 2008).

16.7.2 Methods

The experiment was repeated twice in one building of a commercial farm.

In each experiment matched pairs of pens were selected across the age groups present in the building. The two pens within each pair of pens were located in the same unit (same start date of the growing phase of the pigs) and the pens of a pair were as much as possible similar with respect to the number of pigs in the pen and their location in the unit (front, middle, back). One pen of the pair was provided with a jerrycan on the day before the NOT. The jerrycans had been in the barn for longer, and all jerrycans had been used as enrichment material in previous batches of pigs raised in the same building.

Different pairs of pens were located in different units in the building (containing batches of pigs of different age groups). The units were replicates containing 8 pens per unit.

As a general rule the pens contained rather uniform groups of mostly 11 crossbred growing pigs per pen. Pens were 3.05 m deep and 2.65 m wide. They had a partly solid, convex floor (1.2 m deep), extending from 0.4 m from the front wall to 1.45 m from the back wall, with slatted floors in the front and the back of the pen. All pens had a dry feeder containing a drinking nipple and a chain hanging on the pen wall dividing neighbouring pens. There was no additional environmental enrichment in the pen.

In the first experiment 8 pairs of pens were used. Each pen contained between 7 and 11 pigs. The pigs had been on the premise for between 21 and 126 days at the day of testing.

In the second experiment 15 different pairs of pens were used. Each pen contained 10 or 11 pigs (except for 1 pair with 5 pigs per pen, 1 pair with 8 pigs per pen, and 1 with 9 pigs. The pigs had been in the building for between 26 and 138 days.

The novel object, a nylon rope, was introduced in each pen. In Experiment 1 a longer orange nylon cord (diameter: 4 mm; reaching till 20 cm above the floor) with untwined strands was used, while in Experiment 2 a shorter (nose-height) white nylon cord (diameter: 3 mm) with twined strands was used. The interactions with the object were counted 'online', using a so-called AMI sensor (modified after Zonderland et al., 2001) and recorded after respectively 7 and 8 intervals of 15 min each.

Statistics: A Split plot ANOVA (on observations within pens within units) was done on log transformed data using Genstat 8 (Anonymous, 1993). Since this analysis assumes a constant covariance between observations the dataset was condensed to 3 data points per

pen (each consisting of the average AMI for the first, second and third half an hour respectively). The measures taken after 90 min were ignored in the Split plot analysis, also because a feasible test should preferably take a limited period of time to record.

In order to show the ‘full’ dataset (not transformed) mean values and their standard errors were graphically represented, and an ANOVA was done on the intercepts (with the y-axis) and slopes of the log-transformed curves (see Oude Voshaar, 1995). Finally, one-sided Sign tests were done comparing treatment effects under the hypothesis that (matched) control pens had higher AMI values than pens enriched with a jerrycan.

16.7.3 Results

In Experiment 1 a significant effect of time was found in that the predicted mean values for the first, second and third half an hour were 12.82a, 7.36 b and 5.75b respectively (where different superscripts differed significantly, F value was 20.50, $p < 0.001$). There were no further noteworthy effects found in the Split Plot analysis or on intercepts and slopes of the time-series regression lines.

Figure 16.6 shows that on each of the 7 recorded time points the mean value for the controls was higher than the mean value for the jerrycan-treated pens. This would be significant in the Sign test ($p = 0.007$). However, when the 15 min average AMI values and the cumulative AMI values per time period were compared both sets of Sign tests showed trends only for the time points 15 min and 45 min ($p < 0.1$).

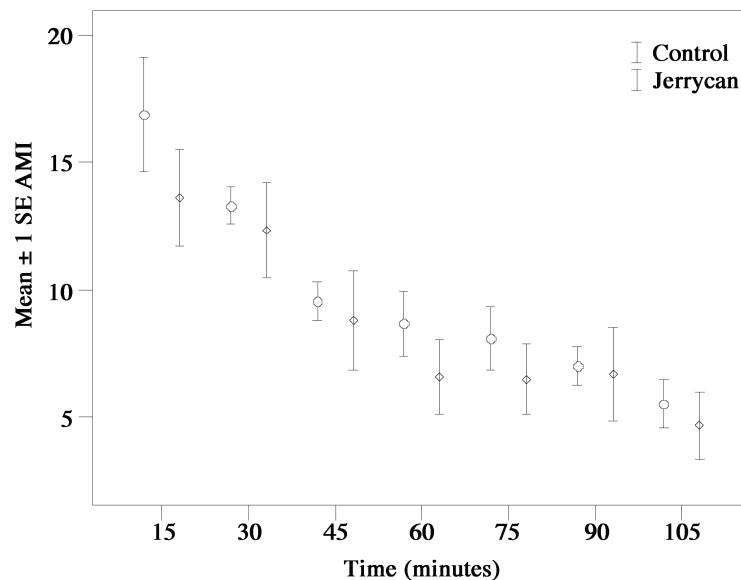


FIGURE 16.6 Means and standard error (SE) bars of interaction-frequency with a novel rope (AMI) over time in Experiment 1 comparing 8 pens provided with a jerrycan with 8 matched controls.

Notes: At each time point controls are represented by the first, round and Jerrycan-pens by the second, diamond-shaped bar.

In Experiment 2 the provision of the jerrycan significantly reduced AMI (predicted means were 2.53 and 4.08 for jerrycan and controls respectively, $F=5.59$, $p = 0.036$). No significant effects were found of time, of the covariates 'age' and 'number of pigs per pen' and of any interaction with treatment. The predicted means of both controls and jerrycan-treated pigs decreased progressively, but not significantly over the 3 half-hour time periods in the Split plot ANOVA.

In the analysis of the intercepts a trend ($p = 0.099$) was found for a treatment effect, while no effect (of any factor or interaction) was found for the analysis of the slopes of the time-series regression lines. Figure 16.7 shows that, again, all mean values for the controls in each of the 8 time periods were higher than the means for the jerrycan-treated pens (8 out of 8). This too would be significant in the Sign test ($p = 0.004$). When the 15 min average AMI values per time period were compared only a trend was found for the 30 min time period ($p < 0.1$). The cumulative averages per time period, however, were significant at times 75 min and 90 min, while a trend was observed for the times 30, 105 and 120 min.

When the Sign tests were done over the dataset combining both Experiment 1 and Experiment 2, the 15 min average AMI values for each time point were significant at time 15 min, a trend was found at times 30 min and 45 min, while a near trend ($p = 0.13$) was observed at time 75 min. The cumulative average AMI values for the 7 time points tested in the combined dataset all either were significant (times 15, 45, 75, 90) or showed a trend (times 30, 60, 105).

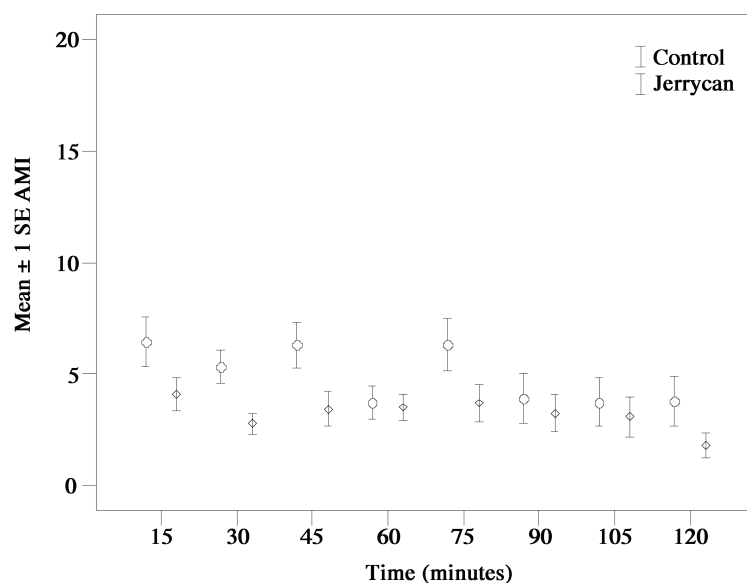


FIGURE 16.7 Means and standard error (SE) bars of animal-material (novel rope) interactions per minute (AMI) over time in Experiment 2 comparing 15 pens provided with a jerrycan with 15 matched controls.

16.7.4 Discussion

When a jerrykan was provided the previous day pigs showed a very small but significant decrease in their interest in a novel rope. The effect was detected under matched control conditions and only when as many as 15 repetitions were performed. The effect, however, was also present in the first experiment in that the Sign test too indicated some effect in that experiment.

In the previous experiments (comparing organic and conventionally housed pigs and comparing pens with and without chopped straw) the rate of decline appeared to be the main indicator of enrichment. In the present experiment(s), however, this effect was not present, perhaps indicating that the potential enriching effect of the jerrykans was small.

Possible explanations for reduced AMI in the jerrykan treatments compared to controls include a reduction in reinforcement of the novel rope (inversely indicating positive emotions related to the provision of the jerrykan) and an ‘exhaustion’ effect of (unmeasured) interaction with the jerrykan. Casual observations, however, indicated that the pigs were hardly interacting with the jerrykans, at least at the time when the NOT was done.

In these experiments pairs of pens differed considerably with respect to age, covering almost the entire growing and fattening period. The absence of an ‘age’ effect in the analyses, therefore, is noteworthy and is beneficial for the feasibility of application of the test in practice.

The progressive decline over time observed in Experiment 1 was not repeated in Experiment 2 (see Figures 16.4 and 16.5). This may have been due to differences between the experiments, e.g. the type of rope used or a time effect. This unexplained variation is problematic for application of the test, indicating that further work into potentially confounding factors would be required before the test can be made suitable for comparison across farms.

The main conclusion was that there is a very small but significant reduction in response to the novel rope when the pigs had been provided with a jerrykan on the day before the test. Under the hypothesis that the NOT inversely reflects positive emotions, this may indicate that a jerrykan is slightly enriching for pigs.

16.8 GENERAL DISCUSSION

This section discusses issues applying across the experiments done so far for the development of a novel object test (NOT) for assessing different levels of environmental

enrichment in pigs in the context of a welfare monitoring system (for certifying farms with respect to welfare).

Since a full meta-analysis could not be performed on the limited data set, selected issues using information from the different experiments will be discussed. It concerns the effects of the potential covariates ‘group size’ and ‘age’, differences between farms housing pigs under intensive conditions and validity of the NOT for detecting positive emotions in pigs.

16.8.1 Effects of Group Size and Age

Initially (when describing the process in time in a pilot experiment involving only 4 pens, 2 pens with 8 pigs per pen and 2 pens with 5 pigs per pen), a very preliminary indication of an effect of group size was found in that the two pens with a larger group had higher initial values and lower values later in time. However, this effect was not observed in the statistical analyses of the experiments testing the effects of straw, the jerrycan and organic housing in weaners. However, an effect of group size was found in the experiment comparing growing pigs in organic and conventional housing. Since the differences in group size were most pronounced in this latter experiment, it appears that small differences in group size may not have substantial effects on the outcomes of the NOT.

A similar conclusion seems to hold for the covariate ‘age’, as apparent (but in the present dataset not yet finally testable) differences seemed to be present between weaners and growers in the experiments comparing conventional and organic pigs. Fortunately, no effect of ‘age’ was found in esp. the jerrycan experiment, in which growers of a wide range of ages were tested. This suggests that moderate differences in age may not substantially affect the pigs’ responses in the NOT. This is accordance with our expectation, as older animals (i.e. beyond the start of the growing phase in pigs) are known to play less than younger animals.

The present results, therefore, justify a moderate optimism with respect to the potential of the NOT for on-farm welfare assessment of positive emotions in pigs in that the test appears to be rather insensitive to (relatively small) changes in group size and age.

16.8.2 Differences between Farms Housing Pigs under Intensive Conditions

Differences between enrichment conditions (e.g. between pens with chopped straw in one experiment and a jerrycan in the other experiment) could not be compared, as there were insufficient data for such a comparison. As a first step towards a comparison of NOT results measured across farms, however, we tried to compare the results for conventionally housed growing pigs (i.e. the ‘controls’) in the 4 relevant experiments. This concerned the controls in the chopped straw experiment, the conventional growers in the organic-conventional comparison and the 2 control groups in the repeated jerrycan experiment. Their AMI values appeared to share a similar, rather horizontal, pattern over time (with a progressive decline only in the first jerrycan experiment), perhaps indicating sustained

interest under more barren conditions. However, the degree to which even these subsets of data can be compared turned out to be limited due to unexplained variation (e.g. between the two jerrykan experiments that were carried out in the same building but on slightly different times of day and using slightly different types of rope).

The type of rope used in the 2nd jerrykan experiment was comparable to the rope in the organic-conventional experiment. It appeared that for the first 90 min the (estimated) average AMI for the control pens was 4.8 in the jerrykan experiment and about 3 in the organic-conventional experiment. A possible explanation for the apparently somewhat lower score in the latter study could be that these pigs had received sawdust/chopped straw in the morning of the day on which the experiment had been carried out. This appears to be in accordance with the findings in the chopped straw study where the predicted mean value for 'straw' pens was 4.6, whereas the control pens had a somewhat (but not significantly) higher mean of 6.15.

Again, the presently available information, therefore, justifies a moderate optimism with respect to the potential of the NOT for on-farm welfare assessment of positive emotions in pigs, as the (perhaps slightly modified) NOT may seem to be generating findings that could be generalised across farms. However, because of unexplained variation in test results between different experiments, this is a tentative suggestion that would need to be verified in further work.

16.8.3 Validity, Reliability and Feasibility of the Novel Object Test

The validity, reliability and feasibility of the novel object test (NOT) for assessing positive emotions in pigs as well as directions for further research are discussed in this section.

When the NOT was used to test different levels of environmental enrichment (jerrykan, novel fine chopped straw, organic housing) compared to (less enriched) control pens a number of significant effects on overall animal-material interaction (AMI) levels and the rate of decline of interest in the rope were observed. Firstly, a jerrykan hardly (but significantly) reduced overall AMI levels. Secondly, a small amount of newly provided fine chopped straw resulted in a more rapid decrease in AMI. Finally, elevated overall AMI levels were found in organic pigs (growers and weaners) compared to conventionally housed pigs, while the rate of decline was significantly higher in organic weaners, but not in growers (where the conventional controls had been enriched with a moderate provision of sawdust or chopped straw). The NOT, therefore, can distinguish between different levels of enrichment and a tentative suggestion could be that it is esp. the rate of decline over the first 90 min. that may be related to the level of enrichment. A larger dataset and/or a systematic investigation into explanatory variables would be required, however, to confirm this hypothesis.

The NOT is expected to have a high inter- and intra-observer reliability (esp. when compared to other animal-based measures), perhaps it is even comparable to the inter-observer reliability of resource-based measures such as pen space and the presence/absence

of enrichment materials. This is because the measure does not rely on traditional behavioural observations which require defining an operational ethogram. Instead, a newly developed sensor, called an AMI-sensor, is used (AMI = 'Animal-Material Interaction'), and the counts generated by the sensor merely have to be registered (much like the registration of the length using a measuring tape).

The feasibility of the NOT has markedly benefited from the use of a sensor that could ultimately be made available for a reasonable cost. The time required to take the measurements can also be improved further. This project was a pilot experiment proposing a potentially feasible test worth further (fundamental and applied) investigation for incorporation into the welfare monitoring scheme. In the experiments mostly 15 min periods were recorded over about a 3 hour period. This was done for experimental purposes, to increase the level of detailed information at this experimental stage of test development. Further simplification would be required to make the test applicable for practical application for on-farm welfare auditing. Before such application is warranted, however, potentially confounding variables such as group size, age, breed and time of day would need to be examined further. Another, more fundamental thesis that remains to be verified is which aspects of positive emotions, enrichment and play are reflected in the NOT.

16.9 CONCLUSIONS

In order to be a useful measure of positive emotions in pigs the novel object test (NOT) must be valid, reliable and feasible.

With respect to validity, the present test was able to detect differences in apparently large contrast situations (as was created between organic and conventionally housed pigs). Furthermore, it appeared to be rather specific, in that it was able to give a differential response between smaller contrast situations (as was created in pens with and without fine chopped straw and in pens with and without a jerrycan).

The test appeared to be somewhat robust with respect to the potentially confounding variables 'group size' and 'age', but other potential confounders remain to be examined.

The reliability and feasibility are strong points of the NOT, which is mainly in need of further validity testing.

It is advised not to discard this test lightly, as it is not only a (rare) behavioural measure with potential, it is also a (even rarer and scientifically, strategically and politically more important) potential measure of positive emotions.

16.10 ACKNOWLEDGEMENTS

We wish to thank all those who contributed to this work, esp. Linda Keeling and Patrick Zimmerman, as well as the farmers/stockpersons, for their hospitality.

HUMAN-ANIMAL RELATIONSHIPS: VALIDATION OF MEASUREMENTS ON SOWS

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17.1 SUMMARY

Different methodologies for assessing fearfulness of people in sows have been documented in the scientific literature. The selected methodology for on-farm assessment needs to be applicable to both sows in stalls and sows in groups, to accommodate the different ways in which sows are housed across Europe. Previous methodologies based around three different approaches were selected for animal trials:

1. response of free moving sows to a stationary observer in an open field test (animal-initiated approach: AA);
2. response of sows in stalls to approaching hand contact (human-initiated approach – stalls: HAS);
3. response of free moving sows to approach by an observer (human-initiated approach – free: HAF).

AA had previously been demonstrated to reflect the effects of positive handling on sows, and was intended to provide a standard against which the other two tests could be judged. Fifty-five crossbred sows and gilts were each subjected to all three tests. Within each test, the response of the sows was scored according to a predetermined scale of approach-withdrawal behaviour. The correlations between responses to the different tests were investigated to determine whether they measured the same level of underlying fear. A Kendall coefficient of concordance suggested that there was no significant overall relationship between the three tests ($W=0.507$, $P>0.05$). Rank correlations showed a significant relationship between AA and HAS ($r=0.270$, $P<0.05$), a stronger correlation between HAS and HAF ($r=0.404$, $P<0.01$), but no significant correlation between AA and HAS ($r=0.198$, $P>0.05$). The repeatability of HAF and HAS was high, as shown by rank correlations ($r=0.777$, $r=0.628$; $P<0.001$), whereas AA had poor repeatability ($r=0.153$, $P>0.05$). There were no significant effects of parity or stage of pregnancy on fear responses in any of the three tests.

Since test HAS and HAF both gave good repeatability and were significantly correlated with each other, we recommend both these tests for on-farm welfare assessment. HAS was the most repeatable test, and is perhaps the most convenient test to conduct under practical conditions. Housing sows in stalls is already banned in some EU countries; however, in such cases individual feeding stalls could be used temporarily for testing. If this is not possible, HAF should be used.

17.2 INTRODUCTION

The aim of this study was to investigate the validity and repeatability of measures of the human-animal interaction in sows.

Fear reactions are the most immediate responses that animals show to potentially dangerous stimuli in the environment (Andersen et al., 2006). Fear is associated with physiological stress and has been shown to have negative effects on performance (Hemsworth et al., 1989), health status and reproductive performance (Von Borell, 1995). Human–animal interactions are much reduced in modern commercial practice compared with traditional pig farming; however the importance of the relationship between animals and the carers should not be underestimated. Hemsworth et al. (1989) reported that the behaviour of the stockperson towards a sow in their care was a strong determinant of the level of fear the animal would show towards humans. Therefore, fear of humans can be an important welfare indicator.

In the presence of humans, farm animals can display behaviour patterns commonly labelled as ‘fear responses’. These include, amongst others, withdrawal from or avoidance of humans (Hemsworth et al., 1996). Previous methodologies using withdrawal and avoidance behaviour have included three different approaches: response of animals to approaching hand contact (e.g. calves; Rousing et al., 2005), response of free moving animals to a stationary observer in an open field test (e.g. sows; Andersen et al., 2006), and response of group-housed animals to approach by an observer (e.g. calves; Rousing et al., 2005). Fear responses to humans show great similarities between different species of farm animals (Andersen et al., 2006); therefore the methodologies used with calves can be translated to pigs. However, different methodologies may be more or less sensitive than others in determining the level of fear shown by an animal. The aim of this study was therefore to compare three different methodologies to measure fear of humans in sows and identify the most feasible and reliable method for on-farm welfare assessment. Response of individual free moving animals to a stationary observer in an open arena had previously been demonstrated to reflect the effects of positive handling on sows (Andersen et al., 2006), and was intended to provide a validated standard against which other more practical tests carried out in home pen conditions could be compared.

17.3 METHODS

17.3.1 Animals and Housing

Fifty-five crossbred sows (Landrace x Large White x Duroc) of different parities and stages of pregnancy were used in the study. Animals were provided from the experimental herd of the School of Agriculture, Food and Rural Development, Newcastle University, in the autumn of 2005. All animals were housed within the same dry-sow house, in groups of 4–5 sows per pen. Pens (concrete flooring) consisted of an exercise area (2.3m x 2.3m), a kennelled lying area (2.3m x 2.3m) and individual feeding stalls. Sows were secured in the feeding stalls at feeding time; at all other times the stalls could not be accessed. On alternate days, sows were shut in the kennelled area whilst the exercise area was scraped through, after which fresh chopped straw was provided.

17.3.2 Fear Assessment Tests

Each animal was subjected to three different fear assessment tests, each of which was repeated after a period of no more than one week. The order in which sows experienced the tests was fully balanced to account for any confounding effect of previous experience. None of the tests were conducted around feeding time, as this could have affected the sow's response.

17.3.3 Response of Free-moving Sows to a Stationary Observer in an Open Field Test (AA)

This methodology was based on that of Andersen et al. (2006). Sows were removed from their group and placed in a separate experimental pen (3m x 3m) within the dry-sow house. All the sows were familiar with the pen (it was also a service pen), however they were still allowed two minutes adaptation period in the pen before the observer entered and the test commenced.

The test began with the observer, wearing clean stockperson's overalls, entering the pen and walking around its perimeter at a steady pace (about one step per second), thus alerting the sow to his presence. The observer then moved slowly and silently towards the sow, squatting down in front of the sow at a distance of approximately 0.5m from her head. The observer's head was directed towards the sow, and both his hands were resting on his knees, and he held this position for two minutes.

The behavioural response of the sow was categorised as 1–6 as follows:

1. The sow actively flees at a distance of more than 1m from the observer.

2. The sow withdraws some steps away from or turns its head away from the observer, and stays there or continues with activity for the rest of the test period.
3. The sow withdraws some steps away from or turns her head away from the observer, but approaches the observer again and initiates physical contact within the test period.
4. The sow neither withdraws from nor approaches the observer, but remains in the same posture or continues with activity.
5. The sow neither withdraws from nor approaches the observer for most of the test period, but initiates a brief contact at the very end of the test period.
6. The sow approaches and initiates physical contact with the observer.

17.3.4 Response of Sows in Stalls to Approaching Hand Contact (HAS)

The housing of sows in stalls is prohibited in the UK; therefore the individual feeding stalls in each pen were used to simulate sow stalls. Prior to the test commencing, sows that were not under test were released from the stalls. The feeding stalls did not contain any food, as this may have influenced the results of the test. The test was carried out as a three-step procedure (based on Rousing et al., 2005):

1. The observer, wearing clean stockperson's overalls, walked up and down in front of the stalls, alerting the sows to his presence. The observer then moved to the 'start' position, approximately 0.5m away and slightly to the right hand side of the first sow under test, and stood motionless in a relaxed posture with hands by his side for 10 s.
2. From the start position, the observer approached the sow in a standardised way, i.e. slowly and diagonal from the front, looking at the sow without staring and keeping arms and hands close to his body. Once at the head end of the stall, the observer stopped, knelt down and remained motionless for 10 s.
3. The observer attempted to reach over the top bar of the stall and touch the sow between the ears for 10 s.

The behavioural response of the sow was categorised as 0–6 as follows:

Whilst the observer was at the start position (Stage 1):

- 0 Sow withdraws;
- 1 Sow withdraws initially but then approaches

Whilst the observer was crouched down in front of the sow (Stage 2):

- 2 Sow withdraws and remains withdrawn;
- 3 Sow withdraws initially but then approaches

When the observer attempts to touch the sow (Stage 3):

- 4 Sow withdraws when the observer attempts to touch her between the ears and stays withdrawn;
- 5 Sow withdraws when observer attempts to touch her between the ears, but then approaches;
- 6 Sow allows observer to touch her between the ears without any withdrawal response.

17.3.5 Response of Free-moving Sows in Group to Approach by an Observer (HAF)

For this test, sows remained within their pen group (i.e. normal farm situation), however the exercise area available was doubled in size by closing sows in the adjacent pen in their kennelled lying area (new activity area: 2.3 x 4.6m). Sows were given two minutes to acclimatise to the larger pen size before the test commenced. The test was carried out as a three-step procedure (after Rousing et al., 2005):

1. The observer, wearing clean stockperson's overalls, walked around the perimeter of the pen at steady pace before moving to the 'start' position, 0.5–1.0 m away from the test sow, and remained motionless for 10 s.
2. The observer approached the head end of the sow, and crouched down, remaining motionless for 10 s.
3. The observer attempted to touch the sow between the ears and maintain contact for 10 s.

If at any point the sow moved away from the observer due to interruption or distraction, apparently unrelated to fearfulness, the observer followed the sow to another location and continued with the test. The continuation repeated from the beginning of the phase which was interrupted, but not any previous completed phases. A sow moving away three times in succession, although not apparently fearful, was scored as withdrawing for that phase.

The behavioural response of the sow was categorised from 0–6, using the same scale as in HAS:

Whilst the observer was at the start position (Stage 1):

- 0 Sow withdraws;
- 1 Sow withdraws initially but then approaches.

Whilst the observer was crouched down in front of the sow (Stage 2):

- 2 Sow withdraws and remains withdrawn;
- 3 Sow withdraws initially but then approaches.

When the observer attempts to touch the sow (Stage 3):

- 4 Sow withdraws when the observer attempts to touch her between the ears and stays withdrawn;
- 5 Sow withdraws when observer attempts to touch her between the ears, but then approaches;
- 6 Sow allows observer to touch her between the ears without any withdrawal response.

17.3.6 Statistical Analyses

Spearman rank correlations (Minitab 13) were used to assess the repeatability of the tests. A Kendall coefficient of concordance was calculated for the level of agreement between all three tests, whilst Spearman rank correlations were used to investigate agreement between the individual tests. The effects of testing order, parity and stage of pregnancy were investigated using a Kruskal Wallis test.

17.4 RESULTS

17.4.1 Data Distribution

The median score and interquartile range for the three tests are given in Table 17.1. Scores were similar for the two human-initiated approach tests, whilst responses in AA were lower (i.e. less approach).

17.4.2 Repeatability

Each test was repeated after no more than one week. Initial plots of the data (Figure 17.1) suggested good repeatability for the human-initiated approach tests, and this was subsequently confirmed by statistical analysis. For HAS there was a significant correlation between repeat one and two ($r_s=0.777$, $P<0.001$), and similarly for HAF ($r_s=0.628$, $P<0.001$). AA, however, showed poor repeatability ($r_s=0.153$, $P>0.05$).

TABLE 17.1 Median and interquartile range for each test.

Test Number	Median Score	Interquartile range
AA	4	3.5–5.0
HAS	5	4.5–6.0
HAF	5	4.0–5.5

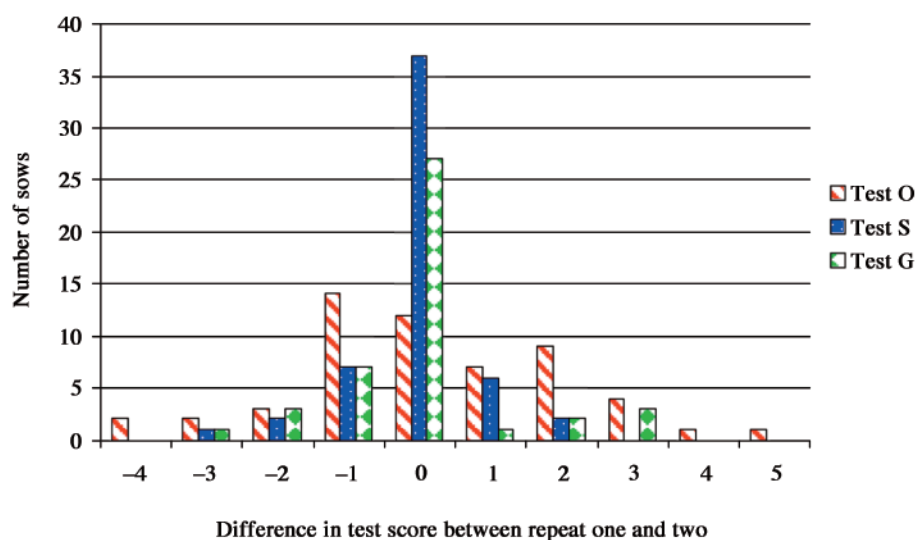


FIGURE 17.1 The difference in sow behavioural response score between repeat one and two for each test.

Notes: O=animal initiated approach; S=human initiated approach in stalls; G=human initiated approach in groups.

17.4.3 Agreement between the Tests

A Kendall coefficient of concordance suggested that there was no significant overall relationship between the scores from the three tests ($W=0.507$, $P>0.05$), indicating that the tests were not measuring the same level of underlying fear in each sow.

Agreement between the tests was further considered on a paired basis. Rank correlations showed a significant but weak relationship between AA and HAS ($r_s=0.270$, $P<0.05$), a stronger correlation between the two human-initiated approach tests ($r_s=0.404$, $P<0.01$), but no significant correlation between AA and HAF ($r_s=0.197$, $P>0.05$).

17.4.4 Effect of Test Order

The order in which the tests were given to the sows had no significant effect on the score for any of the tests (Table 17.2).

17.4.5 Stage of Pregnancy

Sows used in the study varied from those not pregnant to those more than three months pregnant. The stage of pregnancy was found to have no significant effect on fear scores for any of the three tests (Table 17.3).

TABLE 17.2 Effect of test order on median test score (mean from two repeats).

Test Number	Median when first test	Median when second test	Median when third test	Significance
AA	4.5	4.0	4.0	NS
HAS	5.0	5.0	5.5	NS
HAF	4.5	4.5	5.0	NS

Notes: ns $P>0.05$.

TABLE 17.3 Effect of stage of pregnancy on median test scores for the three tests (mean from two repeats).

Test	Not pregnant	≤ 1 month	$1 - \leq 2$ months	> 2 months – farrowing	Sign.
	N=12	N=11	N=20	N=12	
AA	4.0	4.0	4.0	4.0	ns
HAS	5.5	5.0	6.0	5.0	ns
HAF	4.0	5.0	5.0	5.0	ns

Notes: ns $P>0.05$.

17.4.6 Effects of Parity

Animals in the study varied from gilts to sows that were entering their ninth parity. As there were small numbers in each group, parities were divided into four arbitrary groups. There were no significant effects of parity on the fear scores for any of the three tests (Table 17.4).

17.5 DISCUSSION

It is important that a test is repeatable, since only if repeat measurements of the same test give the same results can the test be considered reliable. The two tests with human-initiated approach showed good repeatability. The methodology for these tests was based on that of Rousing et al. (2005), who reported relatively high repeatability when looking at the behavioural responses of group-housed calves towards humans (weighted kappa coefficient 0.62). The test with animal-initiated approach gave poorer repeatability, and was therefore considered to be unreliable as a validation standard for the other tests, despite the findings of Andersen et al. (2006), who developed the methodology used in the present study. In their study, sows in a positively handled group showed a reduction in fear score. Sows in the control (minimal handling) group showed no significant change in fear response between test repeats, although no specific assessment of individual repeatability was made.

Statistical analyses suggested that the three tests did not all measure the same level of underlying fear in sows. However, when the tests were considered on a paired basis, there was a significant relationship between HAS and HAF, suggesting that they were measuring the same level of fear. There was a weaker significant correlation between AA and HAS, but no significant relationship between AA and HAF. The strong correlation between the human-initiated approach tests may be due to their similar methodology, as both are approach tests that involve actively initiating contact with the sow. In contrast, in the AA it is the sow who must initiate contact. Observations made during AA noted that often the sows were more interested in exploring the test arena, despite the fact that they had had an acclimatisation period prior to entry of the observer. It is possible that some of the low

TABLE 17.4 Effect of parity on median test scores for each of the three tests (mean from two repeats).

