Proof of Principle of the Comfort Class concept in pigs. Experimenting in the midst of a stakeholder process on pig welfare☆

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A B S T R A C T

Animal welfare in livestock systems is strongly dependent on husbandry conditions. ‘Comfort Class’ is defined as a specific minimal level of husbandry conditions of animals, at which the ability of animals to meet their needs is not compromised by husbandry conditions. It is assumed that if this level is attained, animal welfare (the quality of life as experienced by the animal) will not be restricted by husbandry conditions. This idea of a Comfort Class level originates from an early interdisciplinary innovation trajectory in pig husbandry and was adopted by the major Dutch pig farmers’ organisation and the major Dutch animal protection organisation. These two parties built a Comfort Class facility as a proof of principle to test and demonstrate the idea. The aim of the first study in this facility was to empirically test whether a facility that meets the Comfort Class level results in good animal welfare for pigs. In two batches each with 144 undocked pigs, housed in three group sizes, observations were made on tail integrity, skin lesions, activity patterns and degree of synchronisation and clustering of eating and lying behaviour. In the first batch, tail and skin damage was at a low level. The second batch, starting with 64% of the animals having bitten tails, ended with almost all tails recovered. Activity patterns were similar for group sizes and growing stages. Resting behaviour was highly synchronised, but rather spread out over the lying area. Synchronisation of eating was limited, as 52% of the meals were taken alone and a further 29% by two pigs together. The study offered support for the hypothesis, that the Comfort Class level results in a good quality of life for pigs, especially based on the absence of observed welfare infringements (conclusion 1). Results on space use, synchronisation and clustering indicated that the theoretically derived requirements on space allowance and number of feeders might be reduced without compromising the Comfort Class level. The expected limited statistical power of the experiment did not hinder further development, as, during the process, working on the scientific underpinning of the concept was more important than the actual rigidity of the conclusions. The concurrent scientific activities legitimated the stakeholders’ activities and emphasised their claim that practical animal welfare improvement is possible. The project initiated further experimentation and design in practice and contributed to market introduction of welfare improved pork. The methodology applied in the project turned out to be the start of a series of interactive innovation initiatives in animal production sector, leading to the RIO ("Reflexief Interactief Ontwerp", Dutch for Reflexive Interactive Design) innovation approach. Conclusion 2 of this study is that this interactive approach to experimentation facilitates the implementation of science based welfare improvements in practice.

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1. Introduction

1.1. Context

The context of modern intensive livestock production in the Netherlands has changed at a fast pace in the late nineties/
early new millennium. Several disease epidemics (starting with swine fever in 1997) brought awareness of, and raised a public voice against, evolved practices in dealing with animals, especially pigs. After the initial governmental response to intervene with legislation (especially on husbandry conditions affecting animal welfare), the political choice was made to expect solutions from stakeholder/market initiatives instead. Government wanted to refrain from legislative interventions in the commodity system, despite its explicit ambition to enhance sustainability. At the same time the classical public role in organising agricultural research and extension was no longer taken. For this reason, the ministry of agriculture sought a way to use agricultural research as an intervention tool in organising sustainable development. A series of projects (Bos et al., 2009a,b; Bos et al., 2011; Groot Koerkamp and Bos, 2008; Eijk et al., 2010) on pigs, dairy cattle and laying hens was initiated that aimed to provide inspiring alternative arrangements for conventional agricultural practices with a higher level of sustainability. Characteristically, these projects involve stakeholders in the design process, incorporate interdisciplinary knowledge, and stimulate systematic reflection on basic assumptions that guide incumbent practices and bodies of knowledge (‘reflexivity’).

The study described here originates from one of the first of these projects. It started as an effort to address societal concerns on farm animal welfare, by carrying out a multi-stakeholder experiment. In collaboration between scientific organisations and an animal welfare NGO, the idea was pursued to develop a husbandry concept according to a ‘radical welfare approach’. The resulting concept discriminates between human and animal interests and bases its welfare claim on fulfilment of the needs of pigs. The concept was given the name Comfort Class, referring to the intended improvement of the husbandry facilities for the animals involved. Subsequently, the concept was adopted as a guide for collaboration by a welfare coalition between the major national farmers’ organisation and the animal welfare NGO. These parties joined forces to apply the welfare concept for animal welfare studies, farm innovation initiatives and societal interaction. The goal of the coalition is to reveal and stimulate opportunities for improved animal welfare in the pork commodity chain.