Parity	No. of sows	Test			Significance
		AA	HAS	HAF	
0	18	4.0	5.25	4.5	ns
1–2	10	4.5	4.5	3.75	ns
3–4	16	4.75	5.25	5.0	ns
5–9	11	4.0	6.0	5.5	ns

Notes: ns $P > 0.05$.

scores from AA were a not a reflection of more fearful behaviour, but rather influenced by factors other than a fear of humans, such as exploratory motivation.

Sows were randomly assigned one of six different test orders; however the order in which the sows received the tests did not affect their fear response. It would therefore appear that the brief duration of the tests was not long enough for the sows to become habituated to the presence of the unfamiliar observer. The lack of effect of stage of pregnancy and parity means that these tests can be used without discrimination in the dry sow house.

17.6 CONCLUSIONS

HAS and HAF gave good repeatability and thus appear to measure the same level of underlying fear. We therefore recommend both these tests for on-farm evaluation. HAS gave better repeatability, and may be easier to carry out under practical conditions, but it should not be associated with food provision cues. As this may not always be practicable, we therefore recommend that assessors also be familiar with HAF, which also showed good repeatability and agreement with HAS. Methodologies are similar for both tests, and the scoring systems are identical, both of which should make things easier for the assessor.

HUMAN–ANIMAL RELATIONSHIPS: VALIDATION OF MEASURES ON FATTENING PIGS

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18.1 SUMMARY

The objective of the study was to devise and validate an on-farm behavioural test to evaluate the human–animal relationship (HAR) in growing pigs. To generate a population of pigs with exposure to a range of different levels of human–animal interaction, groups of growing pigs were submitted to one of three types of handling, namely minimum, mild (stick) or aversive (electric prod). The on-farm test was based on the response of the whole group of pigs to three successive situations: a human walking around the pen (W1), a human staying motionless during 30 sec (S) and then walking again around the pen (W2). Responses identified in steps W1 and W2 were expressed as Panic, Avoidance or Contact. For step S, the number of pigs approaching within 50 cm of the human was recorded. In order to validate the on-farm test, two individual tests were carried out in a corridor (Corridor test) or in an arena (Arena test), considering the score for each pig being the score of its pen.

The different types of handling experienced by groups of pigs were associated with clearly different scores in the on-farm test. In most of the pens with aversive handling, animals presented a Panic response. W2 response was the best way to discriminate between groups in relation to the whole behavioural measures of both individual tests. Pigs from groups scored as Panic were characterized by a higher flight distance to a moving human than the other groups and it took a greater effort for the handler to move them towards a stationary human. In the arena test, pigs issued from Panic response groups showed a higher latency to approach and interact with a stationary human, and a lower time spent within the 50 cm area close to the observer, compared to the ‘Avoidance’ and ‘Contact’ groups.

In conclusion, the on-farm test devised and evaluated in this study is easy to perform and allows for the classification of the quality of the HAR experienced by pigs in well-known experimental situations. The score of the pen has to be limited to the response observed during the second walk around the pen (W2), but the two previous stages of the test are

important to remain in the test since they focus the attention of pigs to the arrival of the human, and therefore the W2 response of the animals reflects their perception of the human and not only a reaction of surprise.

18.2 INTRODUCTION

Numerous tests have been used in pigs to assess human–animal relationships (HAR) according to the nature of human involvement (stationary, moving, handling). The tests are mainly carried out in experimental conditions, on the basis of individual testing in a test arena outside the home pen, as reviewed by Waiblinger et al, 2006 and Forkman et al, 2007). These reviews of HAR tests also highlight the relevance of the application of HAR tests in an animal's home pen for on-farm welfare assessment and the need for these tests to be validated prior to their inclusion in a robust on-farm welfare monitoring protocol. Such a test should detect any obvious situations of bad human–animal relationships at a farm level, situations which can be due to poor human supervision leading to a risk of fear or even panic reactions within groups of animals. These negative behavioural reactions may in turn induce body lesions when pigs are moved or submitted to human interventions.

A previous study was conducted to evaluate the feasibility of simple procedures to assess the human-animal interaction on farm (Courboulay and Foubert, 2007). It was based on the behavioural reactions of the animals towards different actions of a human operator: presence of a human in the corridor of the room, at the entrance to the pen, walking in the pen, present motionless in a corner of the pen and finally attempting to touch the ear of some pigs of the group. The behavioural responses of pigs to the walk of the operator walking through the pen appeared to be the best one to evaluate the relationships towards humans.

The purpose of this current study then was to develop an on-farm test based on these previous observations and to validate it by comparison with individual tests existing outside the home pen. Groups of animals with different experience of human contact were created, by exposing animals to different situations ranging from minimum handling to handling associated with electric shock. The on-farm test based on the reaction of animals to the approach of a human observer was used. To validate the relevancy of this test to measure the quality of the HAR, we compared the results of the individual behavioural responses of pigs to the various human approaches.

18.3 METHODS

The study was conducted on fifty-six pens of finishing pigs in two experimental farms, which offered different flooring conditions (24 pens on slatted floor and 32 pens on concrete floor covered with straw) and group sizes (from 8 to 12). Pigs were fed *ad libitum* and subjected to routine farm management concerning the cleaning and inspection. At 70kg liveweight, groups of pigs were submitted to one of the three treatments relating to the nature of human handling: minimum intervention of the stockman (MIN), mild interaction through physical contact with a soft stick (MED) and potentially aversive interaction with an electric prod (AVE). Treatment was allocated to 18 pens for the MIN treatment and 19 pens for both MED and AVE treatments. The treatment was applied for seven consecutive days. A stockperson entered the pen every day at the same time, walked calmly around and initiated one of the three HAR treatments whenever an animal approached the stockperson. He/she remained in the pen for two minutes. On D8, each group was submitted to the on-farm test. Tests outside the home pen used to evaluate the validity (described below) were carried out on D10 (Corridor test) and D13 (Arena Test). Between each test, the treatment was applied again (D9, D11 and D12).

The handler and observer involved in the test procedures were different from persons who implemented the handling treatments and were therefore unfamiliar to the pigs.

18.3.1 On-farm Test

For each group tested, the penmates were standing up before the beginning of the test. The test started when the observer entered the pen and it involved three stages: the observer walked slowly all around the pen once then stood without moving for 30 seconds at one side of the pen, before finally making a second walk similar to the first one. After each walk through the group, the observer noted the reaction of the majority of pigs in the group (>60% of pigs) while he/she was moving (responses W1 and W2). The four scores consisted of panic (P), where animals ran away and/or huddled at one side of the pen with squeals or vigilance postures (ears erect or tonic immobility of the body), avoidance (A), where animals moved aside from the approaching observer, contact (C) where animals followed and/or initiated physical contact with the observer and finally no reaction (R) where animals exhibited no modification in the behavioural activity of the group. As the observer stood motionless for 30 sec, he/she counted the total number of pigs approaching within a 50 cm area of him/her (response S).

18.3.2 Corridor Test

The corridor test was undertaken on 478 animals from the 56 pens studied. For each pen to be tested, all pigs were moved from their home pen to a waiting pen and each pig was

tested separately. The animal was separated from its group and introduced to a waiting pen adjacent to a 13m x 2m corridor. The corridor was formed from solid partitions (what height?) delineated with marks on the floor (or was it on the side) every 50 cm. Three different measurements were then applied. The handler opened the access to the corridor and stood motionless, then recorded how far the pig moved away from him. When the pig stopped moving, an observer placed at the end of the corridor approached the animal, speaking to it to catch its attention. The flight distance was measured when pigs moved in the opposite direction. For the third measurement, the observer stood at the end of the corridor and stayed motionless. Then the handler made the pig pass the observer, using a panel of board used by stockpersons to direct pigs around the farm (dimensions). The handler kept a distance of 30 cm from the animal except if the pig stopped, he used the panel to push the animal. The observer recorded the mobility of the pig (S: spontaneous walk, T: tried to return or R: returned back towards the holding pen) and the effort the handler expended to move the pig expressed as push (P) or forced (F) contact. A combined criteria was defined as the sum of responses including mobility (S, T, R) and handling action (P, F) taking into account a gradient in the response as following: $S*1 + (P+F)*2 + (T+R)*3$.

18.3.3 Arena Test: Approach of a Motionless Human

The arena test was carried out on pigs derived from 24 pens and the procedure was similar to the human approach test developed by Paul Hemsworth in pigs (Hemsworth et al., 1996). For the group to be tested, all pigs in a pen were moved from their home pen to a waiting pen. Individual pigs were then separated from the group and introduced into a rectangular solidsided arena, measuring 4m x 2.5m. After a 2 minute adaptation period when the pig was alone in the arena, an observer entered the pen and remained motionless at the mid point of the wall opposite the entrance for a period of 3 minutes. A 50 cm area was delineated on the floor around the observer who then recorded the latency for the pig to approach within 50cm of the observer and latency to initiate physical contact with the observer. The cumulative time spent in the 50 cm area close to experimenter and the total number of physical contacts with the experimenter were recorded.

18.3.4 Statistical Analysis

A number of different ways to score the pen in the on-farm test were considered, either in relation to the response at each stage (W1, S or W2) or to a profile determined by a combination of responses as shown in Table 18.1.

The distribution of the scores defined from the on-farm test and according to the treatments applied previously was tested by chi-squared tests using the statistical package XY. All variables scored in the corridor and arena test were submitted to GLM analysis, taking into account the effect of the responses at the three stages of the on-farm test or the combined profile described in Table 18.1. The score of the pen from which the animal was derived characterized each pig. Where the assumptions necessary for parametric

TABLE 18.1 Profiles taking into account the responses obtained at the three stages of the on-farm test.

Response W1	Response S	Response W2	Profile
P	0 pig	P	Panic
P	1 pig or more	P	Intermediate
A	0 to n pigs	C	
C	0 to n pigs	A	
A	1 pig or more	A	Avoidance
A	0 to n pigs	C	
C	0 to n pigs	A	

Notes: n number of animals; P panic; A avoidance; C contact.

statistical analysis were not met, and transformations were not sufficient, classical non-parametric tests were used (Kruskal-Wallis, Mann-Whitney). Statistical probabilities were considered as significant when probability associated with the statistical tests was less than or equal to 0.05 and as a tendency when the probability was between 0.1 and 0.05.

The effect of the different scores identified in the on-farm test was analysed in relation to all behavioural measures of the corridor and arena tests. It appeared that the results were similar whatever the measures, but differences were stronger with the response W2. Thus only the effect of this response is presented.

18.4 RESULTS

The distribution of responses recorded in the on-farm test differed significantly between the HAR treatments ($P < 0.05$). A higher frequency of pens exhibiting panic responses was found from the AVE treatment compared to the other treatments. The avoidance responses were obtained mostly in pens which were subjected to the MIN and MED treatment, whereas the initiation by animals of contact with the experimenter was recorded only in pens subjected to the MIN treatment (Table 18.2). The R response was not exhibited by any group of pigs.

The first measure of the corridor test (distance from the handler) presented non-homogeneous data due to the corridor design. Indeed some pigs were attracted by features on the floor or on the wall which provided opportunities to root. In contrast, the flight distance to a human moving towards the animals was significantly higher for animals from groups assigned to the Panic response compared to the two other categories (Table 18.3). When pigs were moved towards a stationary human, animals from the Panic and Contact response groups exhibited significantly higher activity, more involvement of the handler. Pigs from the Panic response groups made more returns when they were closer to the observer (Table 18.3).

TABLE 18.2 Distribution of the W2 responses (expressed in number of pens) according to the treatment (HAR) applied to groups of growing pigs (chi square test, $P < 0.05$).

HAR Treatment*	W2 responses**		
	Panic	Avoidance	Contact
MIN	2	13	3
MED	3	16	0
AVE	17	2	0

Notes: * Human-animal relationships treatment: no or minimum intervention of stockman (MIN), mild interaction through physical contact with a soft stick (MED) and aversive interaction by an electric prod (AVE); ** W2 responses: determined during the on-farm test when the observer walked around the pen for the second time.

TABLE 18.3 Behaviour exhibited during the ‘corridor’ test according to the three W2 scores determined in the ‘on-farm’ test (number of pigs or means $\pm$ sd).

Criteria	W2 responses*		
	Panic	Avoidance	Contact
Number of pigs tested	191	260	27
Flight distance to a moving human towards the pig (m)**	2.74 ± 1.4 a	2.24 ± 1.3 b	$1.87 \pm .8$ b
Nature of displacement when pig was moved towards a standing human***	$8.11 \pm .4$ a	$5.80 \pm .3$ b	7.74 ± 1.0 a

Notes: * W2 responses: determined during the ‘on-farm’ test when the observer walked around the pen for the second time; ** GLM analysis; *** combined criteria: $S*1 + (P+F)*2 + (T+R)*3$, Kruskal-Wallis analysis; values of criteria with different letters between columns differed significantly at $P < 0.05$.

The analysis of the behaviour in the ‘arena test’ showed a significant effect of the W2 response on all criteria measured (Table 18.4). Pigs from the Panic and Avoidance W2 response groups had a significantly higher latency to approach the stationary human and to induce contact, and a lower number of physical interactions compared to those from the Contact response groups (Table 18.4). Time pigs spent within the 50 cm of the stationary observer was lower in animals from the Panic W2 response groups than those assigned to the two other categories ($P < 0.05$, Table 18.4).

18.5 DISCUSSION

In the present study, the association of human presence with electric shock during the conditioning phase induced obvious responses of fear toward the handler, which is typical of poor human–animal relationships. This is in agreement with previous studies on the relationships between humans and farm animals (eg Hemsworth et al., 1989; Waiblinger et al., 2006). Indeed, pigs from groups categorised as having a panic response displayed a higher flight distance to a moving human in the pen, a greater effort for the handler to move the animal towards a stationary human and a higher latency to approach and interact with a stationary human, behavioural patterns which are commonly labelled as fear

TABLE 18.4 Behaviour exhibited during the 'arena' test according to the three W2 scores de-termined in the 'on-farm' test (number of pigs, means $\pm$ sd).

Criteria	W2 responses*		
	Panic	Avoidance	Contact
Number of pigs tested	138	139	25
Approach latency (sec)**	109.6 $\pm$ 5.8 a	107.1 $\pm$ 5.5 a	73.2 $\pm$ 12.9 b
Contact latency (sec)**	142.0 $\pm$ 5.0 a	132.2 $\pm$ 5.1 a	104.7 $\pm$ 13.9 b
Number of interactions with human**	.6 $\pm$.1 a	1.0 $\pm$.1 a	1.3 $\pm$.2 b
Time spent close to the observer (< 50 cm), sec	2.59 $\pm$ 21.7 a	29.11 $\pm$ 27.8 b	27.27 $\pm$ 2.3 b

Notes: * W2 responses: determined during the 'on-farm' test when the observer walked around the pen for the second time; ** Kruskal Wallis analysis; values of criteria with different letters between columns differed significantly at $P < 0.05$.

responses (Hemsworth et al., 1996; Coleman et al., 2000, Forkman et al, 2007). Some pigs from groups categorised as having a Contact response also showed a fearful reaction, especially in the 'corridor test' where the handler had to intervene (use a panel) to move the animals. Such a response can be partly linked to the test procedure, which may have induced fear reactions due to both social isolation and novelty of the environment. Indeed, social isolation is known to induce a fear eliciting response, especially when pigs are moved into an unknown arena (Forkman et al, 2007). Moreover pigs classified as having a panic response differed from the two others groups both in corridor or arena tests, whereas the responses of pigs classified as avoidance were either similar to groups assigned as having a panic response in the arena test or to contact pig in corridor test. This emphasises that although various methodologies to assess fear towards humans are available, some may be less sensitive than others in determining the level of fear of humans and so to evaluate the human-animal relationships. This suggests also that the validity of the on-farm test to assess the human-animal relationships is relevant to identify especially obvious poor human-animal relationships.

The on-farm assessment of human-animal relationship needs to take into account the practical constraints imposed by the on-farm context where, for example, housing system, pen shape and size vary widely from farm to farm. The on-farm test evaluated in this study can be easily performed in home pen conditions and scoring system can provide a standardised method of assessing the human-animal relationship in a variety of different farming systems. The score of the on-farm test should be limited to the response at the second walk, which showed clear differences in HAR between groups. The two previous stages including the first walk around the pen and the period where the human stays motionless in the pen are also important. Indeed, the first walk focused the attention of pigs to the incoming of human, reinforced by his stationary period. In the second walk around, the response of the animals reflects their perception of human and not their reaction to a sudden event.

18.6 CONCLUSION

The on-farm test developed in the present study is an effective and practical way to detect those situations of obvious poor human–animal relationships. It could therefore be used as a measurement of fear of humans in a scheme using animal-based measures of welfare (e.g. Keeling and Veissier, 2005; Main et al., 2001), once the repeatability between observers has been checked. The most suitable conditions for use of the on farm HAR test of growing pigs then are when the social group is stabilized, pigs are old enough to have experienced contact with humans and where the space allowance is adequate for the pigs to show the different types of responses.

VALIDATION OF MEASURES OF FEAR

A. Dalmau, A. Velarde and B. Forkman

19.1 SUMMARY

Fear is an emotional state induced by the perception of a threatening or a potentially threatening (anxiety) situation (Boissy, 1995). Anxiolytic agents, such as benzodiazepines, have been found to reduce anxiety and fear in pigs. The objective of the study was to assess whether 'approach-avoidance' behaviour, as well as other behaviours like vocalizations and defecation are good indicators of fear. The study consisted in two trials, differing in the age of the animals to be tested. A total of 30 'young' piglets (around 35 kg) and 30 'fattening' gilts (around 90 kg) were used.

The fear test was carried out in a test pen similar to that of the home pen of the pigs, but completely isolated from the rest of the building. Pigs entered and exited the test pen through the same door. In the wall opposite to the door a trough containing apples was installed with a lip connected to a rope to be closed and opened manually. On the floor, 6 white lines crossing the corridor were placed 40 cm, starting at 20 cm from the trough. These lines divided the corridor in 7 zones.

For the treatment session, one of the pair of pigs housed together received an intramuscularly injection of 0.2 mg/kg midazolam in young piglets and 0.15 mg midazolam/kg in fattening pigs 20 minutes before start of the session. The other pig was injected also intramuscularly with an equivalent volume of saline. Each pig was allowed to enter to the test pen voluntarily, the door was closed, and after 30 s the lip of the trough that contained apples was opened and a fear stimulus was presented. After 2.5 minutes the door of the pen is opened and the animal returned to the housing pen. The three types of fear stimulus were presented to the pigs visual stimulus, auditory stimulus and olfactory stimulus. The following measuring were assessed: 1) Incidence of feeding behaviour; 2) Distance and position respect to the through 3) General activity ; 4) Reluctant to move behaviour (pigs stopping and not showing exploring behaviour); 5) Turning back behaviour (quick change of direction); 6) Retreat attempt behaviour (pigs backing away); 7) Occurrences of defecation or urination and 8) Occurrence of vocalisations. Defecation,

vocalisation and urination were parameters described in the protocol that could not be assessed during the experiment.

The presence of a fear stimulus reduced the feeding behaviour, increased the distance of the animals to the trough and the general activity of animals. In addition, it increased the incidence of the reluctant to move, turning back and retreat attempt behaviours. A higher responsiveness to the fear stimulus was found in midazolam treated fattening pigs than young piglets, but it was not the case for saline treated animals. The avoidance behaviour is also affected by the age and fear stimulus. The reluctance to move, turning back and retreat attempt behaviours could be valid measures to assess fear in pigs. The reluctance to move behaviour showed the best results, because no differences were found between ages neither stimulus type in their presentation, but a clear treatment effect (midazolam vs saline) was found.

19.2 INTRODUCTION

Fear is an emotional state induced by the perception of a threatening or a potentially threatening (anxiety) situation (Boissy, 1995). The present study was based on the assumption that approach or avoidance is animal's first response to environmental change and, thus, the measurement of this behaviour could be an indicator of fear (Hemsworth and Coleman, 1998). Moreover, anxiolytic agents, such as benzodiazepines, have been found to reduce anxiety and fear in experimental models like the Elevated Plus Maze both in rodents (Cole and Rodgers, 1995) and pigs (Andersen et al., 2000). The objective of the study was to assess whether 'approach-avoidance' behaviour, as well as other behaviours like vocalizations and defecation are good indicator of fear. In addition, an attempt to obtain an objective index (or an 'operational definition') of these parameters (i.e. objective distance of avoidance) was carried out. These parameters were chosen since they could be used on practical grounds to assess how pigs respond to different challenges existing in the production environment. The hypothesis to be tested was that fear can be expressed by means of certain avoidance behaviour (expressed by means of reluctant to move, turning back and retreat attempt). Assuming that anxiolytic agents reduce fear, this avoidance behaviour would be higher amongst the pigs not treated with an anxiolytic agent compared to those treated with the agent.

According to Arnone and Dantzer (1980), an intramuscular injection of 0.8 mg/kg of diazepam, 30 min before the exposition to a fear stimulus reduces anxiety related behaviour without affecting locomotion. A previous study was carried out to validate in piglets the results of Amone and Dantzer. Eighty pigs of 25kg live weight were divided in three groups of 16 animals and 1 group of 32. The piglets of the 3 groups of 16 were treated with an intramuscular injection of 0.6, 0.8 and 1.0 mg/kg of diazepam respectively. The group of 32 pigs was the control group, and treated with an intramuscular injection

of saline solution. No significant differences were found between treated and control animals neither in the activity nor in the response to the fear stimulus. Diazepam is a medium time lipophilic benzodiazepine, and tend to be stored in the fatty tissue. Therefore, the absorption of this drug into the blood could be erratic. For this reason, the use of a short time hydrophilic benzodiazepine as midazolam, was considered instead of diazepam.

A second previous experiment was, then, carried out to determine the effective dosage of midazolam to reduce anxiety without affecting locomotion. In this study, the effect of an intramuscular injection of 0.1, 0.2, 0.4, 0.6 and 0.8 mg/kg midazolam was assessed in 10 pigs of 25 kg live weight during 5 consecutive days. The injection of 0.6 and 0.8 mg/kg induced a sedative state and were rejected after the first administrations. Only dosages 0.1 and 0.2 mg/kg did not affect locomotion, and between both doses, 0.2 mg/kg induced the highest reduction of fear response when a fear stimulus was applied. Therefore, it was concluded that an intramuscular injection 0.2 mg/kg of midazolam, 15 minutes before the exposition to a fear stimulus would be the benzodiazepine and dosage used to carry out the experiment.

19.3 METHOD

19.3.1 Animals and Housing Conditions

A total of 64 female pigs of the same breed and free of the RYR-1 gene were used in two different trials. In the first trial, 32 piglets of 3–4 weeks of age and around 35 kg live weight were used. The piglets were bred under commercial conditions and come from different litters. They were transported to the experimental facilities and mixed in 16 groups of 2 individuals. In the second trial, 32 ‘fattening’ pigs of 16–18 weeks and around 90 kg were used. The pigs were bred under commercial conditions and come from different litters. They were transported to the experimental facilities and also mixed in 16 groups of 2 individuals. During the experiment, each group was housed in pens 90x180 cm. Before the experiment, all animals were weighed and individually identified. Pigs were fed daily with a commercial grower ration ad libitum except for three hours before entering to the test pen. Water was available ad libitum.

19.3.2 Test Facilities

Experiment was carried out in a test pen similar to that of the housing pens of the pigs, located in front of it, but isolated from it with two doors (Figure 19.1).

The test pen measured 16 m², however the space allowed for animals was a 1.0 x 3.0 m steel sided corridor in the middle of the pen (Figure 19.2). Pigs entered and exited the test



FIGURE 19.1 View of the test pen from the housing pens and view of the housing pens from the test pen.

pen through the same door.. In the wall opposite to the door a trough was installed with a lip connected to a rope to be closed and opened manually. The trough contained 1 kg of apple in pieces. Behind the trough, a plastic curtain was placed, to avoid distraction of the animals during the trial. Behind the curtain, a person monitor opened the trough and monitored the fear stimulus. On the floor, 6 white lines crossing the corridor were placed 40 cm, starting at 20 cm from the trough. These lines divided the corridor in 7 zones: 1) trough zone, 2) 20 to 60 cm to the trough, 3) 60–100 to the trough, 4) 100–140 cm to the trough, 5) 140–180 cm to the trough, 6) 180–220 cm to the trough, 7) more than 220 cm to the trough. Two video cameras were placed on the pen to record animal behaviour without disturbing them. These video cameras were connected to a video record and TV placed behind the curtain, so the person responsible to apply the fear stimulus was observing the behaviour of the pigs without disturbing them.

19.3.3 Test Procedure

Before the trials, pigs were trained to enter the pen individually and eat the apples of the trough. The training session lasted 5 to 6 days and the objective of this part was to minimize neophobia and isolation distress. When the pigs were in the test pen, a person closed the door behind it. After 2 minutes and a half the operator opened the door and left the animal return to the housing pen. During the two first days the trough was opened during the whole session. After the second day, the trough was closed when the pig entered the test pen, and after 30 seconds the operator situated behind the curtain opened the trough. Two minutes later, a second person situated out of the test pen, opened the door and left the animal go out.

The two pigs of each trial that showed higher level of fear after the training sessions were discarded and considered as replacement animals. The other 30 pigs of each trial were randomly assigned to three groups. Each pair of animals inside each housing pen was considered of the same group. Each group was marked with a different colour (blue, green or red) and each pig inside the group was marked with a number from 1 to 10. Pigs inside the same pen housing had consecutive numbers.



FIGURE 19.2 View of the test pen before and after the curtain.

The experiment consisted in 3 consecutive weeks by trial. In each trial, two types of sessions were carried out: On Monday to Tuesday all the pigs were submitted to the control sessions. On Wednesday, Thursday and Friday one group of 10 pigs was submitted to the treatment sessions and the other 2 groups to the control sessions. All the sessions started at 12.00 until 16.00 h. Pigs were tested individually.

In the control session the animal was allowed to enter voluntarily the test pen. Then, a person closed the door behind it, and after 30 s opened the lip of the trough that contained apples. After 2 minutes and a half the door of the pen is opened and the animal returned to the housing pen.

For the treatment session, one of the pair of pigs housed together received an intramuscularly injection of 0.2 mg/kg midazolam in the first trial (piglets), and 0.2 mg/kg midazolam in the second trial (fattening pigs). The other pig was injected also intramuscularly with an equivalent volume of saline. Pigs were injected 20 minutes before start of the session. Animals from the same housing pen entered the test pen in a consecutively, first the midazolam treated and second the saline treated pig. Each pig was allowed to enter to the test pen voluntarily. Then, a person closed the door behind it, and after 30 s opened the lip of the trough that contained apples immediately applied a fear stimulus. After 2 minutes and a half the door of the pen is opened and the animal returned to the housing pen. Three types of fear stimulus were presented to the pigs (Figure 19.3):

- A visual stimulus: a ball hung from a rope on the trough.
- An auditory stimulus: A horn.
- An olfactory stimulus: 90% CO₂ inside the trough.

The ball was hung inside the trough. When the lip was opened the ball elevated on it, and maintained this position until the animal left the test pen. The horn was sounded twice, just after opening the trough and one minute later. For the olfactory stimulus, the trough contained 90% CO₂ when it was opened. The concentration of CO₂ was monitored with a mobile infrared sensor (Checkpoint O₂/CO₂, PBI Dansensor A/S, Denmark; Figure 19.3).

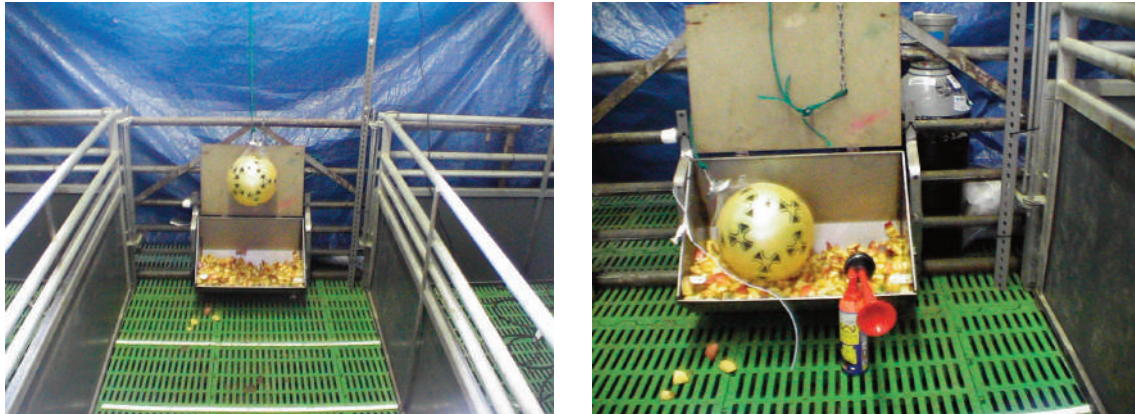


FIGURE 19.3 View of the hung ball of a rope on the trough, the horn and the CO₂ system used.

Each stimulus was applied to each animal only once and only to one group each week. During the first week of experiment, the visual stimulus was applied on Wednesday to the green group, the auditory stimulus was applied to the red group on Thursday and the olfactory stimulus was applied to the blue group on Friday. During the second week, the red group was submitted to the visual stimulus on Wednesday, blue group to the auditory stimulus on Thursday and the green group to the olfactory stimulus on Friday. Finally, during the third week, the blue group was submitted to the visual stimulus on Wednesday, the green group to auditory stimulus on Thursday and red group to the olfactory stimulus on Friday. The same process was carried out for trial 1 and 2.

19.3.4 Measurements

From video records, the following behaviour was scored after the application of the fear stimulus.

- Presence of feeding behaviour: if the pig ate the apples inside the trough.
- Approach/avoidance distance from the trough: the 6 crossed white lines disposed every 40 cm were used to measure the distance.
- Position of the animal respect to the trough: head: watching directly the trough; back: watching directly the door opposite the trough, lateral: crossed perpendicular to the door and the trough.
- General activity: number of lines crossed by animals. The cranial extremities were considered the reference point to count the lines crossed by pigs.
- Reluctancy to move behaviour: pigs stopping and not showing exploring behaviour.
- Turning back behaviour: quick change of direction.
- Retreat attempt behaviour: pigs backing away.

Urination, defecations and vocalisations could not be evaluated from the video records.

19.3.5 Statistical Analysis

As the data obtained were not normally distributed, the statistical analysis was carried out using general models. The data were analyzed by the Proc GENMOD of Statistical Analysis System (SAS; software SAS Institute Inc., Cary, NC; 1999–2001) with Poisson or negative binomial distribution. The significance level was fixed at $P < 0.05$.

19.4 RESULTS

19.4.1 Feeding Behaviour

During the treatment sessions of the first trial, the incidence of piglets that show feeding behaviour was significantly higher ($P < 0.05$) in the midazolam than in the saline group (83% vs 30%). However, no differences were observed neither during the training or the control sessions. Furthermore, in the midazolam group, the incidence of piglets showing feeding behaviour was significantly higher during the treatment session than during the training session. In the second trial (fattening pigs) no significant differences were observed neither between treatments (midazolam vs saline) nor between sessions (Table 19.1).

19.4.2 Approach/Avoidance Distance to the Trough and Position Respect to the Trough

During the control sessions, no significant differences were found between treatments in both trials. However, after any of the three fear stimuli were applied, piglets treated with midazolam spent more time near the trough than piglets treated with saline (Figure 19.4). In fattening pigs, these differences were only observed when the auditory or olfactory stimuli were applied.

TABLE 19.1 Percentage of animals that showed feeding behaviour during training, control and treatment sessions.

	Young piglets		Fattening pigs	
	Midazolam	Saline	Midazolam	Saline
Training sessions, before the application of the first fear stimulus (animals without treatment, without stimulus)	20% ^b	24%	53%	67%
Control sessions, after the application of the first fear stimulus (animals without treatment, without stimulus)	58% ^{ab}	44%	46%	66%
Treatment sessions. During application of fear stimulus (animals treated with midazolam or saline)	83% ^a	30% [*]	60%	44%

Notes: * Significance difference between midazolam and saline treatments ($P < 0.05$); different letters means significance difference ($P < 0.05$).

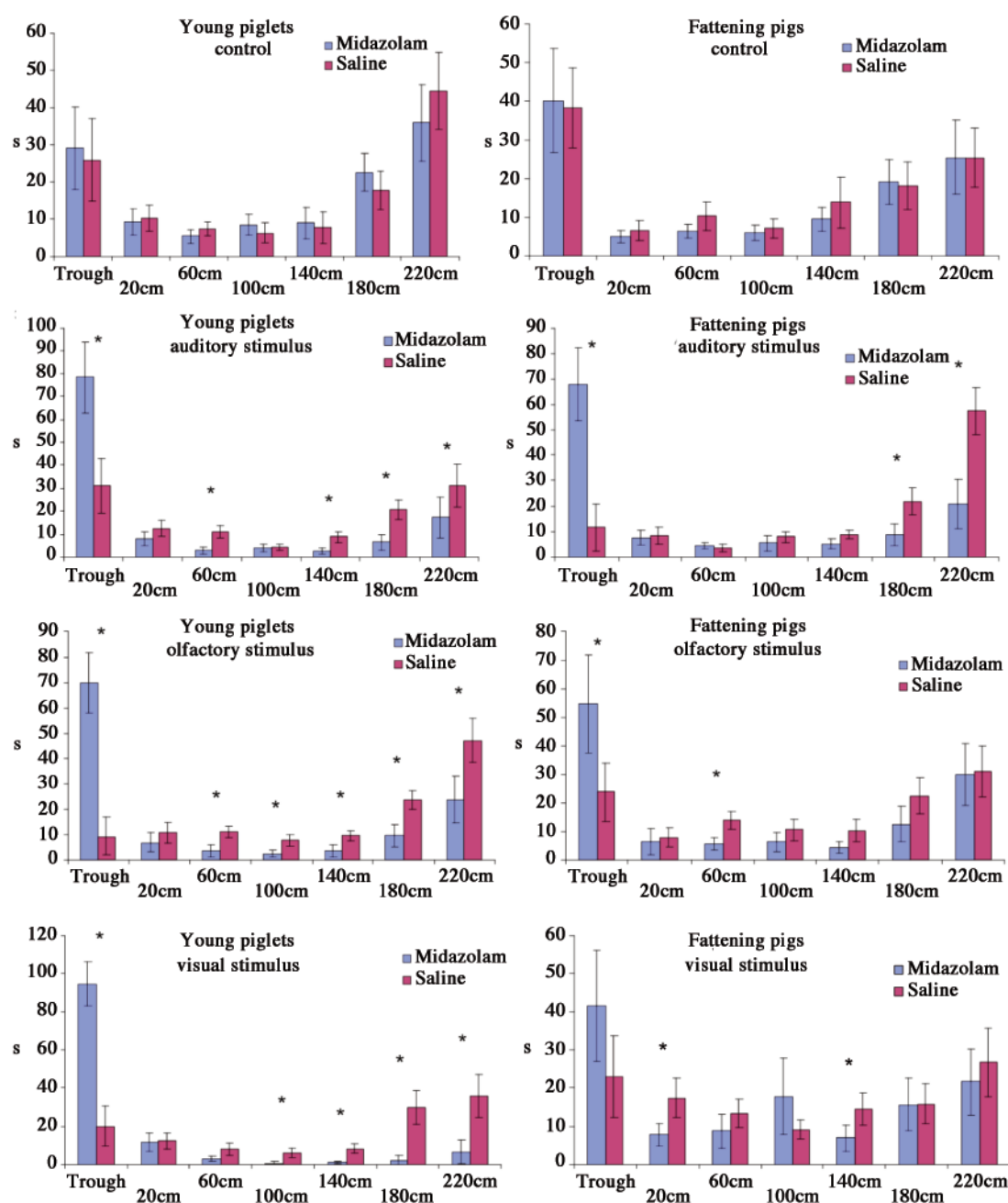


FIGURE 19.4 Mean time and SE at each position by treatments.

Notes: * statistic differences at $P < 0.05$.

In the first trial, when comparing between stimuli (visual, auditory and olfactory) piglets treated with midazolam spent more time behind the 140, 180 and 220 cm lines when the visual stimulus was applied than when the auditory stimulus was applied ($P < 0.05$, in all cases). Furthermore, the piglets treated with midazolam spent more time in lateral position after the visual stimulus than after the olfactory or auditory stimulus ($P < 0.05$, in all cases) and more time in back position after the visual stimulus than after the olfactory stimulus ($P = 0.0486$). In the saline treated group, piglets spent more time in the area of 20–60cm

and 100–140 cm from the trough, and more time in lateral position when the visual stimulus was applied than when the olfactory stimulus was applied ($P < 0.001$, and $P = 0.0024$, respectively).

In the second trial, comparing between stimuli (visual, auditory and olfactory), fattening pigs treated with midazolam spent more time in the area of 180–220 cm from the trough when the olfactory stimulus was applied than when the auditory stimulus was applied ($P = 0.02$). In the saline treated group, fattening pigs were less time in the area of 60–100 cm from the trough when the auditory stimulus was applied than when the visual or olfactory stimulus was applied ($P < 0.05$ in both cases). On the other hand, they spent more time in the area of 20–60 cm when the auditory stimulus was applied than when the olfactory stimulus was applied ($P = 0.01$). Furthermore, in this saline treated groups, pigs spent more time in back position after the olfactory or auditory stimulus than after the visual stimulus ($P < 0.05$, in both cases) and spent more time in head position when visual stimulus was applied than when auditory stimulus was applied ($P = 0.01$).

Comparing both trials (piglets vs. fattening pigs), after the auditory stimulus piglets spent more time around the trough and in the area of 20–60 cm than fattening pigs ($P = 0.02$ and $P = 0.03$). After the olfactory stimulus, piglets spent more time near the trough than fattening pigs ($P = 0.002$), and less time in the area of 60–100 cm and 100–140 cm than fattening pigs ($P = 0.01$ and $P = 0.0003$). Finally, after the visual stimulus piglets spent less time in head position than fattening pigs ($P = 0.04$).

19.4.3 General Activity

A treatment effect (midazolam vs saline) on general activity (number of lines crossed) was found in young piglets when the olfactory and the visual stimulus was applied (chi-square= 5.86, d.f. = 1; $P = 0.02$ and chi-square= 6.56, d.f. = 1; $P = 0.01$, respectively) and in fattening pigs when the auditory stimulus was applied (chi-square= 5.63, d.f. = 1; $P = 0.02$). In all cases saline treated pigs showed a higher general activity than midazolam treated pigs. On the other hand, no differences were found between treatments in piglets after the auditory stimulus (chi-square= 3.35, d.f. = 1; $P = 0.07$) and in fattening pigs after the olfactory or visual stimulus (chi-square= 3.32, d.f. = 1; $P = 0.07$ and chi-square= 1.74, d.f. = 1; $P = 0.19$, respectively; Table 19.2).

TABLE 19.2 General activity (number of lines crossed) by treatment and fear stimulus in young piglets and fattening pigs.

	Young piglets		Fattening pigs	
	Midazolam	Saline	Midazolam	Saline
Auditory stimulus	10.4 ± 3.84	23.0 ± 3.84	13.3 ± 3.50b	28.2 ± 3.50a
Olfactory stimulus	17.3 ± 4.42b	44.7 ± 4.42a	13.7 ± 4.16	27.8 ± 4.16
Visual stimulus	8.27 ± 3.84b	26.9 ± 3.84a	13.1 ± 4.56	23.6 ± 4.56

Notes: * different letter means differences at $P < 0.05$.

When the three stimuli were compared (visual, auditory and olfactory), no differences were found in the midazolam treated piglets and fattening pigs, and in the saline treated fattening pigs (chi-square= 1.74, d.f. = 2, $P=0.4622$; chi-square= 0.01, d.f. = 2; $P=0.9932$; chi-square= 0.39, d.f. = 2; $P=0.8245$, respectively). Nevertheless, saline treated piglets showed a higher general activity when the olfactory stimulus was applied than when the auditory or visual stimulus was applied ($P < 0.01$, in both cases).

No differences were found between young piglets and fattening pigs in the general activity for the different fear stimulus applied neither in midazolam treated animals (chi-square= 2.27, d.f. = 5; $P=0.8143$) or saline treated animals (chi-square = 9.70, d.f.= 5, $P = 0.0843$).

19.4.4 Reluctant to Move

A treatment effect (midazolam vs saline) was found for auditory, olfactory and visual stimulus in both piglets (chi-square= 23.17, d.f. = 1, $P < 0.0001$; chi-square= 4.42, d.f. = 1; $P=0.0356$; chi-square= 40.34, d.f. = 1; $P < 0.0001$, respectively) and fattening pigs (chi-square= 29.45, d.f. = 1, $P < 0.0001$; chi-square= 9.86, d.f. = 1; $P=0.0017$; chi-square= 12.80, d.f. = 1; $P = 0.0003$, respectively; Table 19.3). The incidence of reluctance to move was significantly higher in the saline group than in the midazolam group.

No differences were found between young piglets and fattening pigs.

19.4.5 Turning Back

A treatment effect (midazolam vs saline) was found for auditory, olfactory and visual stimulus in young piglets (chi-square= 4.72, d.f. = 1, $P = 0.03$; chi-square= 19.27, d.f. = 1; $P < 0.0001$; chi-square= 10.82, d.f. = 1; $P = 0.001$, respectively). For fattening pigs a treatment effect was found for auditory and olfactory stimulus, (chi-square= 13.28, d.f. = 1, $P = 0.0003$ and chi-square= 12.83, d.f. = 1; $P = 0.0003$, respectively), but not for visual stimulus (chi-square= 3.48, d.f. = 1, $P = 0.06$, Table 19.4). When different, the incidence turning back behaviour was higher in the saline group than in the midazolam group.

In young piglets, the incidence of the turning back behaviour was higher after the olfactory stimulus than after the auditory or visual stimulus ($P < 0.001$, in both cases). On the other hand, the incidence of turning back behaviour was higher after the olfactory or auditory stimulus than after the visual stimulus ($P < 0.05$, in both cases).

TABLE 19.3 Reluctant to move behaviour by treatment and fear stimulus in young piglets and fattening pigs.

	Young piglets		Fattening pigs	
	Midazolam	Saline	Midazolam	Saline
Auditory stimulus	.6 ± .42b	2.8 ± .42a	.3 ± .39b	2.4 ± .39a
Olfactory stimulus	.9 ± .38b	1.7 ± .38a	.5 ± .32b	1.6 ± .32a
Visual stimulus	.2 ± .36b	2.8 ± .36a	.6 ± .46b	2.1 ± .46a

Notes: * different letter means differences at $P < 0.05$.

TABLE 19.4 Turning back behaviour by treatment and fear stimulus in young piglets and fattening pigs.

	Young piglets		Fattening pigs	
	Midazolam	Saline	Midazolam	Saline
Auditory stimulus	.4 ± .26b	1.1 ± .26a	.3 ± .22b	1.2 ± .14a
Olfactory stimulus	.7 ± .36b	2.7 ± .36a	.1 ± .25b	1.1 ± .25a
Visual stimulus	.2 ± .27b	1.1 ± .27a	.1 ± .26	.6 ± .19

Notes: * different letter means differences at $P < 0.05$.

Differences were found between young piglets and fattening pigs when the auditory stimulus was applied to the midazolam and saline treated animals and when the visual stimulus was applied to the midazolam treated animals, being, in all cases, higher in the fattening pigs than in young piglets ($P < 0.05$, in all cases).

19.4.6 Retreat Attempts

A treatment effect (midazolam vs saline) was found for auditory, olfactory and visual stimulus in young piglets (chi-square= 9.77, d.f. = 1, $P = 0.002$; chi-square= 7.53, d.f. = 1; $P = 0.007$; chi-square= 9.42, d.f. = 1; $P = 0.002$, respectively). In fattening pigs the treatment effect was only found after the auditory and olfactory stimulus (chi-square= 11.56, d.f. = 1, $P = 0.0007$ and chi-square= 7.07, d.f. = 1; $P = 0.008$, respectively), but not after the visual stimulus (chi-square= 0.93, d.f. = 1, $P = 0.34$, Table 19.5). When different, the incidence of retreat attempt behaviour was higher in the saline group than in the midazolam group.

In young piglets, the incidence of retreat attempt behaviour was higher after the visual stimulus than after the auditory stimulus ($P = 0.02$). In addition, in fattening pigs, the incidence of retreat attempt behaviour was higher when the visual stimulus was applied than after the olfactory or auditory stimulus ($P < 0.05$, in both cases).

Differences were found between young piglets and fattening pigs in the presence of retreat attempt behaviour when the visual stimulus was applied in midazolam treated animals, being higher in the fattening pigs than in the young piglets ($P < 0.05$).

19.5 DISCUSSION

Defecation, vocalisation and urination were parameters described in the protocol that could not be assessed during the experiment. A high number of pigs defecated just at the exit from the housing pen before arriving to the test pen. These defecations were not recorded by de video camera. Urination was not assessed due to the difficulty to evaluate from the

TABLE 19.5 Retreat attempt behaviour by treatment and fear stimulus in young piglets and fattening pigs.

	Young piglets		Fattening pigs	
	Midazolam	Saline	Midazolam	Saline
Auditory stimulus	.2 ± .27b	1.1 ± .27a	.3 ± .36b	1.5 ± .36a
Olfactory stimulus	.5 ± .33b	1.4 ± .33a	.6 ± .42b	1.6 ± .42a
Visual stimulus	.6 ± .36b	1.8 ± .36a	1.5 ± .58	2.0 ± .58

Notes: * Different letter means differences at $P < 0.05$.

video records and vocalisations were not assessed due to the difficulty to distinguish objectively some squeal sounds from ground sounds.

According to our results, the administration intramuscularly of 0.2 mg/kg midazolam in young piglets, and 0.15 mg/kg in fattening pigs increased feeding behaviour, and reduced the avoidance distance of the animals to the trough, the general activity, the incidence of reluctant to move, the incidence of turning back and the incidence of retreat attempt behaviours. All these behaviours have been suggested as indicators of pain (Hemsworth and Coleman, 1998). It is known, that anxiolytic agents, such as midazolam, reduce anxiety and fear (Andersen et al., 2000). Therefore, this experiment suggests that reluctant to move, turning back and retreat attempt behaviours are valid indicators of fear. However, some differences were found between fear stimuli (auditory, olfactory and visual) and ages (piglets and fattening pigs).

When the visual stimulus in young piglets and the olfactory stimulus in fattening pigs were applied, animals spent more time in the area further away from the trough (140–220 or 180–220 cm) than when the auditory stimulus was applied. Therefore, the auditory stimulus, was the stimulus that showed the shorter avoidance response in pigs, probably due to the lower time of exposition (only two times in two minutes) compared to the other stimulus (the whole time exposed). Regarding the position of the pigs, when the visual stimulus was applied young piglets spent more time in back position than when olfactory stimulus was applied. Fattening pigs spent more time in that position when the visual stimulus was applied than when the auditory or olfactory. Nevertheless, the turning back behaviour was higher when olfactory stimulus was applied than when visual or auditory at both ages. In saline treatment group, young piglets showed a higher activity when the olfactory stimulus was applied than when the visual or olfactory was applied. Finally, the incidence of retreat attempt behaviour was higher in young piglets exposed to a visual stimulus than exposed to olfactory stimulus. In fattening pigs, the incidence of retreat attempt behaviour was higher when exposed to a visual than olfactory or auditory stimuli. Therefore, it is concluded that the presence of 90% CO₂ induces in pigs an important increase of activity with a high incidence of turning back movements. In contrast, when a visual stimulus is applied, pigs tend to avoid it, staying far away (in this study from 140–220 in young piglets and 180–220 in fattening pigs), and show a higher incidence of retreat attempt movements. Finally, the auditory stimulus showed the lower response to fear responsiveness in pigs, probably because it was the only stimulus that was not continuously exposed.

Some differences were found in the responsiveness to the fear stimulus applied in both young piglets and fattening pigs. When the auditory or olfactory stimulus was applied, the time spent near the trough was higher in the midazolam treated piglets than in the midazolam treated fattening pigs. Furthermore, midazolam treated fattening pigs showed a higher incidence of turning back behaviour when the auditory or visual stimulus was applied and a higher incidence of retreat attempt behaviour when the visual stimulus was applied than midazolam treated piglets. Therefore, it is suggested a higher responsiveness to the fear stimulus in midazolam treated fattening pigs than in midazolam treated young piglets, but not in saline treated animals. Nevertheless, the other parameters measured to assess fear were not significantly different between ages. In fact, the general activity and the reluctant to move behaviour did not show differences between ages of animals.

For the presence of feeding behaviour, only was found a treatment effect (midazolam vs saline) in young piglets, but not in fattening pigs. These results could be the consequence of a higher preference for apples in fattening pigs, as it was observed during the training sessions.

According to our results, avoidance distance could be used to assess fear. However, differences between ages and fear stimulus have been observed, that could affect the validity of the measure. On the other hand, no clear effects were found for the position of the animal respect to the trough or the fear stimulus.

On the other hand, the reluctant to move, turning back and retreat attempt behaviours could be valid measures. In fact, reluctant to move could be the most valid measure of the three studied, due to no differences were found between ages neither fear stimulus applied, but a clear treatment effect (midazolam vs saline) was found. The turning back is the second one, with some difficulties if it is used to assess fear of only visual stimulus. Finally, according to the results, the retreat attempt behaviour could not be useful to assess visual fear stimulus in fattening pigs.

19.6 CONCLUSION

Fear stimulus reduced the feeding behaviour, increased the distance of the animals to the trough and the general activity of animals. In addition, it increased the incidence of the reluctant to move, turning back and retreat attempt behaviours.

A higher responsiveness to the fear stimulus was found in midazolam treated fattening pigs than young piglets, but it was not the case for saline treated animals.

It is not possible to give a standard distance of avoidance behaviour for pigs in the present study due to some animals were in the area further away from the fear stimulus. The avoidance behaviour is also affected by the age and fear stimulus.

The reluctant to move, turning back and retreat attempt behaviours could be valid measures to assess fear in pigs. The reluctant to move behaviour showed the best results, because no differences were found between ages neither stimulus type in their presentation, but a clear treatment effect (midazolam vs saline) was found.

INTER-OBSERVER VARIABILITY OF THE INDICATORS OF FEAR DURING LOADING AND UNLOADING AT SLAUGHTER OF PIGS

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20.1 SUMMARY

The objective was to assess the inter-observer variability of the indicators of fear and pain and unloading at slaughter. The approach/avoidance behaviour, freezing, reduced exploratory behaviour, and vocalisation have been used to assess fear in animals. On a practical context of loading/unloading a truck, the avoidance behaviour could be translated into behaviours like number of pigs turning back, number of pigs reluctant to move, number of pigs showing retreat attempt movements and number of pigs showing vocalisations. These parameters have been already validated as fear and pain indicators (see Chapter 11).

Evaluation of inter-observer variability was scored from video clips and by direct observation at 4 slaughterhouses in Belgium and Spain. Observations were assessed at group level and, therefore, the group was the experimental unit. Fifty groups were observed from the video clips, and 100 by direct observations at the slaughterhouses. 20 observers assessed the video recordings and 6 observers in Belgium and 7 in Spain the observations made directly at the slaughterhouses. According to the results obtained, none of the behaviours studied to assess fear/pain during unloading of pigs (reluctant to move, retreat attempts, turning back or vocalisations) showed a mean repeatability higher than 0.7. The highest correlations obtained between observers were the reluctant to move behaviour with video clips and the turning back behaviour by direct observation at slaughterhouse (mean Spearman rank correlation between paired observers of 0.54 in both cases). One of the sources of error between observers could be the scoring of four different behaviours at the same time in a high number of animals. If fear and pain is assessed by one or two indicators, the repeatability between observers would increase. In the study carried out to validate the measures of 'approach-avoidance' behaviour to assess general fear, it was found that the most valid measure was reluctant to move, followed by turning back

behaviour (see Chapter 19). Therefore, it is suggested to include the reluctance to move or turning back behaviours in the protocol to assess fear and pain during unloading. However, to increase inter observer repeatability, a proper training of the observers and a correct position of the observer for assessing the behaviour of the animal during unloading should be taken into account.

20.2 INTRODUCTION

Several different indicators have been used to assess fear, such as approach/avoidance behaviour; freezing or reduced exploratory behaviour; amount of defecation; failure to feed in a strange environment; vocalisation. Pain has also been associated with behaviours like vocalisation and evidence of problems like lameness or difficulty to move. Provided that the validity of behaviours as reluctant to move, retreat attempt and turning back as approach/avoidance behaviours to assess general fear in pigs have been demonstrated in previous studies (see Chapter 11).and clear guidelines to record this behaviour has been defined, the repeatability and reliability of approach/avoidance behaviour and vocalisation has been assessed as follows. On a practical context of loading/unloading a truck, the avoidance behaviour could be translated into behaviours like number of pigs turning back, number of pigs reluctant to move, number of pigs showing retreat attempts movements and number of pigs showing vocalisations.

20.3 METHODS

Four abattoirs (two in Spain and two in Belgium) were visited to assess the presence of approach/avoidance behaviour and vocalisations during unloading. In three abattoirs, pigs were unloaded from the different decks of the lorry by means of a ramp. In the fourth abattoir, pigs were unloaded with the lift of the trucks.

The behavioural parameters scored during unloading were:

- reluctant to move: pigs stopping and not showing exploring behaviour;
- retreat attempts: pigs backing away;
- turning back: quick change of direction;
- vocalisation: pigs squealing or with vocalisations different to grunt.

Observations were collected at group level and, therefore, the group was the experimental unit. The size of the group was that decided by the stockperson of the abattoir.

Evaluation of inter-observer variability was scored 1) by video records and 2) by direct observation at slaughterhouses.

1. A total of 75 truck unloads were recorded with the video camera. The mean group size was 18 pigs and ranged from 6 to 51 pigs. Eight of these video clips (2 from the first and third floor of the truck and 4 from the second one) were used to train observers. After training, 9 observers counted from 50 records, the number of pigs in each group that show reluctant to move, retreat attempts and turning back behaviours. Twelve more observers counted from 41 records, only the number of pigs in each group that show reluctant to move behaviour. Three observers scored the video recording alone on a computer. The rest of observers scored the video recordings in two separate sessions, at the same time with a projector. The 26% of the groups were unloaded from the first tier, the 42% from the second one and a 32% from the third one. The video records showed the whole ramp of the slaughterhouse and the elevator of the trucks. In the video records, vocalisations were not considered due to the difficulty to know which pig shows this behaviour.
2. Direct evaluation at slaughterhouses was carried out by 7 observers in the two abattoirs of Belgium and 6 observers in the two of Spain. A total of 100 unloading groups were assessed. The mean group size was 26 pigs and ranged from 4 to 73 animals. The 39% of the groups were unloaded from the first tier, the 31% from the second tier and the 30% from the third tier. Observers were in front of the ramp or the lift of the truck, to see the whole ramp or lift but without disturbing the unloading of animals.

To calculate the association between observer pairs, two statistical analyses were carried out using the Spearman's Rank correlation. In the first one, it was considered the presence of the behaviour studied (i.e. reluctant to move) inside each group (i.e. if any animal of the group showed the reluctant to move behaviour according to the observer studied, this group was considered as 1 for this observer but 0 if no animal was countered with this behaviour inside the group). In the second analysis, it was considered the percentage of animals by group showing each behaviour studied. Student's t test was used to compare between correlation values obtained from different tiers. The statistical analyses were carried out using the Statistical Analysis System (SAS; software SAS Institute Inc., Cary, NC; 1999–2001). The significance level was fixed at $P < 0.05$.

20.4 RESULTS

20.4.1 General Description of Data

A general description of the data is shown in Table 20.1. The group size was higher when direct observations were made than when video recordings were used. Groups unloaded with the lift were smaller than with the ramp. Therefore, groups of the third deck, that usually had to be unloaded with the lift, were smaller than groups of the other decks. According to all observers, the percentage of animals showing reluctant to move, retreat attempts and turning back behaviours was higher in the 2nd and 3rd tiers than in the 1st, and, in the majority of cases, in the 3rd tier than in the 2nd.

In the video recordings, for reluctant to move and retreat attempts behaviours, the highest correlation obtained was for animals coming from the first tier. In the case of direct observations at slaughterhouse, the higher correlation between observers was found on the turning back behaviour in animals coming from the second tier. The percentage of animals showing vocalisations was the same for every tier. Finally, the reluctant to move behaviour was the behaviour more recorded, followed by the turning back, vocalisations and retreat attempts behaviour.

20.4.2 Video Recordings

Three behaviours were scored from the video clips, reluctant to move, retreat attempts and turning back. When reluctant to move was scored, the mean correlation value obtained between paired observers was lower when the presence of the behaviour in the group was analysed (presence in one or more pigs scored as 1, total absence scored as 0) than when the percentage of animals showing the behaviour was considered. The mean correlation

TABLE 20.1 Group size, percentage of groups (% over groups) and animals (% over animals) in each tier, percentage of animals showing reluctant to move (Reluct. Move), re-treat attempts (Retr. Attempts), turning back (Turn. Back) and vocalisation (Vocal.) by group and mean R Spearman Rank correlation (R) between paired observers on video recordings (Videos) and direct observations at slaughterhouse (Direct) respect to the different tiers of the truck.

	Tier	Group size	% over groups	% over animals	Reluct. move	R	Retr. attempts	R	Turn. back	R	Vocal.	R
Videos	1	22.07	26%	32%	7%	64.1a	1.4%	26.7a	3%	28.9	–	–
	2	19.67	42%	45%	15%	52.3b	1.8%	22.4ab	4%	36.8	–	–
	3	13.00	32%	23%	11%	46.4c	2.5%	12.2b	7%	27.6	–	–
Direct	1	29.10	39%	42%	4%	35.7	1.0%	28.9	2%	43.8ab	3%	35.4
	2	27.30	31%	32%	8%	34.9	1.6%	40.7	4%	51.5a	3%	36.3
	3	21.60	30%	26%	11%	43.2	2.0%	31.0	7%	40.6b	3%	39.4

Notes: * Mean with different letters means significant differences at $P < 0.05$.

values were 0.41 and 0.54, respectively. In the move/non-move situation 136 out of the 190 correlations between paired observers were significant, and in the 'percentage situation' 174 out of 190 correlations were significant.

When retreat attempt was scored, the mean correlation value obtained between paired observers was very similar between the presence of that behaviour in the group (presence in one or more pigs $\rightarrow$ 1, total absence $\rightarrow$ 0) and the percentage of animals in the group showing that behaviour. The mean correlation values were 0.15 and 0.14, respectively. In the move/non-move situation 3 out of the 36 correlations between paired observers were significant, and in the 'percentage situation' 4 out of the 36 correlations were significant.

When turning back behaviour was scored, the mean correlation value obtained between paired observers was very similar between the presence of that behaviour in the group (presence in one or more pigs scored 1, total absence scored 0) and the percentage of animals that show that behaviour in the group. The mean correlation values were 0.24 in both cases. In the move/non-move situation 15 out of the 36 correlations between paired observers were significant, and in the 'percentage situation' 17 out of the 36 correlations were significant.

20.4.3 Direct Observations at Slaughterhouses

Four behaviours were considered on direct observations at slaughterhouses: reluctant to move, retreat attempts, turning back and vocalisations. When reluctant to move was scored, the mean correlation between paired observers was lower when the presence of the behaviour was considered (presence in one or more pigs scored 1, total absence scored 0) than when the percentage of animals in the group showing the behaviour was considered. The mean correlation values were 0.31 and 0.43, respectively. In the move/non-move situation 15 out of the 26 correlations between paired observers were significant, and in the 'percentage situation' 24 out of the 26 correlations were significant.

When retreat attempt was scored, the mean correlation obtained between paired observers was lower when the presence of the behaviour in the group was considered (presence in one or more pigs scored 1, total absence scored 0) than when the percentage of animals by group showing the behaviour was studied. The mean correlation values were 0.25 and 0.27, respectively. In the move/non-move situation 9 out of the 26 correlations between paired observers were significant, and in the 'percentage situation' 13 out of the 26 correlations were significant.

When turning back was scored, the mean correlation value obtained between paired observers was lower when the presence of the behaviour in the group was studied (presence in one or more pigs scored 1, total absence scored 0) than when the percentage of animals showing the behaviour was considered. The mean correlation values were 0.43 and 0.54, respectively. In the move/non-move situation 24 out of the 26 correlations between paired observers were significant, and in the 'percentage situation' 24 out of the 26 correlations were significant.

When vocalisation was scored, the mean correlation value obtained between paired observers was higher when the presence of the behaviour in the group was studied (presence in one or more pigs scored 1, total absence scored 0) than when the percentage of animals showing the behaviour was considered. The mean correlation values were 0.39 and 0.28, respectively. In the move/non-move situation 13 out of the 24 correlations between paired observers were significant, and in the 'percentage situation' 9 out of the 24 correlations were significant.

20.5 DISCUSSION

According to the results obtained, none of the behaviours studied (reluctant to move, retreat attempts, turning back or vocalisations) to assess fear and pain during unloading has a high repeatability (>0.7).

The measures with a highest repeatability are reluctant to move using video clips and turning back by direct observation at slaughterhouse. These two measures were the two best considered from the study of validation of measures of 'approach-avoidance' behaviour to assess general fear in pigs (see Chapter 19). For reluctant to move, the repeatability between observers was higher when the groups were scored from the first tier. For turning back, the repeatability between observers was higher when the groups were scored from the second tier.

One reason for the low repeatability between observers is the fact that observers had to score four different behaviours at the same time. Scoring only one or two behaviours, could improve the repeatability between observers. In that case, turning back is the measure with a higher repeatability when pigs are directly evaluated at slaughterhouse. Furthermore, a more specific training session would also improve the repeatability between observers.

When direct evaluation was carried out, the 6 observers were scoring the same group from different positions. While some observers had a better view of all the pigs during the unloading, other might have a blind zone. Therefore, the correct position of the observer will also improve the scoring of the measure and increase the repeatability between observers.

20.6 CONCLUSIONS

1. None of the behaviours studied (reluctant to move, retreat attempts, turning back or vocalisations) to assess pain during unloading of pigs have a high repeatability (>0.7).
2. The highest repeatability found in this study was for the reluctant to move behaviour on video records and the turning back behaviour on direct observations at slaughterhouse. The mean Spearman rank correlation between paired observers was 0.54 i.

MEASURING HIGH PITCH VOCALISATIONS IN PIGS DRIVEN TO SLAUGHTER AT ABATTOIRS

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20.1 SUMMARY

Pre slaughter handling can be very frightening and stressful to animals. Vocalisation scoring has previously been successfully used by Grandin (1998) to address animal welfare problems at abattoirs. A scoring method for measuring welfare related to stress vocalisations (High Pitch Vocalisations) in pigs has been developed and evaluated. Pigs are very social animals that naturally lives in stable groups and can therefore be supposed to send honest signals as they vocalise (Weary et al., 1996). In pigs High Pitched Vocalisations (HPV) are strongly associated with fear, distress and/or pain and discomfort (Weary et al., 1998). Besides indicating a negative emotional state in the vocalising animal (Owings and Morton, 1998), HPV's can cause further stress in pigs that hear them (Weary et al., 1998).

A method for assessment of High Pitch Vocalisations (HPV) in pigs driven to slaughter in abattoirs has been developed and evaluated and the general conclusion is that this is a very promising method to relate vocalisations to welfare. The evaluated assessment method is animal based and scientifically objective and aim to measure instantaneous welfare and reduce subjective opinions between observers.