The current study presents results of an early stage of the animal welfare oriented Comfort Class project: a first demonstration and test of the Comfort Class principle in a test facility. The paper reflects the hybrid nature of the initiative, describing 1) the stakeholder process in which the Comfort Class concept was developed, tested and introduced, 2) the empirical scientific study that supported it, as well as its role and limitations, and 3) a discussion of the results in the light of the transition to a new phase in the innovation process. However, the main emphasis is on a more traditional (animal science style) presentation of the animal research that was conducted to support the welfare claim of the concept and to reduce the gap between conventional husbandry arrangements and the Comfort Class facility requirements. Execution of the study and availability of the results facilitated the stakeholder process to gain practical acceptance. After an introduction of the innovation process and the welfare view, the study will be introduced and results will be discussed.

1.2. The innovation process, the welfare view and the design process

In 2001, a research team was assigned by the Dutch government to conduct a two year desk study that could contribute to the alleviation of the deficit in animal welfare. The notion of animal welfare problems in conventional pig farming had become a societal theme after the swine fever epidemic in 1997, which brought the industrial scale and intensive husbandry conditions into the public eye. The assumption was that the scientifically well known (see EFSA, 2007) causes of reduced quality of life of the animals could be alleviated by a well-designed husbandry system based on existing scientific knowledge. The team consisted of 4 animal scientists (including 2 trained in ethology), a representative of the major Dutch animal protection organisation (academically trained in biology) and a professional process facilitator. The group was required to work interdisciplinarily, keeping in touch with a surrounding stakeholder group and to deliver an approach that could serve as a basis for systems innovations (radical change). Inspired by Gibbons (1999), the project was positioned within the real life context of stakeholder involvement and interdisciplinary gaps, and adopted a systems innovations approach: a specific view and methodology on innovation that stresses the importance of simultaneous social and technological change to attain radical improvements to current practices. It was inspired by the Sustainable Technology Development (Weaver et al., 2000) approach (DTO-approach: parts of which were later published in Grin and van Staveren, 2006; Quist, 2007, Smits and Kuhlmann, 2004). The group aimed to design an idealised pork production system that could claim the absence of animal welfare infringements.

For innovation–methodological reasons (e.g. Gibbons, 1999, Grin and van Staveren, 2006), some explicit choices were made related to the interdisciplinary and systems innovative goals. These comprised the choice for a clear and simple welfare view (see below), and the application of a design approach instead of solely an analytical approach. Also, the choice was made to work with existing knowledge and expertise rather than identifying and addressing scientific knowledge gaps, thereby avoiding the pitfalls of analytical scientific positivism.

The group acknowledged the variety of welfare views, ranging from ‘natural living’ (e.g. Fraser, 2008) to ‘physiologically normal’ (e.g. Broom, 1986) to ‘mental experience’ (e.g. Duncan, 2006). But the group also realised that these were rather (animal science-inspired) academic views on ‘good life’ or ‘normal functioning’. Available concepts such as the five freedoms (Brambell committee, 1965; FAWC, 1979) were judged to be valuable in depicting shortcomings, but difficult to use as the basis for radical design or reframing.

The group refrained from further defining animal welfare, but reframed the problematic by addressing the animal as a subject in its own right with needs and their corresponding requirements. To avoid confusion, the term Animal Welfare and its definition were deliberately avoided. A simple one-dimensional welfare view was adopted, based on Bracke et al. (1999a): the quality of life as perceived by the animal (as inferred by classical animal science). It was further postulated that this perceived quality of life is (to a large part) dependent on the degree to which the needs of the animals are met by
environmental facilities. These identified biological needs were (adapted from Bracke et al., 1999b):

- Exploration
- Social contact
- Rest
- Excretion
- Locomotion
- Satiation
- Health
- Thermocomfort
- Safety
- Comfort behaviour

Needs related to sexual behaviour and reproduction were omitted based on the choice to design for prepubertal animals.

The project group postulated that “the quality of life as perceived by the animal is good when these needs of the animals are met”. The underlying idea was that most of the ‘needs’ are related to the motivational system of the animal. Other factors that are less or not related to the motivational system, such as ‘health’ were analysed and reframed in a way that they could reasonably be forced into a perceived quality of life (no suffering) view. To avoid confusion with other welfare views, the term animal welfare was replaced with a notion of ‘satisfied pigs due to meeting their needs’. Alongside the project, this welfare view was further elaborated in order to address other values related to dealing with production animals as well, such as intrinsic value and naturalness (de Greef et al., 2006). However, the project reported here kept its sole focus on the first dimension: quality of life as experienced by the animal, facilitated by the husbandry environment.

In order to translate this welfare view into a contribution to real life pig husbandry, a design method was adopted: the Methodisch Ontwerpen approach (Kroonenberg and Siers, 1998). In short, this method comprises an explicit distinction between phases in the design process: 1) problem analysis, here: animal needs; 2) brief of requirements; 3) formulating an array of solutions and 4) finding the best combination of solutions into an integrated design. The approach allows introduction of the animal needs as rather technical demands, and allows a stringent separation between problems and solutions.

In this way, the complex, and socially constructed concept of Animal Welfare was reduced to the result of the interaction of the animal with its environment. This was subsequently operationalised by defining the requirements for the husbandry environment to address the 10 basic needs. This resulted in a list of 219 requirements per need, in total 57 requirements (Groenestein et al., 2003). In this literature based list, several separate needs required similar environmental attributes. For example space (area) was listed repeatedly as a requirement. During the actual design phase, the project group assessed the degree of overlap between the various space demanding requirements to provide an overall solution. For practical reasons, the project focused on growing-finishing pigs (25–115 kg) only.

The research group (including the NGO-representative) presented its view and results in the stakeholder group, in a multi-actor innovation meeting, in a small series of technical reports and published a brochure for a wide audience. The key message in the latter was that a good life for pigs is feasible albeit with drastically changed housing systems, with associated costs.

For communicative reasons, the term Comfort Class was introduced, in which the term comfort refers to the concept’s claim of comfortable living for the animals involved. The metaphor is drawn from airline travelling quality categories, and was applied to differentiate the animal’s quality of life from conventional husbandry conditions, with reduced comfort for economic reasons (‘Economy Class’). The group acknowledged that quality of life could possibly be improved even further (by realising positive animal emotions), but limited their (Comfort Class) ambition to a level at which environmental conditions do not compromise the quality of life. A clear example was the issue of the necessity of outdoor access. The group inferred that, theoretically, a situation in which all needs are fulfilled to attain a situation of no suffering could be met in an inside facility. Therefore, outdoor access is rather a means than a need in itself. Adding elements such as outdoor access may be very important for consumers and public acceptance, but may not be essential to the animal itself. The same was inferred for wallowing facilities. Phrased in the used metaphor, such additions were rather seen as elements of further improved quality levels above basic comfort (‘Star Class’).

Formally stated, the Comfort Class concept thus comprises a husbandry of animals in which the needs of the animals are met by the facilities and the care offered by the stockperson. A non-compromised Comfort Class approach is assumed to bring welfare (quality of life as experienced by the animal) to a level that it is not compromised by the husbandry environment.

Important stakeholders saw the relevance of the innovation and the concept attracted considerable media attention. The major Dutch animal protection NGO (‘Dierenbescherming’) and the major Dutch farmers’ organisation (‘LTO’) formed a strategic alliance to realise a ‘proof of principle’ unit: a facility to demonstrate, test and further develop the Comfort Class principle. Their activities were funded through a dedicated project initiated by the Dutch government, and further supported by a diverse group of other actors (charity fund, bank, feed company, vocational education body and provincial governments). The activities were directed towards three themes: proof of principle of the welfare concept, incorporation into standard farming practice, and visibility to the public (societal presence). In this paper, after an introduction to the stakeholder driven interactive initiatives, the focus will be on the proof of principle study of the animal component of the project, and the interpretation and use of the results.

1.3. Organisation of the innovation project

The farmers’ organisation and the animal welfare organisation formulated a project to test, develop and disseminate the Comfort Class concept. In this project, three central activities were undertaken.

1) Experimental evaluation in the specially designed and built experimental facility. This will be presented in detail below.
2) Interactive development towards commercial practice. An innovation group with pig farmers was formed in which the experiments were discussed, and husbandry design workshops were held. Gradually, this group developed towards a network that translated the Comfort Class approach towards their own farms. On an ad hoc basis, other relevant parties were involved (other farmers, advisors, government employees, local networks, and chain partners).

3) Active presence in the media (both professional and public). At regular times, initiatives were taken to attract media and explain the initiative. This activity was seen as an important means to bridge the long period between start (2006) and end (2009).

Milestones and important activities are presented in Table 1.

A steering group was formed with representatives from the most relevant participating organisations, with the task to guide the project and to connect it to policymakers and production chain parties.

At the end of the project, the results of the animal study were used to formulate conclusions on the technical applicability of the concept and to influence parties further down the chain (processors and retail) for market initiatives for improved welfare meat.

2. Material and methods of the animal study

2.1. Proof of Principle ambition

The welfare claim of the Comfort Class concept is based on the proposition that meeting the needs of animals results in a quality of life (as experienced by the animals) at a level that is not compromised by the husbandry environment. Thus: there will be no suffering due to shortcomings in the husbandry environment. This proposition is based on the assumptions that 1) the needs are known, 2) requirements can be formulated and quantified to fulfill these needs and 3) translation of the complete set of requirements results in a husbandry system that facilitates meeting all needs.