During sampling the occurrence or absence of high pitch vocalisation (HPV), during the last stages of group driving into the stun box were registered.

Groups of animals are monitored from the final stages of driving till the stun area (gas stun box or chute leading to restrainer) and HPV are marked in an audit protocol (appendix 1). According to the rate of distress vocalisations emitted in the driving system at an abattoir, the abattoirs may be sorted into three categories: those with low HPV calls, high HPV calls and extremely high HPV calls. In addition to expressed HPV, type and usage level of driving aids is noted in the protocol.

Low HPV calls – not more than 10% of recorded HPV of the observed 20 sec intervals. There are only occasional HPV's that may be related to pig individuality. This indicates a low driving rate, good abattoir management guidelines and staff.

Extremely high HPV calls – at least 90% of recorded HPV of the observed 20 sec intervals. The pigs are constantly heard screaming. This is correlated to maximum slaughter line speed combined with almost constant human interference.

The HPV level in the range left in between these categories should mainly be abattoir personnel induced, as the slaughter line speed is constant.

At stunning with the aid of gas, sampling is done at group level. The group of animals driven together is monitored from walking in the driving chute or alley into the final stun box. If an animal in the group emits the defined vocalisation, it is recorded in the audit protocol (Appendix 1). At electrical stunning, preceded by the alley or chute leading to the restrainer, sampling will include the number of animals in the alley or chute at any time.

20.2 INTRODUCTION

Welfare problems arise when pigs are subjected to an unpredictable or uncontrollable environment (Fraser and Broom, 1990). A sound driving behaviour at the abattoir is of great concern to assure a high standard of animal welfare. Group driving to the gas stun box or restrainer are common methods to drive fattening pigs to slaughter in Europe, although driving chutes are sometimes also used.

Facility design and animal handling practices are well known to influence fear level and the behaviour of pigs at slaughter plants (Gregory, 1998; Weeks et al., 2002; Grandin, 2005). Distractions which impede animal movement and poor maintenance of facilities such as worn, slick floors, too narrow aisles where the pigs can not move side by side are identified as common causes of animal welfare problems in slaughter plants (Grandin, 1996). Animals will often stop and even refuse to move through a handling system if there are distractions such as sparkling reflections, air blowing towards the animals, high pitched noise and movement up ahead of the approaching animals. These distractions can ruin the performance of a well designed facility (Grandin, 1996; Gregory 1998).

Vocalisation has also been shown to be strongly associated with stressful events at pre-slaughter handling, such as electric prodding, slipping, etc. The 'squeal/scream' is an intense, high pitched vocalization that is emitted when the animal is in pain, frustration or fear (Weary et al., 1998). The intensity of distress vocalization varies with the intensity of the situation (Houpt 1998). As pigs are highly social animals that under natural conditions

live in stable groups, these vocalizations serve a communicative purpose as reliable distress signals. Welfare problems may arise when the pigs are subjected to the abattoir environment that is highly unpredictable and/or uncontrollable.

The aim of this study was to develop and evaluate an objective scoring method for driving of pigs at abattoirs, possible to conduct during commercial conditions.

20.3 MATERIAL AND METHODS

Four different pig abattoirs in two EU countries were visited on 7 occasions. Three used group driving to a CO₂ gas stun box and the forth used electrical stunning using an 8m single chute leading to the restrainer and to the electrical stunner. All observations were conducted during regular procedures at the abattoirs while the slaughter line was in motion. During each visit HPV were recorded and pigs were also filmed during the last stages of driving into the stun box. After this, vocalisations possible to monitor during commercial conditions were defined. (For definitions, see Chapter 3.1.) At the abattoirs ca 350–1,500 animals in groups of 7–20 individuals were monitored from the final stages of driving to the stun area (stun box or restrainer). The occurrence of HPV's was marked in an audit protocol (Appendix 1). All the visited abattoirs slaughtered more than a hundred animals per hour.

The observer was equipped with a beeper that produced a sound signal each 20 seconds. Recordings were made using prepared protocols with rows as intervals of 20 sec (appendix 1). During each 20 sec interval, the observer listened whether any of the pigs had vocalised or not vocalised (one-zero sampling). At the tone, marking the end of the interval, the observer recorded whether any of the pigs was vocalising at that moment (instantaneous sampling). Additionally, in a third column the observer noted if it was a single pig vocalizing or several pigs, thus modifyng the information gained in the previous instantaneous sample column. The observer monitored the pigs for 25 minutes each session. The observer also noted type and excessive usage of driving aids.

20.3.1 Monitoring Group Driving into Gas Stun Box

At stunning with the aid of gas, sampling was done at group level. The group of animals driven together was monitored from walking into the final pre-stun box, until entering the stun box. At final pre-stun driving, the animal group was subdivided by a mechanical gate into smaller groups, whose size was based on stun box capacity. The monitoring was performed until the last pigs from the original group in the driving alley entered the stunner. Not until then monitoring of the next group began. The observer was placed right next to

or as close as possible to the stunner entrance. If one or more animals in the group emitted the defined HPV, it was recorded in the audit protocol (Appendix 1).

20.3.2 Monitoring Driving in a Single Chute

At electrical stunning, preceded by the chute leading to the restrainer, sampling for HPV's included the number of animals in the chute at any time. As soon as a pig entered the chute it was included in the audit group and as soon as a pig entered the electrical restrainer it was excluded from the audit group. If an animal or more in the group emitted the defined HPV, it was recorded in the audit protocol (Appendix 1). The observer was placed right next to the chute, on the opposite side from the abattoir staff.

20.3.3 Training of Observers

According to the original proposal, live observations were supposed to be carried during training of observers. Only one slaughter plant did allow this and training of one observer who was then tested against a standard was carried out.

Three observers were trained by watching video clips and listening to recorded examples of the HPV. They were then instructed of how to monitor the defined behaviour at the final stages of driving. After training, testing from monitoring a video clip was done simultaneously by the observers. If an animal was prodded, hit or if animals started to fight, the observers were instructed to leave additional comments about this in the audit protocol.

All statistical analysis was performed in Minitab (MINITAB® Release 14.1, Minitab Inc, 2003). The combined monitoring results of all three observers was statistically analysed for validation and inter-observer reliability. The inter-observer agreement was evaluated by analysis of Fleiss' kappa test (Fleiss, 1971). The value of kappa evaluates the strength of agreement between observers. It has a maximum value of 1.00 when agreement is perfect. A value of zero indicates no agreement better than chance and a negative value shows that the agreement is worse than chance. According to Altman (1991) the strength of agreement for a value of kappa between 0 and 1.00 can be interpreted as 'poor' if less than 0.20, 'fair' if 0.21–0.40, 'moderate' if 0.41–0.60, 'good' if 0.61–0.80 and 'very good' if 0.81–1.00.

Fleiss' kappa coefficients (Fleiss, 1971) for inter-observer reliability during monitoring of driving into stun box were calculated by using the 'Attribute Agreement Analysis' function in Minitab (MINITAB® Release 14.1, Minitab Inc, 2003).

20.4 RESULTS

The inter-observer agreement evaluated by analysis of Fleiss' kappa test (Fleiss, 1971), was found to be fair to good (at the first trial with naïve observers) for monitoring of driving of pigs into the stun box; Kappa equals 0.49 (65% match between observers during instantaneous sampling). When the observer's instantaneous sampling was tested against each other on a pair wise basis, Kappa values were A–B 0.55, A–C 0.61, and B–C 0.29. The somewhat low group Kappa was due to a poor inter-observer value between observer B and C.

No kappa value could be calculated from the one-zero sampling, due to not enough variation of HPV calling rate in the video training material. Still, the inter-observer match from the scoring sheets was 100%. The Minitab software could not interpret the data, as the 3 observers' one-zero samples consisted of almost only 1's, instead of a more mixed occurrence of 0 and 1.

The inter agreement results from live monitoring within two observers (one trained, one naïve) were 0.94 (one-zero sampling) and 0.51 (instantaneous sampling).

20.5 DISCUSSION

The test persons found it hard to analyse from video clips and felt unable to define an auditory reception area and trace back the vocalisation direction from either monitoring area or holding pens. As the test leader had the stopwatch, to make sure the signal marking the end of an 20 sec interval and the onset of instantaneous sampling, came simultaneously for all test persons, they felt startled as the signal came, not being able to follow the count down. This problem will disappear as monitoring at an abattoir will be done individually with a personal stop watch. This will make the observer prepared for the instantaneous samplings. The testpersons expressed observer fatigue and lack of focus between the interval signals. With further training focus automatically increases and the results will most definitely improve. Combining confounding technical issues and the testpersons' comments, training should preferably be conducted live at the abattoir.

According to the original proposal, live observations were supposed to be carried out by the trained observers. Only one slaughter plant did allow this and training of one observer who was then tested against a standard was carried out. The results were indeed better from the live observation. The trainee found it easy to distinguish the HPV and to define the vocal reception area.

Due to the reasons discussed above, an early idea of filming at the abattoir for analysis *ex situ* was rejected after a period of testing. Abattoir reluctance concerning video documentation at the site was also taken into account.

Pigs are social animals and the behaviour of one animal will often influence other animals in the group. At many abattoirs in Europe, pigs are driven in groups ranging from 4 to approximately 20 animals. In our opinion, sampling of vocalisations at group level is therefore more informative and more related to animal welfare than sampling on individual basis. The animals are likely to be diverse in their sensitiveness to the new environment at the abattoir, due to previous experience, different strains or just pig personality. Human behaviour and handling technique have an influence on fear and productive performance in an on-farm situation (Coleman et al 2000), as well as human behaviour and attitudes towards pigs (Hemsworth et al 1989) can influence the abattoir experience. Negative handling results in an acute stress response by the animal in the presence of humans. For instance, Grandin (1998) demonstrated how aversive behaviour from abattoir staff while driving, was strongly correlated with vocalisations. Something that have been observed by the authors as well. As human interference, such for example, electrical prodding, is reduced during final stages of the driving, so is the over all vocalization level. If the pigs are previously unaccustomed to human handling, they also try to avoid human contact and the pre slaughter procedures will add to the total stress.

A significant difference in vocalisation level, due to different conduct in the driving systems could be assessed with the proposed method. We have in this study shown that there is a good possibility to measure distress vocalisations on an objective basis.

20.6 CONCLUSIONS

The presented method is a promising method for measuring HPV in pigs driven to slaughter.

A considerable difference in vocalisation rate and intensity between different driving systems and handling could be assessed with the evaluated method.

Live monitoring at training is preferred over video clip monitoring.

QUALITATIVE BEHAVIOUR ASSESSMENT

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22.1 SUMMARY

Qualitative Behaviour Assessment (QBA) is a method that relies on the ability of human observers to integrate perceived details of behaviour, posture, and context into descriptions of an animal's style of behaving or 'body language', using descriptors such as 'relaxed', 'tense', 'frustrated' or 'content'. Such terms have an expressive, emotional connotation, and provide information that is directly relevant to animal welfare. Previous research with pigs, cattle, poultry, sheep and horses has shown QBA to have high inter- and intra-observer reliability and to be coherent with traditional behaviour and welfare measures, both when animals were assessed individually and at group level. Previous QBA work however was based on a Free-Choice-Profiling methodology that asks observers to develop their own descriptive terminologies and is unsuitable for on-farm inspection work. The aim of this study therefore was to design, and test the inter-observer reliability of, a fixed rating scale for QBA of pig expression.

On the basis of previous QBA research with growing pigs and consultation with pig experts, we designed a rating scale of 33 descriptors. This scale was tested by four assessors, who watched 32 video clips of growing pigs filmed during a previous study showing undisturbed home-pen behaviour in different commercial farming systems. Assessors were given detailed instructions on the procedures of assessment and the use of the rating scale. The inter-observer reliability of the QBA scores attributed to the 32 pig groups was tested using Kendall Correlation Coefficient W, and showed satisfactory reliability ($W \geq 0.70$) for 15 out of 33 descriptors. Comparison of Principal Component Analyses (PCA) of each assessor's scores showed similar emergent patterns of pig expression, in which the first principal component (PC1) distinguished between positive and negative mood, and the second (PC2) differentiated these moods in low and high levels of arousal. This pattern was reproduced when we removed 13 descriptors with low loadings and low apparent welfare relevance from the assessor data sets. PC1 of the 'reduced' PCAs explained 57–79% of the total variation between pig groups (depending on the assessor), and showed good reliability (Kendall $W = 0.82$; $p < 0.001$). PC1 scores also

showed a high mean correlation (0.86; $p < 0.001$) to the assessors' scores of the descriptor 'welfare overall', which supports their direct relevance to pig welfare.

Thus we propose that PC1 may provide an integrative measure of positive and negative pig emotion, to be accorded to single farm units through a PCA of assessors' scores on a 20-term QBA rating scale. To calibrate the QBA measures of single farms, testing the QBA scale on a large sample of farm units is required to create a 'benchmark' data base. This will allow identification of cut-off points on PC1 for unacceptable levels of negative mood/welfare.

The application of QBA on farms is highly feasible and easy to learn, however assessors must be experienced in observing pigs, and be given additional training in recognising pig expressions if required.

22.2 INTRODUCTION

Qualitative Behaviour Assessment (QBA) is a method of animal welfare assessment developed in recent years at the Scottish Agricultural College (Wemelsfelder et al., 2000, 2001). This method relies on the ability of human observers to integrate perceived details of behaviour and its context into judgements of animal 'body language', using descriptors such as 'calm', 'tense', 'anxious' or 'content'. Such terms have previously been used to describe individual differences in animal temperament and personality (e.g. Lanier et al., 2000; Gosling, 2001), but they also have an expressive, emotional connotation that provides information which is directly relevant to animal welfare and could supplement information obtained from quantitative indicators (e.g. Carlstead et al., 1999; Wemelsfelder and Farish, 2004; Weiss et al., 2006; Wemelsfelder, 2007). Several years of research with pigs, cattle, poultry, sheep, and horses have shown QBA to have high inter- and intra-observer reliability and to be coherent with quantitative behavioural and physiological measures, both when animals were assessed individually and at group level (Wemelsfelder et al., 2000, 2001; Wemelsfelder and Farish, 2002; Wemelsfelder et al., 2003; Dungey, 2003; Wang, 2004; Rousing and Wemelsfelder, 2006; Napolitano et al., 2008; Minero et al., 2009). In an on-farm context, an important question is whether qualitative judgements of behaviour might not be biased by the prevailing environmental conditions. In a study with individual pigs, digital manipulation of videos demonstrated that whether pigs were observed against an indoor or outdoor background did not unduly bias observers' assessment of the pigs' behaviour (Wemelsfelder et al., 2009).

These studies were all based on a Free-Choice-Profiling (FCP) methodology which asks observers to develop their own descriptive terminologies, and requires a minimum of 10 observers to be statistically viable. Evidently this method is unsuitable for on-farm welfare monitoring purposes, and requires adaptation for use by individual assessors. It was

therefore the aim of the present study to develop, and test the inter-observer reliability of, a fixed qualitative rating scale describing the expressive behavioural repertoire ('body language') of pigs. More specifically, the aim was to investigate the reliability of such a scale for growing pigs and breeding sows kept under a variety of environmental conditions.

Unfortunately, due to the unexpected withdrawal of our WQ collaborator, the on-farm work we had planned with them was cancelled. In place of this work we used high quality digital video footage of growing pigs housed in various commercial farming systems, which we had gathered for a previous FCP-based on-farm study. An advantage of using this video material was that it allowed us to compare the scores generated by the newly developed fixed rating scale with those previously generated through FCP.

22.3 METHODS

22.3.1 Development of Rating Scale

A first selection of qualitative descriptors of pig behaviour was made on the basis of several previous FCP-based studies of on-farm pig welfare. These studies, using different observer groups of pig experts and animal welfare students, all found two main dimensions of pig behavioural expression. These dimensions are characterised by clusters of terms at both their positive and negative ends; from these clusters, a list of 28 terms was selected as a starting-point for this study. This list was sent to 13 research partners in the Welfare Quality pig-subgroup for comments and amendments, of which 6 replied. Feedback of these respondents was generally positive and various suggestions for additional descriptors were made. We decided it would be unwise to be too restrictive in the number of terms we selected at this early stage, and that a possible reduction of terms would be better based on the results of this study. Thus the adjusted list contained 33 descriptors.

The rating scale to be tested was construed by putting each of the 33 qualitative descriptors next to a continuous, undivided visual analogue scale of 125 mm length (the same as used in FCP studies). No definitions of the terms were given, but observers were provided with detailed instructions on how to make qualitative assessments of the behaviour of animals in groups, and were encouraged to discuss and agree on the meaning of the terms as much as possible before starting the work.

22.3.2 Reliability Testing

Four assessors were shown high quality digital video clips of 32 different groups of growing pigs housed in 16 commercial pig farms in the UK (4 slatted floor, 4 solid floor/thin straw, 4 deep straw, 4 outdoor systems; 2 pens per farm). The pigs were mostly

of the same breed (White x Landrace x Duroc), gender (mixed male/female) and age (16–20 weeks old). The 32 clips were each 2 minutes long and showed all pigs in a particular pen in undisturbed home pen behaviour. The assessors were three veterinary science undergraduate students and one animal science undergraduate (2 male, 2 female), all of whom had experience in handling/observing pigs and measuring behaviour.

Before the first assessment, the four assessors familiarised themselves with the rating scale and the written instructions. They discussed the assessment procedures as described in the instructions, but refrained from discussing the meaning of descriptors to enhance independence of assessment.

When assessments of all video clips had been completed, the scores for each descriptor provided by the four assessors were recorded by measuring with a ruler the distance in millimetres between the minimum point on the left side of the scale and the mark on the line made by the assessor. The inter-observer reliability of these scores was calculated using Kendall Correlation Coefficient W. Subsequently a Principle Component Analysis (PCA; covariance matrix, no rotation) of scores was conducted for each individual assessor, to gain more insight in how each assessor had used the various terms to account for the variation between observed groups of pigs. The scores attributed to the 32 pig units on the first two main components of the PCA were then also tested for inter-observer reliability using Kendall W. The outcomes of the PCA then directed us to some further calculations and a reduction of the number of descriptors on the QBA rating scale, which are described below under ‘Results’.

22.4 RESULTS

Table 22.1 shows the Kendall W values for each of the 33 qualitative descriptors on the rating scale. Setting an arbitrary minimum of 0.7 (Martin and Bateson, 1993), 15 terms out of 33 (highlighted in black) reached satisfactory inter-observer reliability (rounded up from 0.65). Another 8 terms reached W values between 0.6 and 0.7 (rounded up from 0.55).

The assessors used the 33 terms in a very similar way, to distinguish between pig behavioural expressions of positive and negative mood (PC1), and between high and low levels of arousal in these moods (PC2). Given this similarity, and the apparent face-value relevance of PC1 to welfare, we decided to make the integrated picture given by the PCA the focus for developing this measure, rather than the separate descriptors. We then tested the inter-observer reliability of the two main PCA components using Kendall W. As a further test of inter-observer reliability, we correlated these PCA components to the equivalent GPA (Generalised Procrustes Analysis) components in a Free-Choice-Profiling study (which used 8 assessors) of the same 32 video clips. These PCA-based outcomes are given in Table 22.2.

TABLE 22.1 Kendall correlation coefficients for all descriptors (N = 4; df = 31).

Descriptor	Kendall's W	p-value	Descriptor	Kendall's W	p-value
Happy	.81	.1	Irritable	.74	.1
Welfare overall	.81	.1	Agitated	.74	.1
Enjoying	.77	.1	Aggressive	.73	.1
Positively occupied	.76	.1	Bored	.72	.1
Content	.74	.1	Frustrated	.72	.1
Relaxed	.73	.1	Uncomfortable	.70	.1
Calm	.69	.1	Fearful	.69	.1
Boisterous	.66	.1	Aimless	.64	.1
Playful	.62	.1	Listless	.64	.1
Confident	.62	.1	Distressed	.62	.1
Friendly	.61	.1	Tense	.60	.1
Lively	.50	.1	Depressed	.57	.1
Energetic	.49	.1	Compulsive	.51	.1
Sociable	.48	.2	Unwell	.47	.2
Active	.41	.14	Nervous	.46	.3
Inquisitive	.34	.81	Vigilant/watchful	.43	.7
			Indifferent	.40	.21

To further prepare the rating scale for practical application, we reduced the number of descriptors from 33 to 20, by removing terms which 1) had relatively low loadings (lower or slightly higher than 0.20) on each of the assessors' PCA components, 2) had meanings without clear relevance to welfare, or 3) were similar in meaning to other terms on the list. We also took out 'welfare overall' as this term includes non-animal environmental features. This reduction led to the removal of 4 terms with Kendall W values of 0.7 or higher (welfare overall, boisterous, aggressive, uncomfortable), and 9 terms with W values lower than 0.7 (confident, friendly, energetic, inquisitive, depressed, compulsive, unwell, nervous, vigilant). The remaining terms with low Kendall values stayed on the list because of their high loadings on the PCA components. Of the 13 terms characterising PC1 (see Table 22.2), 10 had Kendall W values above 0.7, and 3 between 0.6 and 0.7. The reduced QBA rating scale for pigs thus consisted of the following 20 terms: active, positively occupied, sociable, content, enjoying, lively, playful, relaxed, calm, happy, frustrated, fearful, agitated, irritable, listless, aimless, bored, tense, indifferent, distressed.

We then checked the inter-observer reliability of this reduced rating scale by taking out the selected terms and their scores from the assessor files, conducting a PCA on these reduced files, and calculating Kendall W for its main components. Furthermore we investigated the extent to which assessors' PC1 scores reflected their view of the pigs' overall welfare, by correlating these scores to their 'welfare overall' scores (Pearson or Spearman rank correlations depending on the distribution of scores). We also again correlated each assessor's PCA scores to the equivalent FCP-based scores. These outcomes are also given in Table 22.2.

TABLE 22.2 PCA outcomes for full and reduced rating scales.

	PCA Factor 1 PCA of 33 terms/PCA of 20 terms					PCA Factor 2 PCA of 33 terms/PCA of 20 terms			
Kendall's W (N=4, df=31, p<0.1)	.83 / .82					.62 / .56			
% of variation explained	obs1 75 / 79	obs2 44 / 51	obs3 50 / 57	obs4 65 / 71		obs1 8 / 9	obs2 21 / 20	obs3 19 / 19	obs4 14 / 11
Main descriptors of PCA components	Content, enjoying, positively occupied, relaxed, calm, happy Frustrated, bored, aimless, agitated, irritable, listless, tense					Lively, playful, sociable, active, tense, agitated, positively occupied Indifferent, listless, aimless			
Correlation with 'welfare overall' (df=30; all p<0.001)	obs1 .96	obs2 .70	obs3 .88	obs4 .89	Mean .86				
Correlation with FCP-based scores (df=30; all p<0.001)	.91 / .91	.81 / .79	.80 / .81	.92 / .91	.86 / .86	.59 / .59	.57 / .58	.55 / .55	.62 / .56

Notes: roman values refer to the PCA of 33 terms, italic values to the PCA of 20 terms; the main descriptors of PCA components are valid for both analyses.

22.5 DISCUSSION

The aim of this study was to design a fixed rating scale of qualitative descriptors of pig behavioural expression, and test its inter-observer reliability. In designing this scale we preferred to start with a rather extensive list of 33 terms, and use the test results to remove less effective terms. Testing the rating scale with four assessors on the basis of 32 video clips showed that 15 out of 33 descriptors reached satisfactory reliability. However, more importantly, we found that Principal Component Analysis (PCA) of each assessor's scores resulted in remarkably similar clusterings of descriptors at the positive and negative ends of the two principal components (PCs). From these clusterings emerged a coherent pattern of pig expression, in which the first PC distinguishes between positive and negative mood, and the second PC differentiates these moods in low and high levels of arousal. The second PC does not in and by itself appear to bear direct relevance to welfare, but contributes to a meaningful transition between descriptors of positive and negative mood on the first PC. Thus PC2 is an important part of the information on welfare provided by PC1; it is the overall expressive pattern that counts, and that provides farm units with their scores on PC1.

These findings suggest that pig welfare is reflected not so much by single terms, as by the pattern of behavioural expression that emerges from scoring a broader list of terms. This requires an integrative measure, which we propose can be provided by a farm unit's score on PC1. The PCA analyses appear sufficiently robust to support this proposal; PC1 (based on the reduced 20-term PCA) explained a respectable 57–79% of the total variation between pig groups (depending on the assessor), and showed good inter-observer reliability (0.82). Good reliability was also evident in PC1's high mean correlation (0.86)

to the first GPA component in an earlier FCP study (8 observers) of the same video clips. It also, finally, showed a high mean correlation (0.86) to the assessors' score of 'welfare overall', which supports its direct relevance to pig welfare.

Our preference for this approach was strengthened by the results of the 'Welfare Quality' QBA work with poultry and cattle. Here too, PCA revealed patterns of poultry and cattle expression that differentiated between positive and negative mood, and between low and high levels of arousal in these moods. In addition these patterns have emerged in a large number of comparable Free-Choice-Profiling studies with pigs at SAC. Thus, we think it is reasonable to assume that our PCA results reflect a robust pattern of animal behavioural expression, that can reliably be used as an indicator of pig welfare.

Further validation of a PCA-based measure can take place through investigation of its relationship to other welfare indicators, such as those that will be part of the WQ monitoring tool. Perhaps the proposal to make QBA monitoring dependent on multivariate analysis through PCA complicates the use of this measure as part of a larger monitoring tool; however we think this complication will be offset by the advantages of having an integrative measure that contributes to the transparency and face-validity of that tool for the many stakeholder groups involved.

22.6 CONCLUSIONS

In conclusion, we suggest that the Qualitative Behaviour Assessment rating scale developed and tested in this study meets the required criteria of good inter-observer reliability and high pig welfare relevance. This measure is highly feasible and easy to learn, and we recommend that it should be part of the WQ monitoring tool.

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APPENDIX 1

STANDARDISATION OF MANAGEMENT AND HANDLING- BASED MEASURES IN PIGS

B. Algers, A. Butterworth, S. Waiblinger and L.J. Keeling

A1.1 SUMMARY

Management-based measures refer to what the animal unit manager does on the animal unit and what management processes are used. It was foreseen that when no animal-based measure is available to check a criterion, or when such a measure is not sensitive or reliable enough, measures of resources or management will be used to check as much as possible that a given welfare criterion is met.

For pigs, 82 measures are discussed regarding their welfare relevance and a rationale for inclusion or exclusion in the final list of 35 measures proposed to be considered in Welfare Quality® assessment. For those 35 measures in the final list, a short text is added proposing whether the measure can be assessed by questioning (Q), by direct observation of animals, management systems or records (A) or by a combination of both (C). For example the amount and quality of bedding or feeding management are assessed by questioning the farmer as well as checking records or the situation in the barn directly. Further instructions to assessors including a proposed wording of questions are provided in a preliminary assessment tool.

It is the intention that these potential management measures are used in three ways – A) As direct measures of value in the Welfare Quality® assessment. An example would be the maintenance and the cleanliness of drinking and feeding equipment. B) As measures which may be of value in the advisory aspects of the assessment. The information produced is ‘fed back’ to identify areas which may affect economic performance and the welfare of his animals. For a high acceptance of Welfare Quality® among producers we think that this advisory purpose is vital. C) As measures included in large scale on farm assessments, they offer an opportunity for epidemiological analyses aimed at furthering our knowledge of animal welfare.

Because there are a large number of potential management measures it is not assumed that all of these measures will make their way into the Welfare Quality® assessment system, and so, to assist in decision making on inclusion, a ranking table is provided which is based on the assessment of the validity of the measures as well as the proposed use of the measures. Scoring for assessment of validity was done by 7 persons from 5 different countries within the EU (Sweden, Denmark, UK, France, Italy) working with research and/or animal health management in pigs.

A1.2 INTRODUCTION

Management-based measures refer to what the animal unit manager does on the animal unit and what management processes are used. The first and main role of management-based measures in Welfare Quality® is to address issues that can not be dealt with using animal based measures. These measures may represent the only option for a particular dimension of animal welfare to be included in the final monitoring scheme. It is also possible that specific measures will prove to be a more feasible alternative to a single or a combination of animal based measures and so for this reason are kept in the final monitoring scheme.

A second aim of the welfare monitoring system is to be able to give feedback to the farmer/manager to help identify risks to animal welfare and causes of poor welfare so that improvement strategies can be implemented. Thus management questions may be included which we do not intend to contribute to the welfare assessment. In fact, since some of these are questions to the farmer, with little or no opportunity to check the reliability of the answer, we recommend that they do not contribute directly. Nevertheless, we recommend that these are included since they will enable Welfare Quality® to go some way towards explaining to the unit manager what factors might have contributed to the specific results from some of the animal-based measures.

Thirdly, many of the measures are valuable for scientific reasons. Data collected in a standardised way on farm or at slaughter present a unique opportunity for epidemiological analyses aimed at furthering our knowledge of animal welfare. It should be accepted that this is a secondary aim of the work in this deliverable and so, if there is a shortage of time when implementing the Welfare Quality® protocol, these questions are ones that should be excluded first. However, we include them since they could be a valuable scientific addition to the outputs of Welfare Quality®.

A1.3 APPROACH TAKEN

Animal-based measures are the measure of choice in Welfare Quality®, since they are independent of housing system. This is not the case for management measures which are, of course, highly dependent on the type of system. For that reason some questions are relevant in only one system, whereas others may be relevant in all systems. For this reason, in Tables A1.1 and A1.2, the type of animal system where the question can be asked is also specified. We have nevertheless tried to keep to main areas of management that are common to all systems, or on decisions of the treatment of animals, which are relevant to sows and piglets as well as fattening pigs.

There are fewer measures that we recommend be considered for inclusion in the welfare assessment than there are measures that we suggest be used when giving advice back to the farmer/manager. This is because management is an ongoing process and although there may be paper documentation that can be examined (e.g. contract with a veterinarian), or physical evidence of a management process that can be evaluated (e.g. functioning of equipment), most measures are based on questions to the farmer/manager. It is therefore usually impossible to determine if the answer is correct. Thus we recommend that these measures are not sufficiently reliable to be used in the assessment. To maximise the reliability we have been careful in the wording of each question to avoid ‘leading questions’ or an implication through the formulation of the question as to what is the correct or preferred answer. In the tables, we have given the formulation of the questions, although we appreciate that these may have to be modified as well as translated into other languages. We have also given the answer categories (sometimes a scoring system) of how the answer should be recorded so that they can easily be included in the database. For this reason most answers are broken down to a ‘Yes/No’, or require the assessor to tick one of several options. We have not given the exact layout of the questionnaire since we presume that the order in which the questions are asked will depend very much on the decisions related to the structure of the visit itself.

The style of the questions varies and several require that the assessor evaluates the appropriateness of the answer. For this reason we have sometimes given instructions for the assessor to help them understand the exact aim of the question and give guidance on what is an appropriate answer.

Once a first list of the questions had been developed each researcher went through the list of questions and ranked them according to the following questions;

- How critical the issue addressed in the question was for animal welfare (low to high).
- The portion of life referred to in the question (short to long period of the animal’s life).
- The time needed to gather the data (quick or time consuming).
- The quality/reliability of the data (poor to good)

- Whether there was a critical window during which the measurement must be taken (yes or no - it could be gathered anytime).

The answers were discussed. There had already been a large amount of ‘filtering’ of questions and most questions ranked quite favourably (i.e. measures considered of very low value had not even been included in the initial lists). For pigs, the ‘animal welfare impact’ was assessed and scored from low to high (1–5) for each of the remaining measures. Scoring was done individually by 7 persons from 5 different countries within the EU (Sweden, Denmark, UK, France, Italy) working with research and/or animal health management in pigs. Presenting this average is intended to help future prioritising of questions. Table A1.2 shows a final ranking of the 35 measures for pigs which survived this process. We propose those that are ranked lowest are deleted first, even if we have already been ruthless and the list only contains questions that we firmly believe are important to include in the scheme. As a further aid in the development of the operational protocol we have listed whenever we think one of our measures relates to another measure. There are several measures which are closely related to a resource based measure in the area e.g. straw is a resource, but how often it is provided and whether it is clean or not is related to management. Some questions already relate to animal-based measures, especially those related to health.