For the stakeholders involved, the most elementary method of acquiring empirical support for this set of theoretically derived assumptions was an animal study with observations on the animals themselves with the prime aim to get convinced and convince that the idea is feasible. Therefore, this was called the Proof of Principle study. The Proof of Principle aimed to acquire empirical support for the stakeholders that the theoretical animal welfare performance of the Comfort Class concept would result in 'real life pigs with no welfare problems' in a 'real life system'. A secondary aim was to collect data to assess the necessity of the assumed amounts and levels of the facilities (for example space allowance). The empirical setup was designed to meet the first aim. The secondary aim was seen as subsidiary.

2.2. The facility and the setup

2.2.1. Housing design

An experimental unit was designed and built taking into account both research needs and the requirements as specified in the Comfort ClassBrief of Requirements that was formulated on the basis of the animal needs (Groenestein et al., 2003). An existing organic production research facility was used as the base model. The developed system was a naturally ventilated house (30 × 20 m) with 1.50 m inflatable curtains in the side walls above a height of 1.50 m, regulated by outdoor sensors monitoring air speed and temperature. The room consisted of three blocks of four pens each. Pens could be combined within block (resulting in pens for 12, 24 or 48 pigs). Corridors for research and management activities were provided between the blocks and adjacent to all outside

Table 1
Time schedule of major project activities.

<table>
<thead>
<tr>
<th>Date/period</th>
<th>Actor group/theme</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 2001–March 2003</td>
<td>Academic and NGO</td>
<td>Development of the animal oriented design approach, resulting in the Comfort Class concept</td>
</tr>
<tr>
<td>March 2003</td>
<td>Academic</td>
<td>Presentation of the ideas to the outside world</td>
</tr>
<tr>
<td>May 2003</td>
<td>Stakeholder organisations</td>
<td>Adoption of the principle by a consortium of LTO and DB, ambition for a testing unit</td>
</tr>
<tr>
<td>October 2003</td>
<td>Stakeholder organisations</td>
<td>Press announcement by LTO and DB about plans to build a dedicated Comfort Class facility</td>
</tr>
<tr>
<td>January and March 2005</td>
<td>Farmers’ facilities</td>
<td>Test-sessions design with farmers on basis of Comfort Class principle</td>
</tr>
<tr>
<td>April 2005</td>
<td>Farmers’ facilities</td>
<td>Individual farmer starts plans to adapt pig unit ahead of the rest of the project based on Comfort Class ideas</td>
</tr>
<tr>
<td>April 2006</td>
<td>PoP facility</td>
<td>Opening of the experimental facility</td>
</tr>
<tr>
<td>April 2006–October 2008</td>
<td>PoP facility</td>
<td>Studies in the experimental facility</td>
</tr>
<tr>
<td>April 2006–November 2006</td>
<td>PoP facility</td>
<td>Proof of principle study</td>
</tr>
<tr>
<td>December 2006–</td>
<td>PoP facility</td>
<td>Study on stocking density and group size</td>
</tr>
<tr>
<td>December 2007</td>
<td>PoP facility</td>
<td>Study on stocking density and group size</td>
</tr>
<tr>
<td>January 2008–October 2008</td>
<td>PoP facility</td>
<td>Study on stocking density and group size</td>
</tr>
<tr>
<td>November 2006</td>
<td>Farmers’ facilities</td>
<td>Initiation of farmers’ design studies</td>
</tr>
<tr>
<td>October 2007, May 2008,</td>
<td>Farmers’ facilities</td>
<td>Finish pig unit alterations finished on pilot farms 1, 2 and 3, and subsequent monitoring of results</td>
</tr>
<tr>
<td>October 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November 2009</td>
<td>Chain partners</td>
<td>Concluding meeting of the project, directed at stakeholders higher up in the chain.</td>
</tr>
<tr>
<td>January 2010</td>
<td>Farmers</td>
<td>2 farmers’ meetings</td>
</tr>
</tbody>
</table>

a ‘Land- en Tuinbouworganisatie Nederland’, the major Dutch entrepreneurs and employers organisation for the agricultural sector.

b ‘Nederlandse Vereniging tot Bescherming van Dieren’, the major Dutch animal protection organisation.
walls, resulting in each pen being approachable from two or more sides.

2.2.2. Pen design

The pens were designed for 12 animals each, meeting the requirements as stated in the Brief of Requirements (Groenestein et al., 2003). Resulting key characteristics (deviating from conventional practice and related to the welfare study) were

- adequate space (~2.4 m²). This value was based on the brief of requirements, assuming partly an overlap between space demanding activities and no overlap with resting area needs
- clear distinction between functional areas
- ample opportunity for behavioural synchronisation.

Each pen (see Fig. 1) consisted of a covered resting area (‘creep’, 2.0 m × 3.8 m), separated from the rest of the pen with semi-transparent flaps, a concrete floor (4.0 m × 3.8 m) and a slatted area (2.0 m × 3.8 m) at a 20 cm elevated level.