There is some concern among those working with the animal-based measures related to fear and human animal interactions that the measures will not be independent of housing system and so may not be accepted for inclusion in the full monitoring scheme. We feel it would be a deficiency to have nothing in the monitoring system that addressed these areas. We have therefore included a series of questions related to the farmer’s/manager’s behaviour towards the animals and some observations of handling that we propose to be included, at least during the large scale testing of the protocols. If animal-based measures of fear and the human animal relationship are included in the final assessment system, then those findings can be correlated with this (perhaps more feasible) approach. If those animal-based measures are not included then these questions would at least allow investigation of the human-animal relationship. However, the more feasible, quick approaches would need some investigation with regard to reliability in case of latter use in the Welfare Quality® assessment.

A1.4 MEASURES

Table A1.1 lists the potential measures to assess management and handling that we think are important for inclusion in the welfare assessment tool, together with measures not recommended for further use, to make the decision process transparent. The list includes all items that were discussed (in total 82 single items), i.e. also items that we decided not to include into the list of recommended measures. Out of these 35 items are recommended

and these are given a number in the first column. In the second column it is specified whether the question is most relevant to the Welfare Quality® assessment (WQA), to some form of advisory tool (AT) or whether it is not to be included (NO). The third column specifies the animal type for which the measure is relevant S= sows, P=pigs, W= weaners, and F=finishers. The fourth column gives the item description and how to assess the measure i.e. whether it is a direct question (Q), whether it is assessed in the house or from paper records (A) or whether it is a combination of both (C). The fifth column gives instructions to the assessor and includes a very brief description of the general approach. The sixth column gives a short description of the reason for including or disregarding this potential measure. The seventh column presents the welfare relevance as scored by the group on average; 1 = low; 5 =high. The eighth and final column gives the links to other sub tasks, that is to say to resource-based or animal-based (AB) measures are indicated.

Table A1.2 gives a ranking of the measures with respect to the perceived value to support decisions about inclusions of measures. The ranking of the 35 items was done according to: (1) the type of measure, i.e. WQA-measures are always ranked higher than AT. This is because it is recommended to not delete any of the WQA-measure, and (2) the average score of the group given to the item with respect to welfare relevance.

Table A1.3 presents the questions that we suggest are important for management-based measures for cattle and how answers can be recorded. The layout is only preliminary, but gives an idea of how such a questionnaire, when a final list is agreed upon, could be formulated. Detailed definitions of the categories of scoring system are given only for the questions that we feel to be relevant directly for welfare assessment, i.e. WQA measures.

In the final section, approaches to assess handling are presented. These include; observations during handling, questions on the frequency of use of particular types of behaviour and a simple observation protocol.

TABLE A1.1 Management and handling practices in pigs – list of measures.

Number of item	WQA/ AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
Farrowing and weaning management							
1	AT	P	Q: What proportion of farrowings is supervised?	Ask farmer	Combined with item nr 1. Reduces piglet mortality and speeds up detection of farrowing problems and onset of treatment. Combined with nr 1. Cross fostering can enhance the survival of piglets in large litters.	3,0	
	AT	P	Q: Are piglets cross fostered?	Ask farmer			
	AT	P	C: Does the farrowing management strategy seem to avoid problems for the piglets?	Ask farmer Check records			
	AT	S	C: Is oxytocin given to sows at farrowing: As a routine to all? In case of long birth times? As prevention for MMA? When is it administered?	Ask farmer Check records			
2	WQA	S	C: Does farrowing management strategy seem to avoid problems for the sow?	Ask farmer Decide on appropriateness	Combined with item nr 2. A poor environment can lead to prolonged farrowings which may increase the use of oxytocin. Treatment with oxytocin during farrowing increase asphyxia and thus piglet mortality.	4,1	
3	WQA	W	C: At what age are the piglets weaned?	Ask farmer Check records	An early weaning increases the risk for piglets to suffer from weaning diarrhoea.	4,0	
Hygiene / Cleaning routine							
	NO	S	How often are breeding facilities cleaned between batches?		NO because low relevance		
	AT	PWF	How often are pens cleaned between batches?	Ask farmer	Combined with item nr 12. Cleaning prevents microbial survival and reduces spread of contagious disease between batches.		

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
4	WQA	S P W F C	Is the hygiene management of pens sufficient?	Ask farmer for frequency and type of A dry and clean floor surface makes cleaning and check cleanliness in the pens; decide for appropriateness	4,0		
5	WQA	S P W F C	Is deep bedding well managed?	Ask farmer for management routines, check cleanliness in the bedding; decide if well managed	3,7	Decreases risk of infection. Dirty, wet litter increases risk of infection and reduces thermo insulating properties	
6	WQA	S P W F C	Are cleaning routines for drinkers sufficient?	Ask about routines and check if clean	3,6	Clean water is important for hygienic reasons as well as pigs prefer clean water	
7	WQA	S P W F C	Are cleaning routines for feeders sufficient?	Ask about routines and check if clean	3,9	Clean feed is important for hygienic reasons as well as pigs avoid feeding dirty food	
8	AT	S P W F C	Is the hygiene management of hospital pens sufficient?	Ask about daily routines and check if clean	4,0	A dry and clean floor surface makes it more difficult for microbes to survive. Decreases risk of infection.	
9	AT	S P W F C	Are the cleaning routines of hospital pens between batches sufficient?	Ask farmer about cleaning and disinfecting routines for hospital pens and check hospital pens as well as existence of disinfecting agents; decide on appropriateness	3,6	Cleaning / disinfecting of hospital pens after use is a necessary disease prevention	
Enrichment	AT	S	Q: Is the sow provided with extra nesting material before farrowing?	Ask farmer	Combined with nr 10.		Resource-based
	AT	S	Q: How much straw is provided for each sow at farrowing? Kg/sow	Ask farmer	Combined with nr 10.		Resource-based
	WQA		C: Is it possible for the sow to perform nest building behaviours before farrowing?	Ask farmer and check what type of material is used.	Sows have a strong motivation for building a nest the day before farrowing. If this behaviour is not satisfied, because of lack nesting material, the farrowing will take longer time and the sow will be restless which increase piglet mortality.	4,3	

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
	AT	S	A: Would you assess the amounts of nesting material and straw given to farrowing sows appropriate?	Ask farmer and check the amount of straw in the boxes, decide on appropriateness	Combined with nr 9.		Resource-based
	AT	S P W F Q	How much straw is provided to the pigs? Kg/pig	Ask farmer	Combined with nr 10.		Resource-based
	AT	S P W F Q	How often is straw provided to the pigs?	Ask farmer	Combined with nr 10.		Resource-based
11	WQA	S P W F A	Is the provision of litter material sufficient for pigs to perform rooting?	Ask farmer and check the amount of litter in the pens, decide on appropriateness	Pigs have a strong motivation for rooting. Lack of material to root in increases the risk for development of abnormal behaviours, such as tail biting.	3,6	
Disease prevention / regular health care:							
12	AT	S P W F C	Does prevention of disease through management seem appropriate?	Ask about cleaning routines between batches, and production strategy. Decide on appropriateness	Planning and cleaning routines between batches can have a large impact on animal health.	4,1	
	AT	S W F	Is an all in all out strategy employed?	Ask and check in stables	Combined with nr. 12. Prevents spreading of contagious diseases since all pigs in the batch are the same age.		
	AT	W F	Are pigs from different farms/units mixed in the same batch?	Ask the farmer	Combined with nr. 12. Mixing of pigs from different farms/units increases the risk for spreading of infectious diseases.		
	AT	W F	Are slow growing individuals sometimes moved to a batch with younger animals?	Ask the farmer	Combined with nr 12. Mixing of pigs of different age increases the risk for spreading of infectious diseases to the younger animals.		

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
	AT		Q: Do you currently have any problems at your farm? (Tail biting, MMA, hernias, fighting/scars etc.) What do you do against these problems?		Welfare related health problems may occur in batches. Appearance or non-appearance of specific problems at only one visit can therefore not be indicative for over all animal welfare. However, if problems are noticed during the visit and the farmer is aware of them it is positive for animal welfare.		
13	WQA?	S P W F C	Is there evidence for effective health strategy? (Health schemes, vaccinations, anti parasite drugs etc.) the herd.	Ask farmer about their health strategy. Compare to assessment in	Combined with nr 13. The health strategy/ speed of treatment and of getting the vet etc. is important for welfare. However, it is difficult to assess. Should be reflected in AB measures.	4,0	Animal-based
14	AT	S P W F Q	Is there a special veterinarian linked to the farm that follows-up the overall health status?	Ask farmer	To have one supervising veterinarian that is familiar with the farm and follows the health status is good for the overall health.	3,4	
15	AT	S	C: Does the claw trimming and checking for lameness seem appropriate?	Ask about claw health strategy. Check animals	Prevention of lames through good claw health strategy must be appropriate to environmental conditions. Should also be reflected in AB.	4,0	Animal-based
16	AT		C: Are production figures thoroughly recorded and accessible for follow-ups?	Ask farmer and check records	Sound records may (i) be indicators of sound management and (ii) help the farmer to realistically assess the health status	2,5	

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
AT	S		Q: Are there any special routines for prevention of shoulder lesions in farrowing sows?	Ask farmer	Combined with nr 17.Shoulder lesions in sows are painful. Thin sows, sows farrowing on hard or slatted floors and sows with long farrowing times are high risk animals.		
17	WQA	S	A: Do the routines for prevention of shoulder lesions seem appropriate?	A: Ask about routines for prevention and count how many sows in one batch of farrowing sows that are affected.	Occurrence of shoulder lesions in farrowing sows is a sign of inadequate management or a poor environment during farrowing. Should also be reflected in AB measures.	4,1	Animal-based
Management of sick animals							
AT	W		Q: Are feed antibiotics used for weaners?	Ask farmer and check records	Combined with nr 18. Antibiotics is a second hand choice. If antibiotics are provided in the feed at all times, it can 'hide' eventual health problems.		Resource-based
AT	W		Q: Is zinc or other feed additives used for weaners?	Ask farmer and check records	Combined with nr 18. Zinc is a second hand choice. If zinc is provided in the feed at all times, it can 'hide' eventual health problems at weaning.		Resource-based
NO			C: If there is an outbreak of diarrhoea, what strategy is there to handle the situation? How often does this occur?	Ask farmer and check records	Not included because only relevant for weaners. See nr 18.		
18	WQA	W	Are handling strategies for avoiding weaning diarrhoea sufficient in relation to the weaning diarrhoea problems present?	Ask farmer about prevention routines and check records for treatments of weaning diarrhoea	Weaning diarrhoea is related to stress 3,3 at weaning. Stress level should therefore be minimized before use of zinc or antibiotics.		

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
19	AT	W F	C: Is the strategy for prevention of tail/ ear biting appropriate?	Ask farmer and check records and stables.	Tail and ear biting is a sign of stress due to inadequate management, feeding or poor environment. Tail docking is a second hand choice treatment. Combined in nr 20.	4,3	
	AT	W F	Q: How are pigs with hernias taken care of?	Ask farmer			
20	AT		C: Does care of pigs with hernias seem appropriate?	Ask farmer and check animals	Pigs with large hernias may need special care.	2,6	
	NO	W F	What treatment is provided in case of pneumonia?	Ask farmer about routines and criteria for treatment of pneumonia. Check records and animals.	Not included because not relevant. For prevention of disease through management, see nr 12.		
	NO		Existence of hospital pens?		Not included because resource-based, should be checked		Resource-based
21	WQA		Use of hospital pens: Are obviously sick animals housed in hospital pens?	Check herd for animals that are obviously sick and need other conditions (e.g. littered area, easy access to feed...without social defeat; e.g. high-grade lame animals, weak animals) Ask farmer for littering, cleaning	Sick animals often suffer from difficult access to resources due to difficulties in walking and/or in social interactions; need for good lying area, quietness; needs well-trained assessors Important, but not reliable; therefore WQA relies on question 20.	4,5	
	NO		Use of hospital pens: Are sick animals put in hospital pens? Criteria for putting in hospital pen. (Question pen in use to farmer)	Ask farmer for littering, cleaning Criteria frequency and check state of hospital pen in use			
22	WQA		C: Criteria for euthanasia: Are any animals in the herd found to be so sick or injured that they should have been euthanized.	Ask farmer about criteria for euthanizing sick animals. Check herd for animals that should have been euthanized already.	Under some conditions pigs can rapidly become very sick such as piglets suffering from starvation, diarrhoea or injuries due to trampling. Waiting too long until euthanizing causes unnecessary suffering.	4,7	

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
Management of housing system							
	NO	S	What proportion of sows is kept in crates during breeding?		Has large impact on sow welfare but not included because resource.		Resource-based
	NO	S	What proportion of sows is kept in crates or tethers during pregnancy?		Has large impact on sow welfare but not included because resource.		Resource-based
	AT	S	What proportion of sows is kept in crates just before and during farrowing?		Related to resources, but also management since farmers with loosed housed farrowings sometimes choose to keep the sows crated for a period around farrowing. Sows in crates can not perform nest building which affect the farrowing and nursing negatively. The risk of MMA increases. Combined in nr 2 and 10.		Resource-based
			What proportion is kept individually but loose?				
			What proportion is kept in groups?				
	NO	S	What proportion of sows is kept in crates during lactation?		Not included because resource-based		Resource-based
Management feeding/ ventilation/ lighting/							
23	WQA	S W F	C: Is competition for food reduced as much as possible?	Ask farmer about feeding practices and check in the barn if aggression level is low or high during feeding	Competition during feeding causes agonistic interaction and may cause stress and impair individual intake and provision	4,6	Resource-based
	NO		Is there a reserve electricity system that powers ventilation and water systems?		Not included because resource-based		Resource-based
	AT		Q: Is there an evacuation plan in case of fire?	Ask farmer	Combined with nr 24.		Resource-based
	AT		Q: Is there an alarm system installed in case of ventilation/power failure?	Ask farmer	Combined with nr 24.		Resource-based

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
24	AT	SWF	Do handling strategies and awareness in case of fire or ventilation/power failure seem appropriate?	Ask personnel if they know how to evacuate animals in case of fire and how to act if ventilation/power fails.	In case of fire or ventilation failure it is important that the staff know how evacuation of the animals is performed.	3,6	Resource-based
Management of group dynamics (social environment)			What proportions of animals are mixed at weaning?	Ask farmer	Mixing of pigs is stressful. The risk of aggression when mixing piglets is substantially increasing from 2-6 weeks of age. In group housing systems, mixing can not be prevented. Combined with nr 18. Combined in 25		
25	WQA	F	Q: What proportion of animals is mixed at finishing? C: Is stress for finishers minimized/avoided as much as possible?	Ask farmer	Mixing of finishers cause aggression and intensive fighting. This is stressful to the animals and can lead to serious injuries.	3,6	
26	AT	S	Q: When (what state of pregnancy) are gilts integrated in the flock with older sows? Q: Is the group of sows kept stable during pregnancy? (In case of group housing)	Ask farmer	Gilts that are introduced to an already stable flock of older sows can suffer a lot from aggression. Mixing of sows causes aggression. If this is done during implantation of the foetus, reproduction can be negatively affected.	4,1	
27	WQA	S	C: Is stress during pregnancy minimized/avoided as much as possible?	Ask farmer about housing of sows and if groups are kept stable	Pigs naturally live in flocks. To keep pregnant sows in groups increase their welfare. Mixing of groups should be avoided.	4,4	Resource-based
Management of reproduction / breeding & genetic strategies			NO S What proportion of sows is mating with a boar?		Relevance not clear		

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
	NO	S	What proportion of sows receives hormones for heat synchronization?		There are some indications that hormonal interventions may cause welfare problems, but evidence is too weak to include as WQA or even AT		
	NO	S	What criteria do you have to keep a sow in the herd for breeding? (Piglet mortality, litter size, growth rate, even litters etc.)		Welfare relevance not clear		
28	AT	S	Breeding management: Are “good maternal abilities” used as criterion for selection of new breeding animals? (In case of raising own gilts.)	Ask farmer about selection strategies	Selection for good maternal abilities reduces piglet mortality	2,3	
Contact to animals							
	NO		Continuous training of staff? How do you keep staff up to date?				
	AT		How many ‘main stock people’ are on the farm and how constant are the ‘main stockpeople’?		combined with 29		
	AT		Do you often have ‘non-regular’ helpers		combined with 29		
29	AT	S P W F Q	How consistent is personnel and care?	Ask the farmer	Consistency in caretakers enhances the predictability / controllability for the animals and enhances the chance of intensive stockperson-animal contact, problem recognition and solving	3,4	
		S W F	A: Is the behaviour of the stockmen pleasant / unpleasant to the animals when he / she are working inside the pens (cleaning, collecting piglets).	A: Watch the stockmen while they are working inside the pens. Check for consistency. Assess if pleasant / unpleasant.			

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
Problem awareness – problem solving / Maintenance of equipment							
AT	WQA	P	S P W F A: Do drinkers function well and are in good condition?	Check in barn	Combined with nr 47.		
AT	WQA	P	S P W F A: Do feeders function well and are well managed? 1–5	Check in barn	Combined with nr 47.		Animal-based
AT	WQA	P	S P W F C: Is equipment (except drinkers, concentrate feeders) functioning well and in good condition? 1–5	Check in barn	Combined with nr 47.		Animal-based
30	AT	P	S P W F C: Does the farmer recognise and solve problems with failing equipment immediately?	Ask farmer and check in barn	Immediate repair / change of defect housing equipment is important to avoid injuries and welfare problems (guarantee for water provision etc.)	4,6	
Mutilations							
31	WQA	P	C: Is pain due to castration minimized/avoided?	Ask farmer about routines and use of anaesthetics/analgesics. Check records	Castration without anaesthetics is very painful and is thus of great welfare concern.	3,7	
32	WQA	P	Q: What proportion of piglets are teeth clipped/teeth grinded?	Ask farmer	Teeth clipping is very painful and increase the risk of tooth infection and is thus of great welfare concern.	3,5	
33	WQA	P	Is pain due to tail docking minimized/avoided?	Ask farmer about routines and use of anaesthetics/analgesics. Check records	Tail docking is painful and is thus of great welfare concern. Tail biting is a sign of stress due to inadequate management, environment or feeding. Tail docking prevents the possibility to use the pig behaviour as an indicator of stress.	4,0	
Loading on farm/transport							
AT	WQA	P	Q: Does moving of animals between different facilities/units include vehicle transport?	Ask farmer	Combined with nr 51.		
NO	S F	P	Are there loading facilities on farm	Ask farmer and check in house	Special loading facilities can ease loading and reduce stress – but not included because resource-based		Resource-based

TABLE A1.1 CONT. Management and handling practices in pigs – list of measures.

Number of item	WQA / AT	Animal type	Item description and how to assess	Instruction to assessor	Reason to include or disregard; welfare relevance; problems	Score	Links to other sub tasks
	AT		Q: Are preparations taken to minimize stress during loading?		Combined with nr 51. Preparations before loading (e.g. appropriate driving alleys, appropriate lighting, feeding regime, enough time so animal can move at their own pace...) can reduce stress during loading and transport, but it is difficult to assess as situation dependent.		
	AT		Q: Do you use special devices for moving animals (electric prod, stick)?	Ask farmer	Combined with nr 51. The use of electric prods causes stress, reliability may be low.		
	AT		Q: Are single or groups of unfamiliar animals mixed during transport?	Ask farmer	Combined with nr 51. Mixing of unfamiliar animals causes stress and fights		Slaughter
34	WQA		C: Are management routines and logistics for moving of animals between facilities appropriate to minimize stress?	Ask farmer about routines when moving animals.	Moving and transport can be stressful to animals.	3,3	
Farmer satisfaction with his/hers system							
35	AT		Q: How satisfied are you with your current system: From a technical point of view? From a management point of view? From an animal welfare point of view?	Ask farmer	A farmer that is satisfied with his/her work will care more for the animals.	2,3	

TABLE A1.2 Ranking of management and handling practices in pigs regarding welfare relevance.

Rank	Score	Number of item in Table A1.1	WQA / AT	Animal type	Item description and how to assess
1	4,7	22	WQA	SWF	A: Criteria for euthanasia: Are any animals in the herd found to be so sick or injured that they should have been euthanized?
2	4,6	23	WQA	SWF	A: Is competition for food reduced as much as possible? (In case of group housing)
3	4,5	21	WQA	SWF	A: Are obviously sick animals housed in hospital pens?
4	4,4	27	WQA	S	C: Is stress during pregnancy minimized/avoided as much as possible?
5	4,3	10	WQA	S	A: Is it possible for the sow to perform nest building behaviours before farrowing?
6	4,1	17	WQA	Sf	C: Do routines for prevention of shoulder lesions seem appropriate?
6	4,1	2	WQA	S	A: Does the farrowing management strategy seem to avoid problems for the sow?
7	4,0	13	WQA? Difficult to assess?	SPWF	C: Is there evidence for an effective health strategy?
7	4,0	3	WQA	P	Q: At what age are piglets weaned?
7	4,0	4	WQA	SPWF	C: Is the hygiene management of pens sufficient?
7	4,0	33	WQA	P	C: Is pain due to tail-docking minimized/avoided?
8	3,9	7	WQA	SPWF	C: Are cleaning routines for feeders sufficient?
9	3,7	31	WQA	P	C: Is pain due to castration minimized/avoided?
9	3,7	5	WQA	SPWF	C: Are deep beddings well managed? (In case of deep bedded housing system)
10	3,6	6	WQA	SPWF	C: Are cleaning routines for drinkers sufficient?
10	3,6	11	WQA	SPWF	C: Is the provision of litter material sufficient for pigs to perform rooting?
10	3,6	25	WQA	F	C: Is stress for finishers minimized/avoided as much as possible?
11	3,5	32	WQA	P	Q: What proportion of piglets are teeth clipped?
12	3,3	18	WQA	W	C: Are handling strategies for avoiding weaning diarrhoea sufficient in relation to the weaning diarrhoea problems present?
12	3,3	34	WQA	SWF	C: Are management procedures and logistics for moving of animals between facilities appropriate to minimize stress?
13	4,6	30	AT	SPWF	C: Does the farmer recognise and solve problems with failing equipment immediately?
14	4,3	19	AT	WF	C: Is the strategy for handling of tail/ear biting appropriate?
15	4,1	12	AT	SPWF	C: Does prevention of disease through management seem appropriate?
15	4,1	26	AT	S	Q: When (what state of pregnancy) are gilts integrated in the flock with older sows? (In case of group housing)
16	4,0	8	AT	SWF	C: Is the hygiene management of hospital pens sufficient?
16	4,0	15	AT	S	C: Does the claw trimming and checking for lameness seem appropriate?
17	3,6	24	AT	SPWF	C: Do handling strategies and awareness in case of fire or ventilation failure seem appropriate?
17	3,6	9	AT	SWF	C: Are the cleaning routines of hospital pens between batches sufficient?
18	3,4	29	AT	SPWF	C: How consistent is personnel and care?

TABLE A1.2 CONT. Ranking of management and handling practices in pigs regarding welfare relevance.

Rank	Score	Number of item in Table A1.1	WQA/ AT	Animal type	Item description and how to assess
18	3,4	14	AT	SPWF	Q: Is there a special veterinarian linked to the farm that follows the overall health status?
19	3,0	1	AT	P	C: Does the farrowing management strategy seem to avoid problems for the piglets?
20	2,6	20	AT	WF	C: Does care of pigs with hernias seem appropriate?
21	2,5	16	AT	SPWF	A: Are production figures thoroughly recorded and accessible for follow-ups?
22	2,3	28	AT	S	Q: Does the farmer use “good maternal abilities” as a criterion for selection of new breeding animals?
22	2,3	35	AT	SPWF	Q: How satisfied is the farmer with his/her current system?

TABLE A1.3 Assessment tool management and handling practices in pigs.

1	<i>Farrowing management</i> Is the sow provided with extra nesting material before farrowing? No Partly Yes* What nesting material is used straw branches wood shavings other How much is used? kg/sow Are sows kept in crates at farrowing No Yes Does the structure of the nesting material allow the sow to build a structural nest? No Yes => Is it possible for the sow to perform nest building behaviours before farrowing? No 1 2 3 4 5 Yes** * Yes: all sows are provided with extra nesting material partly: not all sows are provided with nesting material. ** Yes: all sows can build structural nests and are loose during farrowing; No: no nesting material is provided 2: sows are provided with nesting material but kept in crates around farrowing 3–4: all sows are loose during farrowing but the material provided is not sufficient or does not allow building of a structural nest (i.e. wood chips).
2	<i>Farrowing management</i> What % of farrowings is supervised?% Are piglets cross fostered? No Yes Is a suitable microclimate accessible for the newborn piglets? (Appropriate air/floor temperature or thick bedding)? No Yes => Does the farrowing management strategy seem to avoid problems for the piglets? No 1 2 3 4 5 Yes* * Yes: high % of supervision, pigs cross fostered routinely.
3	<i>Farrowing management</i> What % of sows is loose housed during farrowing? % What % of sows is treated with oxytocin during farrowing? % by routine only in case of long birth intervals What % of sows is treated with oxytocin after farrowing is finished? % by routine only in case of MMA => Does the farrowing management strategy seem to avoid problems for the sow? No 1 2 3 4 5 Yes
4	<i>Piglet handling</i> => What proportion of piglets are teeth clipped? % => What proportion of piglets have teeth ground? %
5	<i>Castration of piglets</i> How many male piglets are castrated? % check in barn When is castration performed? age Is analgesia used during the procedure? No Yes check records Is anaesthetics used during the procedure? No Yes check records => Is pain due to castration minimized/avoided? No 1 2 3 4 5 Yes* * Yes: no castration performed; No: castration performed without anaesthetics/analgesics.
6	<i>Tail docking of piglets</i> How many pigs are tail-docked? % check in barn When is tail docking performed? Age Anaesthetics No Yes check records Analgesics No Yes check records => Is pain due to tail-docking minimized/avoided? No 1 2 3 4 5 Yes * Yes: no tail-docking; no: tail-docking performed without anaesthetics/analgesics.
7	<i>Weaning of piglets</i> => At what age are piglets weaned? days (see also question about weaning diarrhoea)

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

8	<i>Mixing of pigs</i> What proportion of pens with finisher pigs has had an intact group composition since weaning? % of pens with intact group composition Are pigs from more than one farm/unit mixed in the same batch for fattening? No Yes, no. of farms/units Are pigs transported by vehicle for fattening? No Yes, distance km => Is stress for finishers minimized/avoided as much as possible? No 1 2 3 4 5 Yes* * Yes: high % intact group composition, animals from only one farm/unit in the same batch, no vehicle transport; No: low % intact group composition, animals from more than 3 farms/units mixed in the same batch, long distance vehicle transport
9	<i>Mixing of pigs</i> Are sows loose housed and kept in groups during pregnancy? No Yes Is the group composition of sows kept stable during pregnancy? No, it changes times Yes NA => Is stress during pregnancy minimized/avoided as much as possible? No 1 2 3 4 5 Yes* * Yes: pregnant sows kept in groups. The group composition is kept stable from weaning until farrowing; No: pregnant sows are not kept in groups; 2–4: pregnant sows are kept in groups but group composition changes one to several times during pregnancy.
10	<i>Moving of animals</i> Are preparations taken to minimize stress during moving of animals? No 1 2 3 4 5 Yes* Do you use special devices for moving animals (electric prod, stick)? No Yes, ... is used Does moving of animals between different facilities include vehicle transport? No Yes, animal type distance km animal type distance km animal type distance km Are unfamiliar animals mixed during transport? No Yes (animals from different pens/batches) => Are management procedures and logistics for moving of animals between facilities appropriate to minimize stress? No 1 2 3 4 5 Yes** * Yes: appropriate driving alleys, suitable lighting, animals driven in groups at their own pace. ** Yes: preparations are done to minimize stress, no use of electric prodders or hitting with sticks, no vehicle transport.
11	<i>Introduction of gilts</i> => When (what state of pregnancy) are gilts integrated in the flock with older sows? (in case of group housing) ☐ before insemination ☐ when pregnant weeks before farrowing NA ☐ during lactation ☐ after weaning of first litter
12	<i>Breeding management</i> => Are 'good maternal abilities' used as a criterion for selection of new breeding animals? No Yes NA

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

13	<i>Provision of litter material</i> How often and how much do you litter the lying area? Piglets/times per day/week, ... kg/pig/day/week, ... no litter is used, ... pigs kept on deep bedding Weaners/times per day/week, ... kg/pig/day/week, ... no litter is used, ... pigs kept on deep bedding Finishers/times per day/week, ... kg/pig/day/week, ... no litter is used, ... pigs kept on deep bedding Sows/times per day/week, ... kg/pig/day/week, ... no litter is used, ... pigs kept on deep bedding => Would you assess the provision of litter material sufficient for pigs to perform rooting? No 1 2 3 4 5 Yes* * Yes: Pigs kept on deep bedding, alternatively new litter provided every day, enough for all pigs in the pen to root in for several hours; No: if no litter is used; 2–4: depending on how often litter is given and how long time it keeps the pigs occupied with rooting.																																																						
14	<i>Feeding management</i> Study weaners, finisher and group housed sows during feeding. Is it possible for all pigs to eat at the same time (sufficient trough space)? Is aggression level low or high? Are low ranked animals driven away by high ranked animals? <table border="1"> <thead> <tr> <th></th> <th colspan="3">Sufficient trough space*</th> <th colspan="3">Aggression level</th> <th colspan="2">Low ranked animals driven away</th> </tr> <tr> <th></th> <th>No</th> <th>Yes</th> <th></th> <th>low</th> <th>medium</th> <th>high</th> <th>No</th> <th>Yes</th> </tr> </thead> <tbody> <tr> <td>Weaners</td> <td>No</td> <td>Yes</td> <td></td> <td>low</td> <td>medium</td> <td>high</td> <td>No</td> <td>Yes</td> </tr> <tr> <td>Finishers</td> <td>No</td> <td>Yes</td> <td></td> <td>low</td> <td>medium</td> <td>high</td> <td>No</td> <td>Yes</td> </tr> <tr> <td>Lactating sows</td> <td>No</td> <td>Yes</td> <td></td> <td>low</td> <td>medium</td> <td>high</td> <td>No</td> <td>Yes</td> </tr> <tr> <td>Pregnant sows</td> <td>No</td> <td>Yes</td> <td></td> <td>low</td> <td>medium</td> <td>high</td> <td>No</td> <td>Yes</td> </tr> </tbody> </table> => Is competition for food reduced as much as possible? Weaners No 1 2 3 4 5 Yes** Finishers No 1 2 3 4 5 Yes** Pregnant sows No 1 2 3 4 5 Yes** Lactating sows No 1 2 3 4 5 Yes** * If feeding can not be observed then measurements are possible. Recommended trough space: minimum 21cm/pig at 25 kg; min. 34 cm/pig at 95 kg; 34 cm +2cm per 10 kg if above 95 kg. ** Yes: trough space is sufficient, low level of aggression observed during feeding, group housed sows are locked in separately in feeding crates with solid walls where the head is placed during feeding; No: trough space insufficient, group housed sows fed in troughs without any separating walls, high level of aggression observed during feeding; 2–4: trough space insufficient, group housed sows fed in troughs but partly separated by solid walls where the head and shoulder is placed.		Sufficient trough space*			Aggression level			Low ranked animals driven away			No	Yes		low	medium	high	No	Yes	Weaners	No	Yes		low	medium	high	No	Yes	Finishers	No	Yes		low	medium	high	No	Yes	Lactating sows	No	Yes		low	medium	high	No	Yes	Pregnant sows	No	Yes		low	medium	high	No	Yes
	Sufficient trough space*			Aggression level			Low ranked animals driven away																																																
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Finishers	No	Yes		low	medium	high	No	Yes																																															
Lactating sows	No	Yes		low	medium	high	No	Yes																																															
Pregnant sows	No	Yes		low	medium	high	No	Yes																																															
15	<i>Use of hospital pen</i> => Are obviously sick animals* housed in hospital pens? No Yes * Animals with severe disease have difficulties to get access to food a.o., e.g. high-grade lame animals, very weak animals. This question covers management practices but also concerns animal-based measures.																																																						
16	<i>Criteria for euthanasia</i> When do you euthanize an animal in your herd? Only after recommendation from a veterinarian If medication or other treatment does not help If the animal isn't believed to survive Other => Are any animals in the herd found to be so sick or injured that they should have been euthanized? No Yes																																																						

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

17	<i>Prevention of disease</i> Is an all-in-all-out strategy employed? <table border="0"> <tr> <td>Farrowing unit</td> <td>No</td> <td>Yes</td> <td colspan="3"></td> </tr> <tr> <td>Weaners</td> <td>No</td> <td>Yes</td> <td colspan="3"></td> </tr> <tr> <td>Finishers</td> <td>No</td> <td>Yes</td> <td colspan="3"></td> </tr> </table> Are pigs from different farms/units mixed in the same batch? <table border="0"> <tr> <td>Farrowing unit</td> <td>No</td> <td>Yes</td> <td colspan="3">..... no. of farms/units</td> </tr> <tr> <td>Weaners</td> <td>No</td> <td>Yes</td> <td colspan="3">..... no. of farms/units</td> </tr> <tr> <td>Finishers</td> <td>No</td> <td>Yes</td> <td colspan="3">..... no. of farms/units</td> </tr> </table> Are slow growing individuals sometimes moved to a batch with younger animals? No Yes Are all purchased animals (i.e. boars, gilts) kept in quarantine before they are introduced in the herd? No Yes Are the pens cleaned (high pressure), disinfected and dried between every batch of animals? Days empty between <table border="0"> <tr> <td></td> <td></td> <td>Cleaned</td> <td></td> <td>Disinfected</td> <td></td> <td>Cleaning and new batch</td> </tr> <tr> <td>Farrowing unit</td> <td>No</td> <td>Yes</td> <td>No</td> <td>Yes</td> <td></td> <td>..... days</td> </tr> <tr> <td>Weaners</td> <td>No</td> <td>Yes</td> <td>No</td> <td>Yes</td> <td></td> <td>..... days</td> </tr> <tr> <td>Finishers</td> <td>No</td> <td>Yes</td> <td>No</td> <td>Yes</td> <td></td> <td>..... days</td> </tr> <tr> <td>Breeding facility</td> <td>No</td> <td>Yes</td> <td>No</td> <td>Yes</td> <td></td> <td>..... days</td> </tr> <tr> <td>Pregnant sows</td> <td>No</td> <td>Yes</td> <td>No</td> <td>Yes</td> <td></td> <td>..... days</td> </tr> <tr> <td>Quarantine</td> <td>No</td> <td>Yes</td> <td>No</td> <td>Yes</td> <td></td> <td>..... days</td> </tr> </table> Are disinfecting agents stored on the farm? No Yes => Does prevention of disease through management seem appropriate? No 1 2 3 4 5 Yes* * Yes: all-in-all-out is employed and no mixing of animal from different farms/units or different age in the same batch, cleaning and empty days for drying sufficient, purchased animals kept in quarantine before introduction; No: all-in-all-out not employed, no quarantine for purchased animals, pigs from more than 3 farms/units mixed in the same batch.						Farrowing unit	No	Yes				Weaners	No	Yes				Finishers	No	Yes				Farrowing unit	No	Yes	 no. of farms/units			Weaners	No	Yes	 no. of farms/units			Finishers	No	Yes	 no. of farms/units					Cleaned		Disinfected		Cleaning and new batch	Farrowing unit	No	Yes	No	Yes		 days	Weaners	No	Yes	No	Yes		 days	Finishers	No	Yes	No	Yes		 days	Breeding facility	No	Yes	No	Yes		 days	Pregnant sows	No	Yes	No	Yes		 days	Quarantine	No	Yes	No	Yes		 days
Farrowing unit	No	Yes																																																																																									
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Quarantine	No	Yes	No	Yes		 days																																																																																					
18	<i>Prevention of weaning diarrhoea</i> What strategies are used to prevent weaning diarrhoea? ☐ Piglets are offered creep feed during lactation ☐ Extra heating provided at weaning (heat lamp, floor heating, roofs) ☐ Weaning performed late rather than early within the time span of 3–6 weeks ☐ Piglets are restrictively fed during the first days after weaning ☐ Zinc is routinely administered in the feed to weaners ☐ Antibiotics is routinely administered in the feed to weaners ☐ Other What proportion of the litters is kept intact after weaning?% of pens with intact litters Are piglets transported by vehicle at weaning? No Yes Are piglets from more than one farm/unit mixed in the same batch after weaning? No Yes, no. of farms/units How common is weaning diarrhoea? Check for signs of diarrhoea in weaners. Check records for treatments => Are handling strategies for avoiding weaning diarrhoea in piglets sufficient in relation to the weaning diarrhoea problems present? No 1 2 3 4 5 Yes* * Yes: weaning diarrhoea is prevented without need of zinc or antibiotics, handling routines at weaning minimize the stress (late weaning age, creep feed during lactation, extra heating, intact litters, restrictive feeding); No: weaning diarrhoea is prevented due to administration of zinc or antibiotics in the feed.																																																																																										

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

19	<i>Prevention of tail and ear biting</i> If tail/ear biting occurs, what strategy is there to handle the situation? ☐ Provide extra litter material in the pens ☐ Check if something in the stable environment is not functioning (ventilation, temperature, draft) ☐ Check if feeding equipment/feed rations are OK ☐ Tries to identify and move the ‘biter’ ☐ Aggression during feeding due to lack of feeding space is minimized ☐ Treatment of bitten animals ☐ Piglets are tail docked ☐ Other How often do tail/ear biting occur? every week every month times a year Do you have problems with this right now? No Yes Are newly tail/ear bitten animals observed in the herd? No Yes Has the farmer tried to solve this problem? No Yes => Is the strategy for handling of tail biting appropriate? No 1 2 3 4 5 Yes* * Yes: tail/ear biting is treated/prevented by minimizing the stress for the animals (extra litter, check ventilation, temperature, draft, feeding device, feed rations); No: tail biting is treated/prevented by tail docking of piglets.
20	<i>Prevention of shoulder lesions</i> How are shoulder lesions prevented? ☐ Tries to avoid the sows getting too thin, especially at farrowing ☐ Sows developing shoulder lesions are routinely slaughtered ☐ Crated sows are not kept on fully slatted floors ☐ Extra straw is provided at farrowing to give a soft flooring to lay upon ☐ Rubber mats are supplied to farrowing sows to reduce the pressure impact ☐ Other ☐ No special routines are performed Observe one batch of sows around weaning. How many sows have developed shoulder lesions? of sows days after farrowing => Do routines for prevention of shoulder lesions seem appropriate? No 1 2 3 4 5 Yes* * Assessment from farmers question and impression of the herd. Related to animal-based measures.
21	<i>Claw health strategies</i> How often are animals checked for lameness? When are claws trimmed? regularly only if visibly too long horn only if lame due to claw problems Are untreated lame animals found in the herd? No 1 2 3 4 5 Yes Are animals with visibly too long claws found in the herd? No 1 2 3 4 5 Yes => Does the claw trimming and checking for lameness seem appropriate? No 1 2 3 4 5 Yes* * Yes: if results in good claw health and no lameness.
22	<i>Care of pigs with hernia</i> How are pigs with hernias taken care of? ☐ Euthanized ☐ Put in hospital pen ☐ No special routines ☐ Other Do animals with hernias kept in the flock seem to be retarded in growth or vitality? No Yes => Does care of pigs with hernias seem appropriate? No 1 2 3 4 5 Yes* * Yes: if actions are taken when necessary.

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

23	<i>Farm health strategy</i> How would you assess your own health strategy? Bad 1 2 3 4 5 Good Do you think there is room for improvement? No 1 2 3 4 5 Yes How quickly do you react when an animals starts to get ill? waiting a while 1 2 3 4 5 6 treat immediately Are untreated sick animals found in the herd? No 1 2 3 4 5 Yes => Is there evidence for an effective health strategy? No 1 2 3 4 5 Yes* * Assessment from farmers question and impression of the herd; could be checked at the end, compared with animal-based health measures. Difficult to assess?
24	<i>Health supervision</i> => Is there a special veterinarian linked to the farm that follows up the overall health status? No Yes
25	<i>Hygiene management of drinkers</i> How often do you check cleanliness of drinkers? times/day/week/month How often do you clean drinkers thoroughly? every day/week/month Are drinkers clean? No Partly Yes* => Are cleaning routines for drinkers sufficient? No 1 2 3 4 5 Yes** * No: drinkers not cleaned, dirty & water is dirty at moment of inspection; Partly: drinkers dirty (old dirt) – but water fresh and clean at moment of inspection OR only part of several drinkers clean, with clean water; Yes: drinkers clean & water clean at moment of inspection (some amount of fresh food allowed). ** Yes: if results in clean drinkers.
26	<i>Hygiene management of feeders</i> How often do you check cleanliness/clean the feeders/troughs? every day/week not checked regularly How often do you check cleanliness of /clean the mixing tank? every day/week not checked regularly NA Are feeders/troughs clean? No Partly Yes* Are the feed mixing tank clean (in case of liquid feeding) No Yes** NA => Are cleaning routines for feeders sufficient? No 1 2 3 4 5 Yes*** * No: old feed, dung, dirt, no regular cleaning of trough; Partly: no regular cleaning, but feed trough found to be clean; Yes: trough checked/cleaned frequently, no dirt or old feed rests. ** No: old feed rests and mould found on the walls inside the tank, no regular cleaning; Yes: regular cleaning performed, tank clean from mould at inspection; NA: liquid feeding not present. *** Yes: if results in clean feeders and clean mixing tank.
27	<i>Hygiene management of pens</i> How often do you clean the lying area in the pen?/times per day/week only when needed Are pens sufficiently clean and dry? Lactating sows/piglets No 1 2 3 4 5 Yes Weaners No 1 2 3 4 5 Yes Finishers No 1 2 3 4 5 Yes Sows No 1 2 3 4 5 Yes => Would you assess the hygiene management of pens sufficient? No 1 2 3 4 5 Yes* * Yes: if results in dry, clean, lying areas; use 1–5 to describe if dry and clean lying areas are found in all or few pens.

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

28	<i>Hygiene management of deep beddings</i> How often is fresh straw provided in deep beddings? times a week NA How much straw is used? Lactating sows/piglets kg/pig/week, month, year* Weaners kg/pig/week, month, year* Finishers kg/pig/week, month, year* Sows kg/pig/week, month, year* Are deep beddings clean and dry? Lactating sows/piglets No Partly Yes** Weaners No Partly Yes Finishers No Partly Yes Sows No Partly Yes => Are deep beddings well managed? No 1 2 3 4 5 Yes*** NA * Recommended amounts: finishers–weaners: 1 kg straw/kg growth per pig; pregnant sows: 3 kg/day and sow; lactating sows: 5 kg/day and sow. ** Yes: more than 75% of the bedding area is clean and dry; Partly: 25–50% of the bedding area is dirty and wet; No: more than 50% of the bedding is dirty and wet. *** Yes: if results in clean and dry beddings.			
29	<i>Hygiene management of hospital pens</i> How often do you clean the hospital pen on daily basis? /times per day/week only when needed Is hospital pen in use and clean and dry? No 1 2 3 4 5 Yes => Would you assess the hygiene management of hospital pens sufficient? No 1 2 3 4 5 Yes			
30	<i>Cleaning of hospital pens between batches</i> Do you clean and disinfect hospital pens after use and how? clean (high pressure) disinfect No Yes No Yes Do empty hospital pens look cleaned? No Yes Are disinfecting agents stored on the farm No Yes => Would you assess the cleaning routines of hospital pens between batches sufficient? No 1 2 3 4 5 Yes* * Yes: if high-pressure cleaned and disinfected; No: if both not.			
31	<i>Keeping of records</i> => Are production figures thoroughly recorded and accessible for follow-ups? Disease No Yes Treatment/medication No Yes Losses incl. causes No Yes Production No Yes			
32	<i>Handling strategies in case of fire or ventilation/power failure</i> Is there an evacuation plan in case of fire? No Yes Is there any alarm system installed in case of ventilation/power failure? No Yes Are working staff familiar with handling routines in case of fire and ventilation/power failure? No Yes => Does handling strategy and awareness in case of fire or ventilation failure seem appropriate? No 1 2 3 4 5 Yes			
33	<i>Farmer's satisfaction</i> How satisfied are you with your current system? From a technical point of view Satisfied.....Not satisfied From a management point of view Satisfied.....Not satisfied From an animal point of view Satisfied.....Not satisfied			
34	<i>Consistency of personnel</i> Number of stockpeople working regul. with the animals: person(s) for animals How often do caretakers change? every year/month Do you have 'non-regular' helpers taking care of the animals No Yes => Is personnel and care consistent? No 1 2 3 4 5 Yes* * Yes: if low number of stock people (but enough to take care), and very low frequency of change.			

TABLE A1.3 CONT. Assessment tool management and handling practices in pigs.

35	<i>Farmer awareness of failing equipment</i>	
	Are all drinkers functioning at the moment?	No Yes
	Are all feeders functioning at the moment?	No Yes
	Is there any defect equipment in the barn at the moment?	No Yes
	if yes: what equipment? since when? days/weeks/months	
	Is water flow sufficient in drinkers?	No 1 2 3 4 5 Yes
	(recommended water flow is 3–4 l/min for adult pigs)	
	Risk for injuries at drinker?	No 1 2 3 4 5 Yes
	Do feeders function well?	No 1 2 3 4 5 Yes
	(concentrate distributed in the pre-set amount, no loss of concentrate)	
	Risk for injuries at feeding?	No 1 2 3 4 5 Yes
	Is there any other equipment not functioning or with risk of injuries?	No 1 2 3 4 5 Yes
	(e.g. broken iron rod)	
	=> Does the farmer recognise and solve problems with housing equipment immediately?	No 1 2 3 4 5 Yes*
	* Yes: if farmer awareness of failing equipment is high and actions are taken to solve the problems; No: if farmer does report to have no defect, but obvious defects are found.	

Notes: Instructions for using the questionnaire: **Questions that are in blue** are intended to be assessed in the barn; Questions that should feed into the **Assessment score have a gold coloured background**; Other questions for Advisory tool or epidemiological study; Mark NA if question not appropriate to housing system.

A1.5 ASSESSMENT OF HANDLING – AMOUNT AND QUALITY OF HUMAN–PIG INTERACTIONS

The amount and especially the quality of human-animal interaction influences animal welfare by influencing the amount of stress, with potential consequences on health, and risk of injuries. In case, no animal-based measure of the human-animal relationship is included, some (simple) management-based assessment of the quality of human-animal interactions may be included. Three possibilities exist which may, at least initially, be combined.

1. Observation during routine handling

This is reliable in pigs during handling of piglets (castration, teeth grinding etc.) It is also possible to observe when the farmer/caretaker enters pens for daily inspection and cleaning. If possible moving of animals should be observed because then aversive interactions can be detected. This is however not performed so often.

Validity: high; reliability: high; feasibility: low to medium

2. Questions on the frequency of use of special types of behaviour

This would be a short questionnaire, which all stock people having regular contact with the animals would have to fill in.

How often do you:

Talk to animals when approaching them	Never 1 2 3 4 5 6 7 Always
Talk to animals when walking through the group	Never 1 2 3 4 5 6 7 Always
Gently touch or stroke animals when close	Never 1 2 3 4 5 6 7 Always
Wave with the hand to move them	Never 1 2 3 4 5 6 7 Always
Hit animals with the hand to move them	Never 1 2 3 4 5 6 7 Always
Shout at animals to make them move	Never 1 2 3 4 5 6 7 Always
Shout at animals to make them stop walking or stop kicking	Never 1 2 3 4 5 6 7 Always
Use a stick to move them by visual signs	Never 1 2 3 4 5 6 7 Always
Use a stick to move them by (slightly) hitting	Never 1 2 3 4 5 6 7 Always
Use a stick to make them stand up	Never 1 2 3 4 5 6 7 Always

Validity: not known, estimated: medium; reliability: medium (test-retest) to high (inter-observer), but problem with reliability if the measures should feed into WQA since at least from the second visit the farmers should know what is wanted; feasibility: high.

3. Simple observational protocols for a rough assessment

During the inspection the assessor should stand close to the animals when discussing with the stockperson(s) for at least 10 min (e.g. while filling in the management questionnaire) and during that time should additionally observe the behaviour of the farmer and note if the farmer / stockperson uses

- Gentle interactions vocal (softly talking to)
never occurred 1_____ 10 often occurred
- Gentle interactions tactile (gently touching, stroking animals)
never occurred 1_____ 10 often occurred
- Aversive interactions (hitting, kicking, shouting)
never occurred 1_____ 10 often occurred
- Intermediate interactions (pushing animals away with low force, very slight hit, dominant talking to animals to make them stop behaviours)
never occurred 1_____ 10 often occurred
- The relation of gentle to aversive
from 0 only gentle 1_____ 10 only aversive
(with 50% of both in the middle)
- Carefulness / suddenness of movements from
sudden movement always 1_____ 10 always careful, quiet movement

Validity: not know – estimated to be medium; reliability: medium; feasibility: high.

APPENDIX 2

STANDARDISATION OF RESOURCE-BASED PARAMETERS TO ASSESS THE WELFARE STATUS OF PIGS

M.B.M. Bracke and H.A.M. Spoolder

A2.1 SUMMARY

This paper identifies resources for pigs, i.e. environment-based factors affecting pig welfare, while excluding management- and record-based parameters. Lists of resources have been described for both on-farm rearing conditions and for ‘transport and slaughter conditions’. On-farm parameters include general information (such as breed of pigs, age, etc), density, flooring/bedding, ventilation system and dust and other resources such as environmental enrichment, feeding and water system, social conditions and provisions for health care. The ‘transport and slaughter section’ is discussed in an on-farm part (e.g. preparation for transport, holding areas, passageways, ramps and parameters related to the transport vehicle) and an abattoir part (slaughter facilities). Since the area covered is considerable, making it impossible to provide a detailed literature review, the validity, reliability and feasibility of the resource-based parameters have been subjectively assessed by the authors and a small group of expert advisors. The document resulted from repeated upgrading of different versions of the paper based on comments received from expert advisors who independently worked on the text. It attempts to be complete (i.e. classify all relevant resources for pigs) and proposed solutions for the standard collection of the relevant environment-based on-site information to assess pig welfare. The document contains two parts, one on resource-based measures in pigs and the other related to decision transparency. This later part is mainly specified in the methods section.

A2.2 INTRODUCTION

Within Welfare Quality® sub-project 2 will develop monitoring systems for animal welfare based on both on animal parameters and design parameters of both the on-farm and transport & slaughter phases of the life of the pigs. As part of this task, an activity was started to standardise resource-based measures for pigs, i.e. environment-based design criteria for overall welfare assessment.

Available resources include the housing system, floor space, ventilation system, feeding and watering, lighting, temperature control, foraging substrate, bedding and social conditions (group size, composition and stability) for the on-farm period, and e.g. (loading) facilities, vehicle design and stunning equipment for the transport and slaughter periods. Pig production systems vary widely and the influences of the environment in which the animals live are often key to the outcomes of the animal-based measures which will form the backbone of the Welfare Quality® assessment scheme. Existing ‘records’, farm records kept by producers and the immediate ‘record’ available by questioning stockmen on their management (use of resources), may provide useful data, but it is likely that more direct assessment of resource-based measures provides more reliable information. The animal-based measures have been proposed as key to Welfare Quality®, but for proper welfare assessment resource-based measures (in a wide sense, including management-based measures) must be taken for several possible reasons: Firstly, resource-based measures may be necessary for the proper interpretation of what animal-based measures mean for welfare, and, secondly, resource-based measures may fill in the gap where animal-based measures fail (because they are not valid, not reliable and/or not feasible within the constraints of the welfare assessment system). In such cases scientific information concerning how resources relate to welfare performance can be used to solve the problem.

Up to now a number of welfare assessment schemes (e.g. TGI and Freedom Foods) and most legal welfare regulations have been using (lists of) resource-based measures. For the purpose of overall welfare assessment at the European level, however, a standardised list remains to be formulated that can be used not only for (the research purposes of) Welfare Quality, but more widely for gathering the relevant environment-based information to assess the welfare status of pigs during housing, transport and slaughter for the purpose of both scientific study and for the purpose of ethical and political decision making. This information needs to be practicable/operational for on-farm use and reflect a substantial degree of consensus among welfare scientists.

The objectives of this work were to determine

- a. which resource-based measures should be proposed for inclusion in the monitoring scheme;
- b. how valid, reliable and feasible participating experts believe these measures are;

- c. how the most promising resource-based measures are to be operationalised, including the provision of work instructions regarding the collection of accurate and reliable resource availability and use.

Since other projects are dealing with management-based parameters, these will not be considered in detail in this document. Objective c could not fully be met in this project, because it turned out to be inappropriate to make a required fundamental decision within the scope of this work. When conducting this work, it soon turned out that there were very many potentially relevant resource-based measures, and that it would be impossible to record them all in great detail within the total time available to conduct an audit. The choice therefore would be to record fewer parameters in more detail or more parameters with less detail. For example, when the parameter 'space per pen' is to be recorded in great detail (to the exact cm²), it requires much more time in the audit compared to recording the same parameter in to 2 levels (above/below a specified cut-off point, e.g. a legal requirement). This saves time because in most cases measures with few levels (separated by an inherently somewhat arbitrary cut-off point) can mostly be taken with 'clinical judgement' that does not require time-consuming detailed measurements. This trade-off between specificity and feasibility exists not only for resource-based measures, but also for animal-based measures.

The report contains two parts:

1. The factors described have been combined by a consensus of the work partners to provide a practical tool for assessing resource-based measures in pigs and a description of how these can be used.
2. A short report outlining how the decisions on the method were derived has been produced to ensure transparency of the process.

A2.3 METHODS

The focus is on the formulation of a practicable list of resources for which there is (can be presumed to be) consensus among (welfare) scientists. Issues that raise points of (scientific) debate were avoided.

The areas covered by the work as stated in the original assignment included:

- 'On farm', which includes density, flooring/bedding, available resources, ventilation system, dust);
- 'Loading/unloading', which includes design of handling facilities, loading ramps, transport vehicle, transport time, time to slaughter;
- 'Slaughter facilities', which includes equipment used for slaughter.

With these constraints in mind ‘resource-based parameters’ in this paper were (rather narrowly) defined as those welfare-relevant measures that pigs need for welfare, but (largely) excluding social conditions such as mixing (as these can be considered to be animal-based and management-based parameters), and excluding important aspects of management such as stockmanship, handling and health care. Note, however, that while animal-based and management based aspects were excluded (of e.g. handling and health care), the facilities for these practices (e.g. sick pens and handling facilities such as raceways and loading ramps) were included as ‘resources’ in this document.

A first draft of text was prepared by the first author and this text was submitted to the experts from which we received replies: H. Vermeer (NL), E. Lambooij (NL), E. von Borell (DE), S. Edwards (UK), L. Keeling (SE, work package 2 subproject leader), H. Spoolder (NL), A. Velarde (ES), P. Barton Gade (DK). The text was upgraded based on the comments of the first expert and then sent to the second expert, and so on. As a result the final paper is the product of input from all contributors. However, it should be noted that in later stages changes have been made based on received comments, while these changes may not have been evaluated by earlier reviewers, even though the final draft was made available to all contributors.

In the course of the project different issues received more close attention. One aspect was to attempt uniformity across species. This issue was addressed by requesting (and receiving) information from the other groups (working on poultry and cattle) and by sending early drafts of our work to those groups. Another issue concerned specifying cut-off points. It was realised that cut-off points are inherently somewhat arbitrary and problematic from a scientific point of view. Since the starting document for the transport and slaughter section contained specified cut-off points, the experts involved in that phase of work were asked for their opinion on the issue of whether cut-off points should be listed or whether the description ought to be kept more objective (as was done for the original on-farm section). It was decided that both approaches were valuable, as it relates to the fundamental decision (addressed above) on the trade-off between specificity and feasibility of the parameters. This issue, too, was raised as a topic to the participating advisors. The discussions resulted in a mixed approach, where this paper attempted to address main issues and left decisions for the subsequent group deciding on the final protocol for pigs.

For the first draft and later upgrading we used as primary sources of information the EU legislation on pigs, existing EU reports (SVC, 1997, SVC, 2002, EFSA 2004, EFSA, 2005), a report on transport and slaughter (Lambooij, 2004) and a draft of the now published book of COST 846, *Measuring and Monitoring of Farm Animal Welfare*, Subworking Group Pigs, Velarde et al., 2006). In the sections below the different resource-based measures are first identified (and listed hierarchically) for the farm, loading/unloading and slaughter phase respectively. For each phase the measures are specified/defined and they are evaluated in more detail under the headings ‘validity’ (V), ‘reliability’ (R) and ‘feasibility’ (F). Each heading is scored on a 5 point scale ranging from least to most. So when the item ‘floor area’ contains the code ‘V 5’, this means that the validity (V) is scored subjectively (on average) by the experts participating in this project as ‘5’, i.e. best validity relative to most other resource-based measures. Under the

heading ‘validity’ we describe in what way the measure contributes to welfare, i.e. what are the costs (risks) and benefits for welfare. This also includes a specification of the age groups for which the measure is/is not relevant and so-called critical windows (i.e. specific moments/times in which the measure should be taken). Under ‘reliability’ we describe the degree to which assessors can determine in a ‘reliable’ way, including both inter- and intra-observer reliability. Under ‘feasibility’ we describe the extent to which taking the measure requires time, expertise or money (e.g. specialised equipment), and how a problematic measure may be made more feasible (e.g. by specifying cut-off points for welfare). The main references are specified per section.

The section on ‘transport and slaughter’ covers ‘Loading/unloading’, which was originally formulated to include ‘design of transport vehicle, transport time, time to slaughter’) and ‘slaughter facilities’, which included ‘equipment used for slaughter’.

The lists in the section ‘Transport and slaughter’ were initially taken from Lambooij (2004), and supplemented with other information. The lists were subsequently integrated with the format used for the on-farm section, esp. with respect to the objectivity of the description and the specification of cut-off points. Many elements listed in the transport and slaughter section have correlates in the on-farm section, e.g. ventilation system, environmental temperature, space, etc. It was decided to discuss in later sections, e.g. in the ‘Transport and slaughter’ section only issues specific to this phase of the animal’s life, and it was assumed that the principles described in the earlier (on-farm) section also apply for transport and slaughter, unless specified otherwise.

A2.4 RESULTS

ON FARM

See e.g. EFSA 2005, Hoy et al. (2004) and Von Borell et al. (2001).

Resource-based measures to be collected ‘on farm’ included (using the specific wording in the task description) ‘density, flooring/bedding, available resources, ventilation system and dust’. From this wording it was decided to construct sections for the main resources (including space (m² and m³), flooring/bedding and air quality (ventilation system/dust) and for ‘other resources’ (which include other enrichment materials/toys, feeding and watering systems, sick pens, and resources for managing social conditions such as pens for mixing groups of pigs). Excluded resources were social conditions per se and the provision of food, water and health care, in as far as these are either ‘animal-based’, ‘records-based’ or ‘management-based’, as these aspects are covered in separate subprojects. Before discussing welfare-relevant resource-based parameters, however, a short section addressed

‘general information’ to be collected from the farm. The on-farm section ends with a brief section on how to deal with variability (which provides a starting point for a discussion, which could not be solved in this project).

General Information

Type of pig (dry sows, lactating sows, weaners, growers, fatteners, etc.)

Breed

Age/body weights/start date of the pigs (in the pen/unit) This information may not always be available on farms, except in general terms.

Layout of the buildings, units, pens on the farm. Of particular importance with respect to resources of pigs is to specify the animal’s environments, i.e. their enclosure/pen. A drawing and/or picture of a pen could sometimes say more than 1000 words. Included in the pen layout could be pen dimensions, partitions, types of floor and position of the feeder, watering points and other pen fittings (e.g. toys, straw rack, scratch post, etc). This information may be collected on the first visit to the farm, while subsequent visits only need to take note of any changes.

Group size (the number of pigs per pen/enclosure). (Note that ‘group size’ is also a resource-based welfare parameter in the category ‘social conditions’.)

This general information may not be ‘resource-based’ per se, but provides the context for the interpretation (and sometimes derivation) of the other resource-based measures. For example, pen dimensions and floor-type dimensions are used to calculate the available space and dimensions of functional areas.

Density

See EFSA report 2005, COST chapter B. Horning, and EU legislation.

Floor area per pen This is the total space or surface per pen, where a ‘pen’ is defined as the enclosure in which the animals live and have permanent access to (e.g. an outdoor area would be included under ‘pen-area’ if the animals have free access to it). Additional spaces, to which animals have access only part of the time, may have to be listed separately.

V 4 Space is a necessary, but not sufficient condition for different elements of behaviour and welfare. As a general rule, the more space the better for welfare, as more space tends to imply less behavioural restrictions and better space quality.

R 5

F 5 Taking pen dimensions may be done at the first farm visit, even perhaps by the farmer, and then kept in the farm record file, so it doesn’t have to be repeated every farm visit.

Floor area per pig This measure is calculated from floor area per pen and group size.

V 4 Space is a necessary, but not sufficient condition for different elements of behaviour and welfare. As a general rule, the more space the better for welfare, as more space tends to imply less behavioural restrictions and better space quality. Since the pigs in a pen share the available space per pen, in larger groups of pigs lower amounts of space per pig may suffice. As a minimum norm space allowances should be in accordance with legal requirements/SHVO (Hoy et al. 2004).

R 5

F 5

Scaling factor (k) The scaling factor is calculated from the floor area per pig (A) and body weight (W), with the formula $A=kW^{2/3}$ (EFSA, 2005, p 17).

V 5 Space requirements for different behaviours (including resting in a recumbent position when it is hot, resting sternally, stretching, turning around and performing agonistic behaviours) depend on the size of the pigs. According to the EFSA (2005) report on space allowances for pigs the scaling factor is the more appropriate expression of space provided to pigs, and it proposes that future research should use the scaling factor as an expression of space provision for pigs.

R 3 On most farms the weight of the pigs will not be known. Perhaps, a rough estimate could be made from average weight gain figures (if age were known) or by 'clinical' judgement in relation to specified cut-off points (e.g. whether the available space allows simultaneous recumbent resting, i.e. all animals lying flat on their sides). This would also improve feasibility.

F 3

Moving pigs Moving pigs from one pen to another within one farm. This is a management-based parameter that is dealt with below in the transport and slaughter section. It may also affect other parameters e.g. floor area per pen. Suggestions for such 'variability of information' is given in the section below called 'How to deal with variability within farms'.

Flooring/Bedding

See EFSA report 2005, COST chapter B. Horning, and EU legislation.

Floor type qualities

Floor types and bedding Floor types refer to the types of material of which the floor is made and whether it is solid/slatted and/or sloped, e.g. solid convex concrete floor, (expanded) metal slats, (coated) plastic slats, etc. The different floor types and their properties, e.g. dimensions and proportions, need to be registered. Areas of outdoor access should also be identified including its quality, e.g. pasture, bare soil, mud, etc. The term 'bedding' refers to layers provided on top of the floor. Examples of types of bedding are straw, sawdust and compost. Within specific floor types or bedding materials a further distinction can be made with respect to 'quality' e.g. good versus poor quality slats. Such qualifications are classified elsewhere e.g. edges, roughness, 'food quality'.

V 4 Different floor types and bedding provide different levels of comfort for resting (cushioning, thermal insulation), grip on the floor for walking (and other activities), and substrate for exploration (recreation).