Above each pen, a colour camera was mounted to the ceiling. The view of each camera covered the full pen except the inside of the resting area. The camera switched from full colour to black and white at a low light intensity. This switch level was chosen as the day/night criterion.

2.2.3. Meeting the animal needs (⊙ Need: solution)

⊙ Satiation: 6 adjacent ad lib feeders for each unit of 12 pigs. Two drinkers, adjacent to the feeders, one above the slatted area, the other on the opposite wall.
⊙ Health: conventional high health procedures. Active medication- and euthanisation strategy.
⊙ Safety: escape opportunities based on the visual separation between the creep and the other areas.
⊙ Exploration: each unit was provided with a metal half-circle ‘rooting trough’ (height ~20 cm), daily provided with a rooting substrate. In four units, a rooting device was provided additionally. Also, the chopped straw meant for bedding purposes was taken by the animals as a substrate for exploratory behaviour.
⊙ Excretion: a 2.0 m × 3.8 m slatted floor (slot width 18 mm, slat width 80 mm) was provided at the opposite end of the resting area.
⊙ Thermo-comfort: microclimates were available on the basis of the covered and insulated creeps. At ambient temperatures exceeding 25 °C, a water-sprinkler installation above the slatted floor was switched on for about 20 s twice per hour.
⊙ Social facilitation: all levels of the provisions were dimensioned to allow full synchronisation at pen level (resting, locomotion, and exploration) or at sub-group level (feeding and excretion). The size of the sub-groups was assumed to be 6 animals.

Fig. 1. Comfort Class facility plan and pen layout.
respectively, ending at the moment that the pigs in 91 m² (12 pigs in 28 m² = 2.4 m²/pig; 24 pigs in 48 m² = 2.0 m²/pig; 48 pigs in 91 m² = 1.9 m²/pig).

2.3.2. Research questions and measurements
Within the restrictions of the demonstration and test facility, a series of relatively practical observations and measurements was made to assess the functioning of the system as a whole. The main questions were:

A. Is the Comfort Class welfare claim empirically supported by observations of the animals?
B. Is the quantity/level of facilities (space allowance, number of feeders etc.) indeed required by the animals?

A. The question of the welfare claim was addressed by assessing 1) tail integrity; 2) skin injuries; and 3) activity pattern and space use.
B. The question of the number of facilities was addressed by studying synchronisation and clustering. Synchronisation is defined as performing a behaviour at the same time.

Clustering is defined as reduced mutual distance between individuals. For assessment of synchronisation and clustering of eating and of resting behaviour, the pictures that were taken at 15 minute intervals at four days in each batch were analysed. The data set comprised 4608 pictures per batch (4 experimental days with each 1152 observations, composed of 96 pictures of 12 units).

2.3.2.1. Tail integrity. In the theoretical/design phase of the earlier process, the (undocked) tail was considered to be an indicator of the degree to which no frustration behaviour was expressed. In other words, maintenance of tail integrity (i.e. no tail biting) would confirm the welfare claim, based on the view that tail biting is primarily the result of accumulation of (multi-factorial) frustration. Weekly, all tails were visually assessed and scored. The method of scoring is based on the same concept as Velarde and Geers (2007) and Zonderland et al. (2008). Scoring levels were Intact; Bite signs; Presence of tail lesions.

2.3.2.2. Skin injuries. Skin injuries were assessed on the basis of a visual assessment in three body zones: front, middle and hind. The zones were demarcated by the caudal end of the scapula and the cranial part of the hip. Lesions (scratches and wounds) were scored on a 6 point scale of 0–5 (no lesions–severe lesions). Weekly, each pig was observed on both sides and categorised.

2.3.2.3. Activity pattern and space use. During 4 days of spread out over the experimental period (weeks 3, 6, 9 and 12), images were taken from the cameras at a 15 minute interval during 24 h for each pen separately. The location of the pigs was scored (on the slats; on the concrete floor part adjacent to the slats; and on the concrete floor adjacent to the creep; invisible which implies presence in the creep). Activity was scored as either active (all non lying behaviour) or passive (all lying postures). Pigs in the nesting area/creep were assumed to be passive. The results on space use and activity pattern were extensively used in the farmer communication, but will not be reported here as they contribute little to the strict evaluation of the Comfort Class concept.

2.3.2.4. Synchronisation and clustering of feeding. Synchronisation of eating behaviour was assessed by counting the number of pigs visiting the feeder simultaneously during daylight hours on every 15 minute interval picture. The degree of clustering during eating was quantified by counting the number of empty places between the pigs at the occasions where two pigs were eating at the same time. The frequency distribution of these distances was compared to the distribution theoretically expected from random spacing. A shift to the left of the distribution would imply a reduction of distance between individuals (positive clustering), whereas a shift to the right would imply spacing (negative clustering).