R 4

F 4 There may be many different kinds of bedding material, and recognising each of them accurately, may have its limits. A classification system may be used instead i.e. scoring the extent to which the floor provides resting comfort, thermal comfort, grip and recreation, where for recreation, for example, material properties like rootability, destructibility, hygiene, novelty and accessibility could be formulated as relevant dimensions.

Roughness Roughness is to be specified for each floor type and is to be determined for the floor as a whole including bedding, slopes and openings. It can be expressed in different ways (subjectively, but also more quantitatively, e.g. as a Leroux number). For example, newly built concrete slatted floors may be required to have a Leroux number of at least 65.

V 4 The floor should provide sufficient grip to perform the different behaviours e.g. standing up/lying down, elimination behaviour, play. Falling may lead to injuries. Conversely, excess roughness may also cause lesions. As minimum norms the pigs should be able to walk normally without the risk of slipping/falling and the floor should not be so abrasive as to cause evident skin lesions.

R 3 It is difficult to quantify the level of roughness of the floor, and it may vary over time e.g. due to soiling of the floor.

F 3 A subjective assessment on a scale with a very limited number of points e.g. 3 points could be feasible for trained assessors.

Edges Edges and defects in the floor, presence of broken slats.

V 5 Sharp edges pose a risk for injuries.

R 4 Edges may be masked by manure, poor lighting and/or a high stocking density.
F 5

Pen soiling Pen soiling refers to the degree to which the different parts of the pen, especially the different floor types, bedding, walls, feeders, drinkers and the pigs themselves, have been soiled with excreta. Pen soiling is closely related to behaviour (and may be assessed there), but it is classified here as a resource-based parameter by analogy to e.g. environmental temperature (which may also depend on animals being present). Soiling with excreta is to be distinguished from soiling with earth/mud from wallowing.

V 4 In terms of animal welfare pen soiling is not only a hygiene problem (a risk factor for health) but also an aversive stimulus to the pigs e.g. pigs avoid soiled objects and places for manipulation and resting.

R 4 A simple classification system needs to be constructed e.g. expressing pen soiling on a 3 point scale (none, some, considerable soiling).

F 4

Insulation: see below under thermoregulation

*Floor type quantities**Areas of floor types*

Functional areas Dimensions (m²) of the resting area, the dunging area, corridors and areas for general activity and/or their presence/absence e.g. in fully slatted and deep litter systems. Separate areas for elimination, resting and feeding are preferred (Von Borell et al., 2001). For resting a solid and insulated surface is preferred with visual protection towards neighbouring groups and space according to legal requirements (Von Borell et al., 2001).

V 4 Sufficient space in the various functional areas is necessary for the full performance of the required behaviours and for meeting the respective needs of the pigs. However, pigs may not choose to use the functional areas as designed, so this measure should ideally be supplemented with additional performance measures of the use of the functional areas.

R 3 Boundaries between what does and what does not belong to a functional area may sometimes be difficult to draw, and may depend on other factors e.g. what is a suitable resting area may vary depending on the environmental temperature.

F 3 Feasibility may be improved by applying, or perhaps simplifying, rules of thumb. E.g. the perhaps most important aspect of 'functional areas' may be to require a dry and comfortable lying area, while it may be presumed that if this is adequate, then the other functional areas (feeding and dunging) may be adequate too.

Slat dimensions Dimensions (cm) of slat width and slot width, presence of a dung gap. Slat- and slot widths should be in accordance with legal requirements/SHVO (Hoy et al. 2004, see also EFSA, 2005, p. 38-42). For example, Council Directive 2001/88/EC (EC, 2001) states, that when concrete slatted floors are used, the maximum width of the openings must be 14 mm and 18 mm for weaners and rearing pigs respectively. Furthermore, separate drainage of liquid manure in most bedded systems is preferred, except in deep bedded systems.

V 5 Inadequate slat dimensions increase the risk for injuries. Insufficient slot widths can result in soiled and slippery floors, while too wide slots can result in toes getting caught in the slots.

R 4-5

F 3 Some farrowing and weaner perforated floor types can be quite complex. Simplifying cut-off points could be formulated, e.g. legal requirements.

Bedding dimensions This refers to the amount of bedding provided (grams/day), the layer dimensions (cm depth) and particle dimensions (cm).

V 3 Even small amounts may give considerable benefit (see e.g. Day et al. 2002a).

R 3 Bedding dimensions can be quite diverse within a pen.

F 4 Bedding dimensions could only be described at a gross level, and may, to some extent, require information from the stockperson. Simplifying cut-off points may increase feasibility of recording e.g. more/less than 5 gr/day, a layer that suffices to cover the entire floor of the activity area, destructible particles that are at least the width of the snout of a pig, or similar.

Slopes The slope of the floor, especially of the solid floor, is related to other variables such as pen soiling, movement and lying comfort. It would seem sensible to use legal requirements as starting point for welfare auditing.

V 4

R 4

F 4

Pen divisions

Walls Pen walls (front, back, sides) can be described in terms of the degree to which they allow contact between pigs (open/closed).

V 3 Open pen divisions allow pigs to see what is going on in their environment, so providing some predictability, which is especially important for the reduction of fear. This may also provide some additional stimulation, which is especially important for individually housed pigs. However, open pen divisions may also pose an injury risk (limbs or heads get caught if the pen divisions have been incorrectly designed and sized) and may reduce biosecurity (increased disease transmission). If put in the wrong place, they may also increase pen fouling and thus reduce hygiene.

R 5

F 3 The welfare benefits of making this measure fully operational may be considered to be limited. However, the gross distinction 'open/solid partitions' should be feasible and could be used to examine relationships with animal-based health (injury/disease status) and welfare (behavioural) measures. Another argument to include the measure may be that whereas injuries and disease levels may be presumed to be adequately covered by the (animal-based measures in) Welfare Quality® scheme, the presumed welfare benefits of enhanced stimulation may not be.

Divisions within the pen

V 3 Pen divisions may reduce agonism by providing an opportunity for escape, may improve the separation of functional areas and may somewhat improve stimulation i.e. more exploration. Pen divisions may also restrict movements, especially when provided in small pens, and then affect welfare negatively.

R 5

F 4 The interpretation of how the pen divisions contribute to welfare (positively or negatively, and how much) may require too much expertise in relation to the gain of incorporating the measure in the index.

Corridors/fences for moving pigs and holding pens (see Transport)

Ventilation System and Dust

See SVC 1997, COST chapters R. Geers, and EU legislation.

Climatic system The recording of 'climatic system' may be problematic/unworkable. Suggestions are made to address this problem.

Ventilation system The ventilation system is described by its facilities for providing air flow, e.g. natural/artificial ventilation, capacity of ventilators, position of ventilator, air inlets and conditioning (heating/cooling) of incoming air. The whole system may be quite complex. For example, Von Borell et al (2001) prefer fans with a max. speed of 900 revolutions/min, i.e. low-speed fans, controlled exhaust air discharge over fans, exhaust air blown outside 1,5 m above the middle of the ridge,

air supply via drop down channels or via the feeding alley and air exhaust under the floor with a minimum distance of 0,5 m between the manure and the slatted floor.

V 4 Pigs need fresh air, but draughts are to be avoided. Increased air flow can be used for cooling pigs, while reduced air flow can conserve heat.

R 2 Assessing the ventilation system could be difficult, unless we may rely on the farmer's description of building materials and textbook values.

F 2 There are many types of ventilation system and many variations on the themes. The main classes (natural/artificial ventilation, etc) can easily be classified. At some point a substantial degree of expertise is required to determine what exactly the relevant properties of the ventilation system are and whether and to what degree it affects welfare. It may be considered to leave this area to climate specialists (as it may be advised to leave an assessment of the health status to veterinarians and an assessment of the diet to feed specialists). As a very general screening it may be appropriate to measure the environmental temperature, relative humidity, air speed and ammonia levels, in order to detect gross deviations from the norms (e.g. temperature within the thermal comfort zone, depending on the size of the pigs and floor type, RH 40-60%, air speed < 0.2m/s; NH₃ < 15 pp, or similar). Another 'solution' may be to make pictures or video recordings of unfamiliar systems and have an expert backup panel assisting the auditors in their evaluation of whether this system is adequate.

Alarms and failsafe systems These are a legal requirement.

V 4-5 The welfare impact of power and equipment failures may be considerable, but the actual welfare benefit depends on the degree to which the housing system depends on electrical power and equipment, and it also depends on the degree to which the systems actually become operative.

R 4-5

F 4-5 When taken as a legal requirement, it may not be worthwhile to check alarms and failsafe systems for the welfare audit if compliance with minimum legal requirements can be assumed to be present.

Insulation Included under 'insulation' are the insulation properties of the floor, building walls and roof. In the simplest version it could be registered whether the floor, walls and roof are, or are not insulated.

V 3 Insulation co-determines thermal comfort. It depends on other variables such as outside temperatures (climate, season), pig size, heating, feeding level, etc.

R 3

F 3 Interpretation of the measure may require quite some expertise.

Heating system, e.g. air heated outside the unit (in corridor, under roof), heating in the unit (heaters, floor heating), degree of control of heating system (i.e. degree to which the temperature can be controlled automatically and in what range).

V 5 Heating can reduce cold stress (and overheating can induce heat stress).

R 3

F 3 Heater capacity can be quantified but expert input may be needed to calculate its sufficiency.

Cooling system, e.g. wallowing pool, showers, ground tube ventilation

V 5 The provision of cooling is especially important in Southern European summer conditions. Wallows are also important for outdoor animals to avoid sunburn.

R 5

F 5 If scored as presence/absence. Assessing efficacy, however, may be much less feasible without expert input (e.g. F 2).

Air space The term 'air space' refers to the volume of unit. It is to be related to the number of pigs in the unit and their size. Air space is commonly expressed as m³/kg. Pigs with outdoor access have 2 values for 'air space' (one of the indoor volume and one set at 'very high' for the outdoor volume).

V 3 A norm could be ≥ 3 m³/pig of 100 kg, but too high air space with inadequate heating/thermoregulatory opportunities (no deep straw) may also be problematic.

R 4

F 3 It may be rather difficult to exactly measure the volume in some building types. When the objective is to identify the most serious 'outlier' farms, a rough estimate could suffice (certainly in the start-up phase of the Welfare Quality® scheme and when the farmer can provide more accurate details when he/she believes the estimate is unfavourable).

Outdoor access

V 3 Outdoor access provides opportunities for pigs to move around (space) and to breathe fresh air. It provides a different climatic zone (sunshine). Provisions of shade in large outdoor areas are also relevant as pigs may suffer from sunburn. Even though not all experts may agree that outdoor access per se is beneficial to pig welfare, it may be important to record it to address consumer concerns.

R 4-5 There could be problems in defining 'outdoors', e.g. access to roofed and/or concrete floored but otherwise open areas may have to be classified separately and some open front buildings may have some outdoor properties (fresh air) but lack others (e.g. more space).

F 5

Climatic zones Different climatic zones in a pen may be present when there are e.g. different air flow patterns, floor types (slatted/solid floors), outdoor access and localised heat/cooling sources (shower/heat lamp, kennel systems with enclosed lying boxes).

V 5 The presence of different climatic zones within the pen allows pigs to regulate their body temperature (cooling when hot and heating when cold). This is important as pigs cannot sweat and as within a group there may be considerable variation in thermal comfort. This item partly, but not entirely relates to the need to have different functional areas, because in part thermal requirements may differ between activity and resting periods.

R 3 Measurement of airflow patterns can be very variable in natural ventilation systems.

F 5

Slurry pit This includes slurry pit depth/capacity, the potential for slurry pit ventilation and the presence of separate slurry channels.

V 3 The construction of the slurry pit may affect air quality (ammonia levels).

R 3

F 3

Climatic variables Note that climatic variables may not be considered to be fully resource-based criteria because they are ‘performance of design criteria’, i.e. environment-based parameters (e.g. temperature) that are the consequence/output of evident resources (e.g. ventilation system), but that also of animal-based performance criteria (e.g. body temperature, weights and numbers of animals in the unit).

Environmental temperature

V 4-5 The environmental temperature is an important factor affecting thermal comfort. The importance of the environmental temperature varies between animal categories, e.g. a very high ambient temperature is critical for the survival of the newborn piglet, e.g. the temperature in the piglet nest should be > 30 degrees C for the first 10 days of life (Hoy et al., 2004).

R 3 Point measurement of the environmental temperature may not be a very reliable indicator for long term thermal comfort (it may be a hot/cold day today) and should be interpreted in relation to other climatic variables including the management of the farmer and the behaviour and health status of the animals. We could perhaps ask for a max-min thermometer record in at least some units.

F 3 It may be difficult to measure a ‘representative’ value in many buildings because of stratification and airflow patterns. On the other hand, of all climatic variables (including ventilation system, etc), perhaps the main focus should be on air temperature (and air speed and ammonia concentrations) in the lying area.

Chill factor/Humidex The ‘chill factor’ is derived from air temperature and air velocity; humidex is derived from air temperature and relative humidity. These measures are designed to indicate more closely how the temperature feels.

R 2 It may be difficult to determine these factors (especially chill factor) in a representative way.

Air flow This includes air velocity and air flow patterns.

V 5 High air velocity (> 0.2 m/s unless under hot conditions) may lead to cold stress and increased respiratory disease. Air flow patterns can be determined by producing smoke. They may be difficult to describe and interpret. The lying area is probably the most appropriate area to measure.

R 3 Air flow patterns can vary widely over time, especially in natural ventilation or as fan speeds change to maintain the set temperature.

F 3-4 Air speed monitors and smoke can be used to do the measurements. Feasibility may be lower for air flow patterns; very low (perhaps F 1) for natural ventilation.

Relative humidity

V 3 Relative humidity rarely comes in the range of values (very high) where it considerably affects welfare. Under high environmental temperatures it could do so when the relative humidity is very high. Very low relative humidity can exacerbate respiratory disease but does not commonly occur. Condensation can be an issue if insulation is inadequate.

R 4

F 3 Relative humidity should only be recorded if there is an indication of problems.

Light The type of light can be natural or artificial. Access to natural light can be direct exposure to sunlight or indirect via windows. The light level/intensity can be determined using a Lux meter and should be measured at pig height and at several places in the unit. Other measures of light intensity could be the number of bulbs and

window size (as % of floor area). Also relevant is the duration of light (e.g. times the lights go on and off and whether this is controlled manually or automatically).

V 3 The importance of light for pigs, over and above the level required by law (40 Lux) is not known. There is also some evidence that pigs may prefer less than 40 lux under certain conditions (S. Edwards, pers. comm.). The light regime is important as Zeit Geber (i.e. indicator of time), controlling the synchronisation of behaviour.

R 3 Considerable spatial variation may be present. The range and average values may be used if several measurements are taken in a specified protocol.

F 3 Feasibility is relatively low due to high variability between meters

Ammonia

V 3 Within most commonly found ammonia levels there appears to be limited effect on pig welfare. However, in chronically elevated conditions, e.g. when ammonia and dust levels are both high and in combination with suboptimal temperature and humidity the variable would be more important (e.g. V 5).

R 3 Considerable spatial variation may be present.

F 3-4 Ammonia levels can be measured using Dräger-tubes. Digital measures also exist.

Dust

V 3 Dust levels may affect respiratory disorders, but there is only limited information on how dust levels directly affect pig welfare.

R 3 It is difficult to adequately determine dust levels.

F 3 A kit does exist, but is very expensive

Other gasses, e.g. H₂S, CO, CO₂.

V 3 Under most commonly encountered conditions these other gasses have limited welfare impact (unless stored slurry is agitated).

R 4

F 3 Dräger-tubes can be used to do the measurements.

Noise The sound level can be determined in decibels.

V 3 Knowledge about the degree to which noise affects pig welfare is limited, but high noise levels may affect communication, e.g. between piglets and sow.

R 3 Considerable minute to minute variation can occur, e.g. during feeding and agonistic behaviour.

F 3 Feasibility depends not only on the specification of how to measure (as it would not be feasible to measure during a whole day) and on how portable and costly the equipment would be.

Other Resources

Other resources (than space, flooring/bedding and air quality) include: other enrichment materials/toys, body-care facilities, feeding system and the provision of water, social conditions and health care (including e.g. the provision of hospital pens).

Enrichment materials A model was constructed (called RICHPIG) to assess the welfare impact of enrichment materials for weaned and growing pigs. The model scores for a wide range of different materials and the weighting factors of a range of assessment criteria

(welfare relevant material properties such as rootability, novelty and destructibility) have been compared with expert opinion (Bracke et al., 2007-a; 2007-b; Bracke 2008), The model and the lists of scores can be used in the Welfare Quality® assessment scheme. (Note, the same is true for expert and model (SOWEL) scores being available for a range of different housing systems for pregnant sows and the weighting factors for a range of welfare attributes of housing systems, Bracke et al., 2002a and 2002b; and there is a model for scoring risk factors for tail biting (PIGTAIL, Bracke et al., 2004a).

Type of material, e.g. wood, metal, substrate, roughage and plastic/rubber.

V 4 Some materials appear to be more suitable for providing enrichment for pigs (e.g. straw, mushroom compost, soft wood) than other materials (metal, hardwood, plastic/rubber).

R 4

F 4 Compound materials consisting of different types of material may be difficult to classify (or define a separate class).

Amount This includes both the amount provided and the ‘amount’ still present in the pen at the time of recording. Both the total amount and the amount per pig may be relevant. In larger groups lower amounts per pig may be adequate; this is similar to floor area per pen and floor area per pig.

V 4

R 3-4 Farmer statements as to how much a material is provided may not be reliable. Assessing amount of particulate materials could be difficult, but as a starting point gross classifications should suffice for Welfare Quality®.

F 4

Material dimensions, e.g. particle size

V 4 Materials need to be either rootable or biteable for it to have any functional significance. However, there is no uniform relationship with welfare (adequate particle size may depend on the type of behaviour elicited and the type of material involved).

R 4 (at a gross level of description)

F 3-4 (at a gross level of description) A problem with feasibility is that at present there are no really good definitions available.

Provision frequency

V 5 Pigs are curious animals and novelty is an important factor for maintaining interest in a material.

R 3 Farmer statements as to how often materials are provided may not be reliable.

F 4

Accessibility to the pigs, e.g. on the floor or hanging

V 4 Pigs have a tendency to show synchronised behaviour, including synchronised exploration. Although it is not known to what extent time sharing is possible, a somewhat lower level of physical accessibility may be adequate in large groups.

R 3 The degree to which material is accessible simultaneously by all pigs has fuzzy borders and may vary across the day.

F 4

Note: the performance of the design criterion ‘enrichment material’ i.e. the state of destruction of the material may also be recorded e.g. whether materials shows indications of being bitten and whether the material is soiled.

Body care facilities, e.g. (vertical/oblique) scratching posts, body brushes (especially for sows), wallowing pool, mud.

V 3-4 Body care facilities allow natural behaviours like scratching and wallowing, provided they are suited to the size of the pigs in the pen. To some extent pigs may also use pen divisions and feeders.

R 5

F 5

Other pen fittings

V 5 Protruding or damaged pen fittings may cause injury.

R 5

F 5

Feeding system Aspects of the feeding system include feeder type, number of pigs per feeding space, dividers; automatic/by hand, trough length, trough shape, sequential/simultaneous feeding and predictability of food provisioning. The impact of the feeding system on animal welfare may take various forms. Feeding systems differ in the extent to which animals can eat ad lib (reach satiety), in the extent to which they expose pigs to aggression from conspecifics (e.g. floor feeding systems have been regarded as problematic) and in the extent to which pigs can synchronise their feeding behaviour (which is something they 'want to', e.g. electronic sow feeder systems force sows to eat sequentially, rather than simultaneously). The feeding system may also interact with the environmental enrichment, in that some feeding systems e.g. those using high fibre diets, may also provide occupation for the pigs. Because of these diverse impacts of the feeding system on animal welfare, it may be difficult to specify which systems are better and which systems are worse for welfare. (See also note above: leave evaluation of the diet to a feed specialist.) One aspect, available feeding space, could be assessed, provided this is done in relation to both restricted and ad lib systems (see existing guidelines for feeding space per pig in different circumstances).

Food Aspects to be recorded here may be brand name, way in which the food is provided (as meal, pellets, fluid), amount/day, provision frequency, contents (ingredients and nutritional properties) and food 'quality' (but again, this appears to be a specialist area).

Watering system Included here are the type of drinker e.g. nipple or water bowl, flow rate (flow rate should be 2-3 l/min for a sow, 0,5-0,8 l/min for piglets, > 0,8 l/min for growing pigs (Hoy et al. 2004)) and drinking points should be adjusted/adjustable to the size of the pigs (Hoy et al. 2004).

Water Aspects to be recorded here include the type of water quality, e.g. from tap/soil, provision frequency, amount/day, litres/min and the number of pigs/drinker (e.g. ≥ 12 fattening pigs/drinker, Von Borell et al., 2001).

Social conditions This includes aspects related to group size and to mixing and separation of pigs e.g. stable/dynamic groups, family groups, presence of a boar.

Mixing Stable groups are preferred over dynamic groups as mixing leads to fighting and stress. Mixing is a management-based parameter that is dealt with elsewhere. Facilities used for mixing, if any, are dealt with here.

Facilities used for mixing pigs Facilities for mixing of pigs may include specific areas used for mixing of unfamiliar groups of pigs.

V 4 When pigs are mixed, the temporary penning in areas with ample space, adequate grip on the floor and opportunities to escape from other pigs is preferred

for welfare over the direct penning (mostly at high stocking densities in regular pens).

R 3-4 Main distinctions can be made (good facilities present/completely absent), but there are all kinds of intermediate forms related to mixing management, that may make the interpretation and classification difficult.

F 4

Group size The number of animals in the pen

V 3-4 Individual housing (group size = 1) deprives the pig of social contact and is likely to be a deprivation of an important welfare need because pigs, with the possible exception of adult boars, are social animals. Under (semi-)natural conditions pigs organise themselves in small family groups of a few, genetically related sows and their offspring. Larger groups may have both welfare costs and benefits e.g. more risk of aggression (e.g. due to mixing) and more space per pen respectively. In very large groups aggression may be reduced relative to smaller groups, but these also give problems of identifying sick pigs. In addition to being a welfare parameter, information about group size is required to calculate other welfare parameters such as density-related measures (space per pig) and is an important variable in the assessment of risk factors for animal-based welfare measures.

R 4-5 Large groups in complex systems may be somewhat difficult to count exactly, but adequate estimates can be made e.g. by taking the average of several counts.

F 5

Health care Health care is a specialised and multifaceted area, which is relevant for welfare assessment but not its main focus. For norms see e.g. Hoy et al. (2004). Relevant items include not only hygiene provisions, disease pens and equipment used for treatments of animals (which are discussed below), but also other items related to hygiene status e.g. rodent control, equipment used for keeping farm records (computers, recording devices, etc), emergency power supplies, alarm system, monitoring systems (feed intake, body temperatures, etc). These latter items are not discussed in further detail, but could perhaps be included at a general level (present/absent) in the welfare scheme (as a starting point; see also under ventilation equipment).

Hygiene provisions Clean equipment and protective clothes are provided for all personnel and visitors. Suitable equipment for cleaning and disinfecting of people, buildings, equipment and vehicles are present. The barn is built from materials that can easily be cleaned and disinfected properly. A hygiene 'barrier' i.e. hygiene sluice, for vehicles and personnel, is present.

V 3

R 3

F 3

Disease pen A special pen for injured and sick animals is present. When there are (chronically) ill animals on the farm, there is evidence that the disease pen is actively used. There is a sufficient capacity of disease pens (i.e. a capacity of > 1% of the herd; e.g. Hoy et al., 2004). Individual pens for seriously ill animals are preferred, as is a management protocol for re-introduction into the group. Conditions in the pen are adjusted to the needs of the diseased animals (resting comfort, food and water of good quality, in sufficient amounts, within reach of the animals), appropriate environmental temperature, light conditions, pen size, floor type, etc (all

characteristics were also described for regular pens above). Provision of straw or other material providing extra resting comfort and thermal comfort is preferred.

V 5

R 3-4

F 4 Legal requirements could be used as easy cut-off points to determine whether 'disease pens' are suitable (as a starting point for monitoring).

Equipment Equipment used for the (medical) treatment of animals, such as snares for taking blood samples, injection-equipment, castration and tail-docking equipment and equipment for the identification of pigs (e.g. ear tags) should be suited to its purpose (in good working order).

V 3-4 The fact that the equipment is used implies welfare relevance (pain), but equipment use falls outside the scope of this work (is more management-related).

R 3

F 3

How to Deal with Variability within Farms?

A farm may have different types of pen and/or different types of units for one type of pig. Furthermore, over time the conditions under which pigs are kept may change (e.g. organic pigs may have access to pasture, except during the winter months). It may be an issue how to deal with the variability of available resources within farms, as this may affect the final welfare judgement.

Since this problem does not only concern resource-based measures, it must be addressed in the research group constructing the final protocol. In the short description below some possible strategies to deal with this problem are suggested.

Several different strategies could be applied. One extreme example would be to make as many different assessments as there are particular different cases on the farm. Another example would be to select one case e.g. selected randomly or selecting the most prevalent case, as being representative of the farm.

Alternatively, a heuristic strategy may be adopted that is based on general principles and common sense. Here is the proposal for the outline of this strategy.

When a farm operates entirely different systems e.g. both organic and conventional pigs, the welfare assessment body may consider allowing one farm to qualify for more than one welfare label. This would involve operating different audits on the same farm, and tight control of Identification and Registration of individual animals.

When this is not an option and when the variation is relatively small e.g. < 5%, we propose to ignore the fact that there is variability and prescribe to select the most typical case. When the variation is larger (which may mean that a larger proportion of the pens are involved, or that the discrepancy in ultimate welfare score is more substantial), then, a very limited number of cases may be identified, taking some kind of 'average'. This could

be a simple arithmetic average, but better would be to take an average that is proportional to the number of different cases involved and that is proportional to the principle that overall welfare is affected relatively more by the worst cases, in which case a higher weight would be given to the welfare status of the worst-off pigs. Under this rule we partly adopt the view that a chain is as strong as its weakest link. This rule is only adopted partially as otherwise overall welfare should always be equal to the welfare status of the worst off pig in the herd, which would be an unacceptable outcome for most farmers, consumers and scientists.

This rule would still leave considerable room for (subjective) interpretation. When in doubt, it may be advised to register both the average/typical case as well as the main outliers, especially the one deviating downwards with respect to welfare.

A tentative conclusion is that dealing with variability will inevitable involve subjectivity in assessment judgement. General guidelines may be formulated as a starting point for developing the assessment protocol.

Note. Another aspect of ‘variability’ concerns the problem that in pig husbandry there are many different systems (housing systems, feeding systems, ventilation systems) and types of material using in those systems. In addition, there may be unforeseen developments in the use of systems and materials. The auditing scheme may have to be equipped with a facility for upgrading of its classifications. For example, it could be helpful that an auditor who encounters a ‘novel’/unknown type of systems/material, makes more detailed recordings e.g. taking pictures, provided the farmer can agree to these procedures. A committee of experts could then periodically adjust the classification system as required.

TRANSPORT AND SLAUGHTER

For references on ‘loading/unloading’ see Lambooij (2004), SVC 2002 (parts on pigs), Von Borell and Schäffer (2005) and Schäffer and von Borell (2002a, 2002b).

For requirements on slaughter, see e.g. EFSA (2004), Von Borell and Schäffer (2005), Schäffer and von Borell (2002c, 2003, 2004a, 2004b).

Practical sources on these subjects also include Temple Grandin’s work (e.g. Grandin 2000, 2003) and Barton Gade (1997).

*On-farm Part of 'Transport'**Preparation for transport (on-farm)*

Pig identification (if any) Identification of pigs such as slap marking is a management-based parameter. Equipment used for pig identification that is considered unethical, should not be present on the farm.

Passageways Passageways allow movements from the pen to the holding area, and from the holding area to the ramp (leading onto the vehicle) on the farm. The objective is to avoid adverse effects (e.g. animals refusing to move), stress from driving (PSE), (skin and leg) injuries and death by providing conditions allowing and facilitating quiet moving of animals.

Width Passageways should have a sufficient width, holding 4 ± 1 pigs such that the pigs can move together, as they are gregarious animals.

V 3-4

R 4

F 4

Floor of passageways Floors are solid and without (steel) projections. Floors are not slippery and have a good drainage.

V 4

R 4

F 4

Slopes and angles Slopes are absent, or < 15 - 20° . If the race has curves, there should be no sharp corners to facilitate the movement of the animals, i.e. turns are more than 90° .

V 4

R 4

F 4

Walls Walls are solid and without (steel) projections. There are no protrusions or sharp edges of the fences or gateways in areas with pigs, and hinges and latches do not project into the pathway.

V 4

R 4

F 4

Light/shadows/colours Passageways (floor, walls) have neutral colours and no shadows. Animals are moved from areas with reduced light levels to better-illuminated areas.

V 3-4

R 3-4

F 3-4

Driving equipment Pigs are driven (quietly (which is a management-based variable)) using sound cues and driving boards. Wood/plastic 'sticks' should preferably not be used. Electric goads are not used and are not present.

V 3-4

R 3-4

F 3-4

Group size used for driving Pigs are moved in small groups of approx. 15 animals. Smaller groups of 5-6 pigs are even more preferred as this gives the handler more opportunities to reach any animal that stops.

V 3-4

R 3-4

F 3 Recording group size would require asking the farmer and/or being present during driving.

Humans Personnel can return after driving the pigs without disturbing them i.e. the previously driven batch or the next one coming, if any.

V 3-4

R 3-4

F 3

Holding area (on-farm, both for sending pigs off to other farms/slaughter and for receiving pigs from other farms) The facilities provided during holding at the farm before loading will depend on the time that the pigs remain there. If the time is short then access to water may be not be necessary, irrespective of live weight. The absence of holding pens/yards may not be negative for welfare, unless it means e.g. that the moving of animals is less quiet. It may be even positive for welfare e.g. reduces the animals' exposure to unfamiliar pens and may reduce mixing of unfamiliar animals thus limiting aggression.

Floors

V 5 Inadequate flooring may increase discomfort, fear and injuries. A norm could be that floors must be clean, dry (e.g. with sufficient slope/bulging of the floor) and sufficiently rough (comparable to an epoxy-layer of 1 to 2 mm Al₂O₃ or 10 mm rubber). Floors should not have steep slopes.

R 3

F 3-4

Walls The walls are smooth to prevent injuries such as skin damages.

V 4

R 4

F 4

Light/shadows/colours Floors and walls have a neutral colour and no (sharp) colour contrasts to avoid fear of pigs. There should be no dim and uneven lighting.

V 3

R 3

F 3

Ventilation system of holding yards

V 4 The ventilation system is important to maintain the environmental temperature at a level that is comfortable for the pigs. A norm could be that holding yards (preferably) have forced ventilation. At a more elementary level holding yards should be sheltered, i.e. holding yards have protection from influences from outside weather conditions (heat, cold, wind and rain) to avoid heat stress, cold stress and disease.

R 4

F 3

Temperature

V 4-5 The temperature in holding yards is preferably maintained within the thermal comfort zones of the pigs, but at least always between 0 and 32°C. Short term exposures to relatively high or low temperatures in the holding yards are less problematic for animal welfare (which is already reduced because of being in the unfamiliar environment) than more long-term exposures to less severe temperatures in the on-farm stage (also because the consequences in terms of respiratory disease cannot take effect in animals that are to be slaughtered). The air velocity ≤ 0.2 m/s (unless there is a hot climate, in which case an airspeed of up to 0.5 m/s may be appropriate (Whittemore, 1993)).

R 3-4

F 3-4

Cooling system Equipment used for misting or showering is present for arrived pigs to make the animals quiet and reduce aggression.

V 3-4

R 4

F 4

Density Danish industry recommendations for space requirements for holding pens for slaughter pigs up to 110 kg are: 0.45 m² per pig for holding periods below half an hour, 0.55 m² per pig up to 3 hours and 0.65 m² per pig for longer holding periods, where 0.65 m² corresponds to the space allowance for pigs of 85-110 kg in pig housing, as described in Directive 91/630/EEC of 19 November 1991, and where the other values are arbitrary figures that allow a progressively smaller space allowance for shorter holding times (see SVC, 2002, pp. 32). For welfare reasons, it could also be considered beneficial when additional space were provided for exploration and agonistic encounters (the need for which may be elevated in holding areas, esp. when unfamiliar pigs are mixed).

V 4

R 3-4

F 3-4 Feasibility may depend on the presence of pigs in the holding area during an audit.

Social conditions Boars and sows are penned separately to prevent mounting and injuries. Groups of pigs are preferably not mixed.

V 4-5

R 3-4

F 3-4

Water Water is provided via nipples.

V 3-4

R 4

F 4

Ramps Loading (and unloading) on ramps is often psychologically disturbing for pigs and therefore loading ramps must have an angle of < 15 - 20° . Descending ramps must have an angle of $< 20^\circ$. All efforts should be made to eliminate the need for slopes. A much better

alternative, therefore, is the presence of a deck lift (tail gate lift or mobile deck on the transport vehicle). This avoids fear, PSS and stress due to driving. Ramps should also have safe side-walls. At the change over from ramp to floor straw can be used.

V 4

R 3-4

F 4-5

Vehicles

Deck access Vehicles with a single deck (solid top or tarp) are ok. Multi-tiered vehicles must have mobile or floating decks. If not, it is preferable that the vehicle has an elevator for (un)loading at the docking ramp.

V 4-5

R 4

F 5

Deck height Deck heights should not cause discomfort while standing and not cause pain and/or injury when the vehicle accidentally encounters an uneven road deck. In any case the height between decks should be according to law (recommendations: piglets (around 25 kg) and feeder pigs (around 60 kg) > 60 cm; slaughter pigs (around 100 kg) >= 90 cm; adult pigs > 120 cm; Lambooij, 2004). The roof is well above the heads of all animals. A 100 kg pig is on average 77 cm tall at the highest point and most research into deck heights shows that 90 cm is sufficient (P. Barton Gade, pers. comm.). Optimal deck heights also depend on the ventilation system used and with effective air movement 90 cm seems to be OK (P. Barton Gade, pers. comm.). Signs on the vehicle should indicate area and height.

V 4

R 5

F 5

Compartments

Density Animals are able to stand (with their heads up) and move in a natural way, and all can lie down at the same time to avoid exhaustion and injuries. The loading density should be according to legal requirements. Recommendations (Lambooij, 2004, unless stated otherwise) are:

- piglets (20-25 kg): 0.15 m²/animal
- feeder pigs (around 60 kg): 0.35 m²/animal
- slaughter pigs (100-120 kg) 0.42 m²/animal (Lambooij, 2004) – 0,6 m²/animal (Schäffer and von Borell 2002a)
- slaughter pigs (120-140 kg) 0.45 m²/animal (and up)
- heavy pigs (>140 kg) 0.71 m²/animal

Additional space is provided if the temperature rises above 25 degrees Celcius. Signs on the vehicle should indicate area (and height).

V 5

R 5

F 5

Groupings Groups of pigs that have been reared together in the same pen are preferably not mixed to avoid fighting, exhaustion, stress and PSS (but this may be difficult to realise in practice). Partitions between individual pens would be preferred, but moveable internal compartment gates are not always

considered to be an option (P. Barton Gade, pers. comm.). Danish recommendations are for pigs from different farms to be kept separately until loading and the mixed groups, so formed, are not to be mixed any more at the abattoir. Adult boars and sows are kept separately.

V 4-5

R 4 It may be difficult to determine that groups of animals have been mixed.

F 3-4

Hazards Vehicle compartments are smooth, free from obstructions, projecting objects and hazards that could cause skin damages. The vehicle is sound and free from any rot or rust. Vehicle is escape proof and does not cause injury.

V 4

R 3-4

F 4

Maintenance and hygiene The vehicle can be (and has been) cleaned and disinfected effectively to avoid/eliminate contamination, and the vehicle is sound and free from any rot or rust.

V 3-4

R 4

F 4

Flooring The floor is made of non-slip material with a roughness comparable to an epoxy layer with 1 to 2 mm Al₂O₃ or 10 mm rubber, and contains a layer of straw or straw dust of 2 cm or an equivalent. This material is sufficiently absorbent and provides isolation, especially in winter e.g. straw. These measures should avoid discomfort and injuries as well as heat and cold stress.

V 4

R 4

F 4

Ventilation In order to avoid heat and cold stress, the vehicle has artificial/mechanical ventilation, which preferably can be controlled from the drivers cab, and, if not, air inlets are opened or closed depending on the weather conditions. Ventilating compartments and containers have vents positioned at the upper part of the left and right sides. The vents can be opened according to legal prescriptions.

V 3-4

R 3-4

F 3-4

Insulation The floor contains a layer of straw or straw dust of 2 cm or an equivalent, that provides sufficient isolation, especially in winter e.g. straw. The walls and roof of vehicles must be insulated. If not, vehicles have provisions to protect the pigs from freezing to the wall, especially when the walls are made of aluminium.

V 4

R 4

F 4

Temperature The temperature is preferably held within the thermal comfort zone, and certainly between 5 and 25-32°C. Measures are taken when the inside temperature drops below 5°C or rises above 25, respectively 32°C to avoid dehydration and

exhaustion. The optimal air velocity is < 0.2 m/s and the optimal environmental temperature is 16°C for a 100 kg slaughter pig or adult pig.

Additional space is provided if the temperature rises above 25 degrees C. Regulation of the compartment temperature includes the time between loading and departure, depending on the weather conditions.

V 4

R 3

F 3

Food On longer journeys, food and water are available at appropriate times (in accordance with legal requirements and in accordance with the biological needs of the animals). Light food is preferred as pigs can suffer from travel sickness if their stomachs are full. If the transport is over 24 hrs, when feeding will be mandatory, then a light meal should be given at the start of a longer (e.g. 9 hr) stop, so that feed has been digested when the transport starts again. The provision of food is a management-based parameter, but it could be possible to check feeders and availability of food. The vehicle should carry sufficient food for the whole journey.

V 3-4

R 2-3

F 2-3

Water On longer journeys, and especially during stops, water is provided via nipples. Drinking nipples are available for journeys over 8 hours, and have a low level signal system.

The vehicle carries sufficient water for the whole journey.

Per 15 pigs 1 nipple drinker is provided (Lambooy, 2004), an alternative recommendation could be e.g. 2 nipples per compartment. Problems with water availability may occur when the outside temperatures drop (much) below 0°C, and measures are taken to prevent such problems.

V 4

R 3-4

F 3-4

Light Inside light is present for loading and control.

V 4

R 4

F 4

Vehicle driving There is a definite delivery appointment, a complete transport declaration (origin, owner, dispatch location and place of destination, day and time of loading), route planning (road surface, curves, jams, traffic lights), especially in longer transports, professional competence and knowledge of the driver, and a tachometer is present and in use. Highways and main roads are preferred to urban traffic. Domestic transport has a duration < 8 h, including loading and unloading.

V 3-4

R 3

F 3

Pig driving equipment There are no electric goads on the vehicle or in possession of the driver

V 3

R 3

F 3

Signs Symbol and note 'Live Animals' on the vehicle. Signs on the vehicle should indicate area and height.

V 2-3

R 5

F 5

Emergency treatment Legislation states that it should be possible to access all compartments on the vehicle for emergency treatment. However, there may be practical problems with ensuring both safety of the driver and animal welfare concerns. Unaffected animals may be stressed when they must be off-loaded to make emergency treatment possible. Nevertheless it is preferable that manual unloading is possible in case of an emergency to alleviate animal suffering.

V 3-4 Its actual incidence is probably relatively rare.

R 4

F 4

Emergency killing Penetrating captive bolt stunner (or other suitable equipment) is available in case of emergency euthanasia.

V 3

R 4

F 5

Abattoir Part of 'Transport and Slaughter'

Slaughter facilities This section is kept relatively short, because general points applying to on-farm conditions, also apply here.

Vehicles (see above)

Unloading (see above)

Passageways at slaughter (see above)

Holding in abattoir lairage (see above)

Disease pen (see above) A special reception centre for injured and sick animals is present.

Emergency killing A facility to kill animals in case of emergency is available in the form of either penetrating captive bolt or electrical stunning equipment (with 240 V / 1.3 A / > 3s on the head (eye-ear) and > on the heart to induce cardiac arrest).

V 3

R 4

F 4-5

Hygiene provisions (See above)

Clean equipment and protective clothes are provided for all personnel and visitors. Suitable equipment for cleaning and disinfecting of people, buildings, equipment and vehicles are present. Building, yards, passageways and equipment are built from materials that can easily be cleaned and disinfected properly.

Fixation, stunning and killing For this specific item, reference is (again) made to the EFSA 2004 report for further details. Equipment used for fixation, stunning and

killing (sticking) is a rather specialist field that is not easily incorporated into an assessment system (low reliability and feasibility), while also validity of the resource-based item may be questionable as the welfare problem concerns only a very short period (seconds or minutes) of the animal's life. For this reason, too, this section has not been fully elaborated. Only relevant items have been listed, and a general assessment of validity, reliability and feasibility is given here:

V 3-4

R 2-3

F 2

Electrical stunning

Restraining system

Equipment

Electrode application Proper electrodes must be used, which are appropriate for the size of the animals.

Maintenance of the electrodes.

Current flow Minimum current of 1.3 A for at least 1 s to induce immediate loss of consciousness. A minimum of 1.0 A, 50Hz sine wave AC to induce cardiac ventricular fibrillation.

Appropriate and calibrated voltage and current measuring devices should be used to set stunners.

Sticking If stunning head only, sticking should be performed within 15s after stun.

Proper maintenance of the equipment.

CO₂ stunning

Minimum CO₂ concentration of 90% at the bottom of the pit (EFSA 2004 recommendation). Pigs should be exposed to a minimum of 80% with 10s from leaving atmospheric air.

Exposure time (minimum of 100s). (EFSA recommendation)

Captive bolt

Used as back-up stunning method

Restraining system

Appropriate cartridge selection, storage and gun maintenance.

A2.5 DISCUSSION

Evaluation of the 'Tool'

The Appendix described resource-based parameters for welfare assessment of pigs on-farm and with respect to 'transport and slaughter'. Other partners have been working on

animal-based parameters and management-based parameters which have, accordingly, been excluded from incorporation in this report.

A systematic decomposition of all aspects potentially relevant from a 'resource-based' perspective has been made. This has resulted in a long, hierarchically composed list of items, each of which has been subjectively evaluated with respect to its validity, reliability and feasibility for incorporation into the welfare assessment tool.

This document provides the input for the next phase i.e. to integrate information and construct standardised and practicable welfare assessment lists across species (pigs, cattle and poultry). For that phase of the work, a fundamental choice is left between selecting relatively few resources for detailed measurement, or selecting a larger number of resources which are recorded only on a scale with a few (2 or 3) levels, depending on the time (and money) available to do the audit.

Another issue to be addressed there is to further integrate the groups of parameters (resource-, management- and animal-based), for in the end these parameters have to be integrated into the assessment. For example, in order to assess climate and ventilation the management of these resources must be taken into account. Another problem relates to genetics. Pigs are obviously different in their abilities to adapt to certain conditions. Breeds or certain genotypes might be more or less suited or adapted to certain housing conditions, and this paper has not been able to reach that level of detailed discussion (if it were known). This points to a general 'shortcoming' and that is that the animal's environment, its 'resources', cover such a wide range of aspects that the level of description necessarily had to be kept very general, even without detailed references being included. Instead a reference is made to overview-documents (mainly EC reports), because the scope of this work did not allow going into that level of detail. Despite this, the work should provide a good starting point for the further development of the welfare assessment tool with respect to resource-based measures for pigs, and to a lesser extent also for other species such as cattle and poultry.

Evaluation of the Process

Because of the limited budget, a decision was made to progressively upgrade the paper instead of organising one or two workshops. The impression was that this has worked reasonably well, as this has channelled the process from 'talking together' into 'writing together'. A number of relevant authors were prepared to comment on earlier versions of the document in a most constructive way. Their contributions are much acknowledged.

The document has also been sent to other partners working in this Welfare Quality® subproject, especially to groups working on resource-based measures in the other species and groups working on management-based parameters. It is hoped that this will have contributed to the harmonisation of the work.

A2.6 ACKNOWLEDGEMENTS

We wish to thank all those who contributed to this work by giving suggestions and comments. This included H. Vermeer (NL), E. Lambooij (NL), E. von Borell (DE), S. Edwards (UK), L. Keeling (SE), A. Velarde (ES), P. Barton Gade (DK) and A. Butterworth (UK). We also wish to thank others for fruitful discussions while preparing underlying documents, esp. our colleagues from COST 846, SWG Pigs, namely A. Velarde, B. Hörning, F. Wemelsfelder, F. Tuytens, K. Boe, V. Couboulay and R. Geers.

APPENDIX 3

SAMPLING AND STATISTICS: NOTE ON SAMPLE SIZE REQUIRED FOR PROPER INFERENCE ABOUT PROPORTIONS

B. Engel and K. van Reenen

A3.1 INTRODUCTION

Suppose that we are interested in the proportion of defective individuals, i.e. animals with a reduced welfare, as a reflection of quality of welfare due to management at a farm. Assume that we are able to collect a (quasi) random sample of animals of size n at the farm and that x is the number of defectives in the sample. Also suppose that our judgement of an animal is faultless; there are no false positives or false negatives.

The proportion x/n of defectives in the sample is the *apparent* proportion of defectives. Obviously, unless we sampled all animals, this is not the *true* (unknown) proportion p at the farm, due to sampling variation. For the moment, let us assume that the number of animals at the farm is very large. This conveniently allows us to postpone the issue of infinite or finite population size to a later moment.

Suppose that 0.10 is a critical threshold: a true proportion p below 0.10 is acceptable, but a true proportion p above 0.10 is not. If we warn a farmer that the proportion of defective animals at his farm is too large, we want this warning to be correct. Incorrect warnings would make the farmer lose faith in the monitoring system and in due course commitment would be lost. Usually, we cannot be completely sure that a warning is correct. But we can require the probability for the warning to be incorrect to be small, say smaller than 0.05.

Suppose that we give the farmer a warning when x is larger than some boundary value b . So, $x = b$ defectives in the sample is just acceptable, but $x > b$ is not. Formally stated, we want the probability for x to exceed b to be smaller than 0.05 when the true proportion p is below 0.10. When we call the latter probability α , we require:

$$\alpha = \text{Prob}(x > b, \text{ when } p \leq 0.10) \leq 0.05$$

The boundary value b will depend on the sample size n : the larger n , the closer we can choose b/n to the critical level of 0.10. How large do we want n to be? To answer this question, we need to decide what values for p larger than 0.10 we want to be able to detect with some confidence. Ideally we would like to detect even the smallest departures, such as $p = 0.101$. But that is not possible in practice. The reason is that the data generated with $p = 0.099$ (an admissible value) are virtually the same as the data generated with $p = 0.101$ (an inadmissible value). Only for a very large sample size n we would be able to see the difference between the two true proportions that are close together, but on different sides of the critical threshold. So, we need to be more modest. Let us say that at least we want to be able to detect a value of p as large as 0.2 with a probability larger than or equal to 0.95. Formally:

$$\beta = \text{Prob}(x > b, \text{ when } p = 0.2) \geq 0.95$$

The idea of a small probability α for a false warning and a large probability β to detect a certain departure from the critical threshold (the maximum allowable value for the true proportion of defectives) fits quite natural into the frame work of statistical hypothesis testing. The advantage of that is that we can use the well developed theory of hypothesis testing to determine the sample size n and associated boundary value b . Formally, we test the hypothesis:

$$p \leq 0.10$$

When we reject this hypothesis, because the number of defectives x in the sample is too large (when x exceeds an appropriately chosen boundary value b), we give a warning to the farmer. The first probability of falsely accusing a farmer is called the size α of the test. The second probability β to detect the difference between a true proportion $p = 0.2$ and the critical threshold 0.1, i.e. the probability to reject the hypothesis $p < 0.10$, is called the power of the test. We can determine the sample size n for a size $\alpha \leq 0.05$ test of the hypothesis $p < 0.10$, such that the power β to detect $p = 0.2$ (the alternative hypothesis in statistical jargon) is at least 0.95.

A3.2 SAMPLE SIZES REQUIRED FOR LARGE FARMS

In the table below, the required sample size n , and associated boundary value b , to detect the difference between the true proportion $p = 0.2$ and the critical threshold 0.1 are reproduced ($\alpha \leq 0.05$ and $\beta \geq 0.95$). The required sample size n can be quite large. When we are more lenient, for instance increase the true proportion to $p = 0.3$, a smaller sample size n will be required. Therefore, sample sizes for values $p = 0.2, 0.25 \dots 0.50$ are listed.

The sample sizes will depend on the critical threshold (e.g. 0.1). Results are also presented for a larger critical threshold of 0.2 (Table A3.1).

A3.3 EXAMPLE

Suppose that the critical threshold is 0.1, i.e. we regard a true proportion p that exceeds 0.1 as inadmissible. We want to be able to warn a farmer when the true proportion is as large as $p = 0.3$. With sample size $n = 41$ we will be able to detect such a departure from 0.1 with a probability of at least 0.95. With a sample size of $n = 41$, we reject the hypothesis $p < 0.10$, and consequently give a warning to the farmer, when the number of defectives x in the sample is more than 7 ($= b$), i.e. when the apparent proportion x/n in the sample is larger than 0.171 ($= b/n$).

So, with $n = 41$, we warn the farmer when $x = 8$ or more, but we do not warn the farmer when $x = 7$ (or less). We cannot warn the farmer when $x = 7$, despite the fact that the apparent proportion $x/n = 7 / 41 = 0.171$ exceeds the critical threshold of 0.1, because in that case the probability of a false warning would exceed 0.05. In other words, when the true proportion is $p = 0.10$ there is still a probability of finding x as large as 7 that exceeds 0.05. Only when x is as large as 8, we can decide that the probability for this to occur for $p \leq 0.10$ is too small (below 0.05), and we reject the hypothesis $p \leq 0.10$ in favour of $p > 0.10$ and warn the farmer.

TABLE A3.1 Required sample size n (infinite population size, i.e. large farms).

True proportion p	Sample size n	Boundary b : $x > b$ means hypothesis rejected and farmer warned	Proportion b/n : when apparent proportion $> b/n$, hypothesis is rejected and farmer is warned
Critical threshold = .1*			
.20	135	19	.141
.25	70	11	.157
.30	41	7	.171
.35	31	6	.194
.40	24	5	.208
.50	13	3	.231
Larger critical threshold = .2			
.25	756	169	.224
.30	204	50	.245
.35	98	26	.265
.40	60	17	.283
.45	40	12	.300
.50	28	9	.321

Notes: * above this level the true proportion is considered to be unacceptably large). Hypothesis $p \leq .1$ is tested and rejected when $x > b$. Size $\alpha \leq 0.05$ and power $\beta \geq 0.95$.

A3.4 TAKING FINITE HERD SIZE INTO ACCOUNT

The aforementioned sample sizes are derived assuming an infinite population size. This means that the results apply to relatively large farms, chicken farms for instance, where population sizes can be expected to be in the order of thousands if not ten thousands. For dairy cows however, farm size can be as low as 50 cows, while a relatively large farm may have 200 cows. What about these farms of relatively small size?

Suppose that a farm has a herd of 50 animals. In that case we could inspect all animals, i.e. $n = 50$. The sample and the population (the herd) would coincide and the apparent proportion x/n and the true proportion p would be the same. In that case we could choose $b = 5$, which is the maximum number of allowable defective cows when $p = 0.10$, and give a warning when the number of defectives $\geq b$. Because we know the exact value of p , we are in the ideal situation that $\alpha = 0$ and $\beta = 1$.

So, by virtue of a small herd size, we can detect any value of p that exceeds 0.10, without the risk of giving a false warning, when we sample all animals. Actually, to reach a required power $\beta = 0.95$ for $p = 0.2$, we do not need to sample all 50 animals. It will be enough to sample $n = 38$ animals. In the latter case $b = 5$, $\alpha = 0$ and $\beta = 0.954$.

A3.5 A CROSS-SECTIONAL OR A LONGITUDINAL POINT OF VIEW?

Before we proceed with the discussion of relatively small herds, we will first turn to another related and important issue. Do we want to judge a farm on the basis of the present visit alone or do we take the track record of that farm into account as well? In other words: do we take a cross-sectional or a longitudinal point of view? In the latter case we regard a sample of animals collected during a visit to the farm as part of a long sequence of animals produced by the farm: a reflection of welfare of animals in an ongoing management process. The underlying population of animals consists of all animals that are and will be produced at that particular farm. The proportion p is the probability for any cow produced by the farm to be defective. With this longitudinal view point, results for infinite populations apply. If we take the cross-sectional point of view, and we base our conclusions on the current visit only, the population is the herd at the moment of the visit (50 animals in our example) and p is the proportion of defectives among these 50 animals. Results for finite populations apply. Note that the populations involved and the interpretation of proportion p of defectives are different under the two points of view. This difference between the two approaches is important, both with respect to our monitoring strategy and with respect to the sample sizes we can practically acquire.

A3.6 ACCOUNTING FOR FINITE HERD SIZE (SMALL TO MODERATELY SIZED FARMS)

For a small farm of say 50 animals, from the cross-sectional point of view we observed (at the end of Section 4) that we need to sample $n = 38$ animals. But, from the longitudinal point of view, according to the results in Section 2 (true proportion $p = 0.2$, top half of the table) we need to sample as many as $n = 135$ animals. At first sight there is something of a contradiction here. The difference between the sample sizes lies in the different populations assumed and the different interpretation of p . If we sample all 50 animals and we detect $x = 6$ defective animals, we know that at the moment of the visit the proportion of defectives exceeds 0.10. So, it seems that we are right in giving a warning to the farmer. However, if we take the longitudinal point of view, it is quite possible for the proportion p in the long run to be smaller than 0.10. There will be variation in the number of defectives present at any moment and the 6 defectives detected during our visit may just be there by chance. May be the management is in good order. May be at previous visits no defectives were detected at all. We were just visiting the farm at the wrong moment. The number of animals present at our current visit (e.g. 50) is not large enough to offer a reliable impression of the performance of the farm in the long run. Hence, from a longitudinal point of view, no warning should be given.

So, what should a warning reflect: (1) the welfare state of the farm in the long run (longitudinal point of view) or (2) the welfare state of the farm at the moment of the visit (cross-sectional point of view)? Probably a critical discussion with the farmer about the presence of $x = 6$ defectives would be in good order (and possibly an explanation can be found), but the loss of a ‘Michelin star’ should perhaps be based on a longitudinal point of view, taking previous visits into account as well.

A3.7 FREQUENCY OF VISITS

The longitudinal view point seems quite natural. It seems reasonable that we look more critical at farms with a poor track record, may be by increasing the frequency of visits or by planning second visits for confirmation. Likewise, we might decide to visit farms with an excellent track record less frequently. So, if we are willing to postpone a definite warning (may be involving the loss of a ‘Michelin’ star) until several visits are performed, the longitudinal view point allows us to acquire larger (pooled) sample sizes and offer more reliable warnings.

Note that for the longitudinal point of view we can adopt more intricate procedures. For instance, we may combine results from several visits with larger statistical weight for more

recent visits, similar to the use of a moving average. We will not go into this any further, because it does not affect decisions we have to take at this stage of the project. The most important thing now to decide upon is whether emphasis should be placed on the longitudinal or on the cross-sectional point of view. From the longitudinal view point critical comments may be offered on the basis of one visit only, but ‘loss of stars’ should be based on several visits. In order to distribute our limited resources (number of observers, frequency of visits) over the farms, a longitudinal view point with more focus on farms with a poor track record could make sense.

A3.8 THE CROSS-SECTIONAL VIEW POINT FROM A PRAGMATIC PERSPECTIVE

Here we focus on a single visit and on the true proportion of defectives p that is present at that visit. Suppose that we determine, taking account of all practical constraints (such as time and money), how many animals we can inspect during a single visit. So, n is the number of animals that we can afford to inspect rather than the number of animals that is required. What kind of departures from the critical threshold are we able to detect with such a sample size?

For illustrative purposes we will stick to the critical threshold of 0.10. The herd size is $N = 150$. The sample size is $n = 50$. In the table below, a number of values for the true proportion p are listed that all exceed the critical threshold of 0.10. For each value, the probability β of detecting the departure from 0.10, i.e. the probability of rejecting the hypothesis $p \leq 0.10$, is calculated. So, the power β of the statistical test for various alternatives of the hypothesis $p \leq 0.10$ is calculated. In all instances the size α does not exceed 0.05. Because the observations x are counts, it is possible for α to be markedly below 0.05.

Table A3.2 shows what kind of departures from the critical threshold we are likely to detect. For instance, when $p = 0.17$, which means that there are 25 defectives on the farm, we have a probability of 0.46 to detect the difference with the threshold of 0.10.

Some results for a larger herd size $N = 300$ are presented in Table A3.3.

Possibly because in the last case a size α that is much closer to 0.05 can be achieved, the results for power β for the two herd sizes are not that different.

TABLE A3.2 Calculation of the power β = probability to detect that the true proportion of defectives is larger than .10 ($N=150, n=50$).

True p	.13	.17	.20	.25	.30
Number of defectives in the population	20	25	30	37	45
Power β	.17	.46	.74	.94	.99

Notes: herd size is taken into account in the calculations; the probability β depends on the true proportion p of defectives in the population; it also depends on the herd size (N) and the sample size (n); we decide that the proportion of defectives exceeds 0.1 when the number of defectives in the sample (x) exceeds value $b = 8$; value $b = 8$ follows from N, n , critical threshold .10 and the requirement $\alpha < .05$; the size of the (one-sided) test is $\alpha = .024$.

Table A3.3 Calculation of the power β = probability to detect that the true proportion of defectives is larger than .10 ($N=300, n=50$).

True p	.13	.17	.20	.25	.30
Number of defectives in the population	39	51	60	75	90
Power β	.18	.49	.71	.93	.99

Notes: herd size is taken into account in the calculations; we decide that the proportion of defectives exceeds .1 when the number of defectives in the sample (x) exceeds value $b = 8$; again, value $b = 8$ follows from N, n , critical threshold 0.10 and the requirement $\alpha < 0.05$; the size of the (one-sided) test is $\alpha = .042$.

A3.9 WHAT IS NEEDED FOR A POWER CALCULATION?

In order to be able to calculate the power β in other instances, we need:

1. The critical threshold (0.10 in this note).
2. The herd size N (150 and 300 in the examples).
3. The sample size n (50 in the example).
4. The departure from the critical threshold (e.g. $p = 0.20$).

If a range of herd sizes is contemplated, a reasonable lower and upper bound and a mean or median value are required. Likewise calculations can be performed for several alternative values for the critical threshold (within reason).

A3.10 ACCURACY OF PROPORTIONS

This note primarily focuses on accuracy required for estimated proportions such that (1) the probability for a false warning is small (below 0.05) and (2) the probability to detect a departure from a critical threshold is large (above 0.95). In addition, on the basis of estimated proportions, we would also like to assess the variation between herds and possibly compare differences between some of the herds. To that end we have a closer look at the accuracy of an estimated proportion of defectives in a herd.

For any observed proportion x/n we can construct 95% confidence limits for the associated true proportion. For example, if we adopt the longitudinal point of view (infinite population size) and the sample size $n = 135$ (based on several subsequent visits say), while $x = 108$, so $x/n = 0.8$, these 95% confidence limits are: 0.72 and 0.86. The width of the interval indicates how accurate our statements about the true proportion can be. Roughly speaking, the true proportion would be between 0.72 and 0.86. This gives an idea of the kind of variation between farms, or differences between farms, we are able to detect. The interval will be wider, when the proportion is closer to 0.5. When the sample size is not too small, the confidence bounds may be roughly approximated by the following expressions:

$$\begin{aligned}\text{upper bound} &= \frac{x}{n} + 1.96 * \sqrt{\frac{1}{n} \frac{x}{n} \left(1 - \frac{x}{n}\right)} \\ \text{lower bound} &= \frac{x}{n} - 1.96 * \sqrt{\frac{1}{n} \frac{x}{n} \left(1 - \frac{x}{n}\right)}\end{aligned}$$

For $x = 108$ and $n = 135$, the approximate bounds are 0.73 and 0.87, which is indeed close to the aforementioned exact results of 0.72 and 0.86. The approximate bounds are symmetric around the estimated proportion of 0.8. When the proportion is more extreme and / or the sample size is smaller, the exact interval will tend to be more and more asymmetric around the estimated proportion. For instance, for a small proportion, the interval will tend to be shorter on the left and longer on the right hand side of the estimated proportion. So, in that case the approximate interval (that is always symmetric) will differ more from the exact interval. The estimated standard error of the proportion is:

$$\sqrt{\frac{1}{n} \frac{x}{n} \left(1 - \frac{x}{n}\right)}$$

Thus, the approximate interval roughly equals the estimated proportion plus or minus twice the estimated standard error of the estimated proportion. Suppose that for another herd, $x = 35$, $n = 135$, so $x/n = 0.26$. For that herd, the exact bounds are 0.19 and 0.34, while the approximate bounds are 0.19 and 0.33. The fact that the intervals for the two herds do not overlap at all suggests that the proportions of defectives at the two farms are significantly different. An exact comparison may be based on Fisher's exact test, applied to the Table A3.4.

TABLE A3.4 Fisher's exact test.

	Defective	Non-defective
Herd 1	108	27
Herd 2	35	100

The numbers in Table A3.4 are corresponding to the numbers of defective and non-defective animals in the samples collected at the two farms. The P-value of the test is very small ($P < 0.001$), indicating that indeed the two proportions for the two farms are significantly different.

A3.11 FINAL REMARKS

In this note we have focussed on warnings based on apparent proportions. A similar discussion could be held about 'compliments' for excellent welfare, may be resulting in an extra 'Michelin star'. We have assumed that our judgement of animals is faultless. This assumption directly relates to the repeatability and reproducibility of observers (variation within an observer and variation between observers). Introduction of a sensitivity (probability that an observer recognises a truly defective animal) and specificity (probability that an observer recognises a truly sound animal) complicates matters considerably. For instance, when there is a possibility of a false positive (one minus the specificity), with an increasing sample size, more false positives will be introduced. With poor specificity it may simply not be possible, whatever the sample size n , to achieve $\alpha \leq 0.05$ and $\beta \geq 0.95$. We have also assumed that defectives are spread in a random fashion over the population. When there is clustering in time, a statistical evaluation is considerably more complicated. I have assumed that in case of clustering, there will usually be an acceptable explanation, such as a regional outbreak of a disease that makes further evaluation unnecessary. Of course data corresponding to such periods of calamity that are beyond control of the farmer should be no part of a longitudinal evaluation.

Various proportions will be part of the total monitoring system. In WP2.3 these proportions (and other measurements) will be combined into a number of summary scores associated with different broad aspects of welfare, such as animal health for instance. When a farm receives a poor score, we would like to identify the basic measurements that explain this poor score. For a proper advice to the farmer, we need adequate accuracy of estimated proportions. Adequate accuracy of estimated proportions seems a good starting point for good quality of the summary scores as constructed in WP 2.3 as well. However, it is very difficult, if not impossible, to obtain analytic results for accuracy of estimation of these summary scores. In principle, there is the possibility to run the monitoring system on simulated data, where the input for the simulations might be based on the large practical data set that will be collected in WP2.4. But this is not an easy exercise. It is possible to take half of the intended number of farms and double the number of visits, in order to

evaluate the repeatability of the summary measures from WP2.3 from the large practical data set. However, this would mean that effectively far less data would be available for our primary goals in WP2.4, namely quantifying associations between measurements on animals or pens, associations between measurements on animals or pens and farm characteristics, finding risk factors and slimming down the full monitoring system. It would not be unreasonable to state that a direct validation of the summary scores of WP2.3 on the basis of the practical data set collected in WP2.4 is beyond the present resources of the project, but should be part of a future evaluation.