2.3.2.5. Synchronisation and clustering of resting. The degree of synchronisation of resting is based on the observed synchronicity of activity. Synchronisation of activity was visualised by the existence of a consistent activity pattern. The observed numbers (or percentages) of active (or passive) pigs were
plotted against time, and compared for the four phases of the experiment and for the three group sizes. By definition, the complementary values of the activity numbers demonstrate non-activity, which here was indicated as resting behaviour. Resting pigs were considered to be clustered when lying with body contact. Clustering of resting is quantified by the size of each cluster of lying pigs.

3. Results

3.1. The Proof of Principle study

3.1.1. Tail integrity

The first batch started with 100% intact tails. During the fattening period, in 5 out of the 7 pens hardly any tail damage was observed, whereas in two pens (both single units containing 12 pigs), tail wounds were observed around halfway the experimental period. Of all tail observations a score of 3 (wound) was scored in 5.3% of the observations in one pen, and 21.2% in the other problematic pen. At the end of the experiment, all tails were scored having no recent damages in these pens (Fig. 2). No obvious causes for these incidents were present.

The second batch was populated from a weaner group with an acute outbreak of tail biting. Initially, 64.1% of the tails had recent damages, either biting dots (15.8%) or fresh wounds (48.3%). At subsequent evaluations, the number of intact (original and recovered) tails gradually rose (Fig. 2). On the last observation day, 97.2% of the tails was scored intact. No systematic differences between the group sizes were discernable.

3.1.2. Skin damage

During the entire Batch I, no notable skin damages were observed. 95.5% of the observations were scored as 0 or 1, implying no or maximally two scratches. In these sores, no distinct pattern in time, or differences between body parts are present (Fig. 3).

The number of skin injuries in Batch II on the middle and hind was low and stable over time. On average, the score was between 0.5 and 1. Between weeks 1 and 12, the injuries at the front part gradually rose to an average score of 1.5 in that batch. Of all observations, 73.5% had negligible scores (0–1), 24.3% was scored a 2 and in 38 observations (2.2%), the pigs were scored a 3. From week 8 onwards, on more than 50% of
the pigs a score 3 injury was observed on the front part. No pigs with lesions scoring 4 or 5 were observed.

3.2. Required facilities assessed by clustering and synchronisation of eating and resting

3.2.1. Synchronisation and clustering of eating behaviour
In 70% of the observations, no pigs were visiting the feeders. In Fig. 4, the frequency distribution of the number of pigs visiting the feeder at the same time is presented for both batches together. On average, 58% of the meals were taken individually. The rest of the meals were predominantly with 2 pigs. Using a 95% criterion, 3 feeding locations were sufficient for facilitate the voluntary synchronisation behaviour of 12 pigs.

The degree of clustering (reduced mutual distance between individuals) when eating was assessed in Batch II for the occasions where two pigs were eating at the same time (Fig. 5). Compared to theoretically expected distribution when random spacing, the observed distribution is shifted to the left, implying a reduction of distance between individuals (positive clustering). Especially the frequency of full clustering (no space between the pigs) was 40% higher than could be expected based on random spacing.

3.2.2. Synchronisation and clustering of lying behaviour
Synchronisation of lying behaviour was high. At night hours, 3–5% of the pigs were seen active. This was similar in both batches and amongst group sizes and experimental weeks/pig age (data not shown). In Fig. 6, the frequency distribution of the size of the pig clusters as assessed in Batch I is shown. Nearly half the clusters (47%) consisted of 2 pigs (which equals to 27% of the lying pigs).

3.3. Use of the animal results in the stakeholder process

3.3.1. Type of experimentation
At the initiation of the experimental phase in the Comfort Class project, the Proof of Principle (PoP) study presented here, comprising two batches, was planned and designed. At the same time, agreements were made to subsequently allow a further 2 years (about 5–6 batches) of experimentation to be filled in on the basis of requirements or questions of the supporting farmers’ advisory group.

After completion of the second PoP batch, the choice for subsequent studies was based on early impressions of the above presented results. The group chose to continue with studies on the level of requirements for space allowance (factors space allowance and group size, Vermeer et al., 2009; Vermeer et al., in preparation) and later on the need and

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**Fig. 4.** Frequency distribution of number of pigs eating in synchrony in Batches I and II.

**Fig. 5.** Distribution of the distance (number of places) between duos of pigs eating in synchrony in Batch II.

**Fig. 6.** Frequency distribution of the size of the clusters of pigs.
relevance of bedding (interaction of bedding type preference and ambient temperature). In contrast to the PoP studies here, the choice was made to allow the scientist to perform studies with contrasts in the design and with numbers of experimental units that allow statistical analysis.

3.3.2. Communication

Results from the Proof of Principle study were discussed with the farmers’ advisory group before communication to the target group through their professional media. The aim was to put little emphasis on the technical performance parameters (such as average daily gain and food efficiency), as the batches had a small size, and were kept in a non-representative facility. However, the national professional media were primarily interested in the performance levels. Therefore, results were communicated in a sandwich mode: welfare related results were combined with providing batch details on performance. The external representatives (from the farmers’ organisation, the animal protection organisation and from the research organisation) stressed that until completion of the project, all results were only indicative.

From Batch I, it was communicated that 1) the facility performed well, besides some start-up problems 2) the facility almost confirmed the claim that entire tails could remain intact; and 3) both pen fouling as well as tail and enrichment management required substantial labour input. The relatively large space allowance and the inadequacy of the enrichment facilities were given as early explanations for the fouling problem. The isolated incidences of tail biting could not be explained. From Batch II, main additional experiences that were communicated early dealt with the start with a tail biting group. The fading out of the tail biting problem (Fig. 2) was used as an argument that the facilities were able to overcome a tail biting outbreak. Further external communication on animal welfare related inferences was limited, as the people involved realised the limited scientific basis (lack of contrast and small numbers of independent observations).

Late 2009, as the formal project ran to an end, and after completion of the experimental studies, a final activity was carried out. The choice was made to address farmers as one target group through traditional, ‘regular’ farmer meetings. These meetings were planned to inform and convince farmers of the welfare improvement opportunities. The other target group that was addressed consisted of the actors that were seen as those that could provide a solution for the lack of market pull (especially representatives of the retail and the processing industry). The meeting with that group was planned to be an intervention on these actors higher up in the production chain.

A set of brochures was made, with farmers as the target group presenting 1) the process and ambitions as a whole; 2) the key results of the experiments; 3) motives and initiatives of the farmers involved, and 4) farm economic implications. The message was that, based on the experimental studies, the Comfort Class claim is confirmed, and that, on the basis of the farmers’ experiences, production capacity is available. And that the important next step to be realised would be an initiative of the retail and industry to allow a market segment of added value pork.

During the chain actors meeting, information was shared, the Minister of Agriculture made a plea for a market initiative and retail responses were harvested. Two of the leading retail companies expressed willingness to make a substantial contribution. Consequently, the ministry formally invited key players for a discussion meeting. The current status is that intentions for market initiatives by two retail representatives are publicly shared with the general media, originally mentioning the Comfort Class initiative as an inspiring concept. Meat has started to be produced according to welfare improved husbandry conditions, based on a subset of the requirements in the Comfort Class approach. Chain partners are now mobilising production capacity to initiate a market initiative, aiming at 1 million pigs in 2011.

4. Discussion

The Comfort Class approach is based on the assumed principle that offering facilities that meet the requirements of pigs results in good welfare. An important characteristic of this principle is, that it articulates a shared value of groups with different interests such as the government, farmers and animal welfare NGOs (de Greef et al., 2006). The joint adoption of the principle by representatives of the latter two groups and their efforts to conduct studies as presented here illustrate this shared value. The reference to quality of life and animal needs of the animals is easy to communicate. Also, the resulting implications for housing conditions are easy to explain and operationalise. In the Comfort Class process as a whole, this played a larger role than the technical results as produced by the experimentation. The elegant combination of a well communicable idea, a lively network of stakeholders that generally do not collaborate, and the involvement of both science, practice and media proved to be a good blend.

For the actors involved, the proof of principle studies was the start of several experiments, tests and demonstrations that made a promising theoretical concept practical. The results presented here acted as a hinge to switch from practical testing and demonstrating an idea towards scientific and economic assessment in order to facilitate practical adoption. The study was successful in drawing attention to the Comfort Class project as a whole, and in providing trust in the concept being feasible in a practical setting.

Below, the implications and limitations of the results of the animal experiments will be discussed in the order as presented in the results paragraph (proof of principle, number of required facilities, and use of the results in the stakeholder process). Finally, perspectives of the outcomes for the societal search for balancing animal welfare with pork production will be touched upon.

4.1. Tail biting

A major contrast between the study and practice concerns the undocked tails. The initial choice to use the tail as an important indicator was supported by the study. The observations on bite signs and actual lesions provide a nuanced view on undesired interactions between the pigs without the need for actual ethological observations. The project used and communicated intact tails as a natural indicator of ‘normal behaviour’. The results indicate that tail
biting is not absent in a facility like this, but that it is reasonably possible to grow groups of pigs with intact tails to the end of the finishing period. Even in groups of pigs with a tail biting history in the previous phase of life. This fits the expectation, as the animals were provided with straw bedding, a strong enrichment substrate (Weerd et al., 2005) and had ample space. Occurrence of small incidents can well be interpreted as incidents of frustration, albeit that the actual causes remained unclear. The systematic fade out of the tail directed abnormal behaviour in the problem group is a support against the ‘epidemic idea’ on tail biting (Schrøder-Petersen and Simonsen, 2001), at least in facilities such as the tested one. The tail biting events underpin the unpredictable and multi-factorial nature of this abnormal and unwanted behaviour. Also, the stockpersons’ role is of considerable importance, especially with regard to timely interventions.

The main practical implication of the tail results was that a well designed and enriched facility is not enough, and incidences do occur, thus active tail management is still required. Strictly spoken, the study does not prove the facility’s ability to prevent tail biting. But the experience of fading out in a problem group supports the expectation that the likelihood of occurring or maintaining outbreaks is considerably reduced. This fade out observation was communicated to practice, accompanied by the aforementioned nuance on the need for good enrichment and tail management.

4.2. Skin lesions

Overall, the incidences and levels of skin damages were low. In the vast majority of the observations, none or only superficial scratches were observed. From the observation in Batch II that the incidence of damages (slightly) increased at the front, and not at the middle and back, it can be inferred that they originate from interactions between animals that were rather of socio-hierarchical nature than abnormal. Groups were not mixed; the damages thus might be explained from increased interaction due to competition for resources. Yet, given the ample provision of food and feeders this seems unlikely. The availability of lying area in the covered nests reached its capacity later in the period, as the covered nests were calculated to just fit the number of pigs at slaughter weight. However, this does not explain the gradual increase in front scratches from the early weeks onwards. It has to be noted that the level as such is low, but not lower than levels seen in well-managed conventional systems.

4.3. Clustering and synchronicity

From the synchronisation and clustering observations, practical implications for required facilities can be drawn. The observations on degree of clustering of lying behaviour do not confirm the expectation of full clustering. Predominantly, rather small clusters were observed. Regarding the multiple number of clusters of lying pigs in each pen, and the relatively small size of most clusters, the results imply that splitting the lying area into several lying areas in a pen does not conflict with the preferred lying behaviour. Ambient temperature may have played a role in a part of the observations, but also at temperatures that are judged to be within the thermo-neutral or comfort zone (Mount, 1973), dispersed clustering was observed.

The degree of synchronisation of resting behaviour was classically high. At night hours, 3–5% of the pigs were seen active, implying 95–97% resting. This supports the ex ante calculations based on the allometric equation of Petherick and Baxter (1981): the lying area should fit all pigs at the same time. An addition to this is the need for some ‘slack’ area, to facilitate movement of the observed 3–5% of pigs that have some activities during the night. The multi-study meta-analysis result of Averós et al. (2010) finding a minimum k-value of 0.039 for maximising rest supports this.

The required space for synchronicity of active behaviour seems less than calculated ex ante. At peak hours, generally less than 50% of the pigs were active, and this activity was not limited to the activity area.

4.4. Sub-groups?

The needed quantity of facilities (space, number of feeders etc.) highly depends on the degree of synchronisation. Theoretically, some synchronisation could be a result of sub-group formation within the group as a whole. This is observed in peer-groups of gestating sows. Exploratory work in newly weaned pigs confirmed such groups early after weaning and mixing. These groups, however, dissipated rather quickly (Vermeer, unpublished). The question whether sub-groups are discernable is not answered. But the observation of small clusters whilst lying and limited synchronisation when eating at least indicates that such sub-groups, if present at all, will be small.

4.5. Practical conclusions on required level or number of facilities

The work supports the view that resting behaviour is highly synchronised. However, the limited degree of clustering (high incidence of small clusters) implies that provision of dispersed lying areas in a pen (for example in very large groups of pigs) does not conflict with the habit or need of pigs to cluster in their lying behaviour. The degree of synchronicity and clustering in eating was more than random, but relatively limited. When given ample feeder facilities, more than half the meals were consumed alone. And less than 20% of the meals were taken in a group of more than 2 pigs. From this, it is concluded that one feeder per 12 pigs conflicts with the eating habits of the pigs, and that 3 adjacent feeders are required to fit 95% of the meal incidences. The latter was the main message to be communicated to the practical setting.

The space offered to the animals (around 2 m² per pig, dependent on group size) was (economically seen) the largest difference with current practices. The results on degree of synchronisation of resting and activity suggest a minimal space requirement that amounts the lying area plus defecation area plus some slack space for manoeuvre.

The implication for welfare improvement in practice of these synchronisation and clustering results is that the observed feeding behaviour brings forward the need for multiple feeding places in a group. This was communicated to the practical setting as such and adopted there. The
motivation for synchronised lying is of such a degree that inadequate floor quality will not prevent pigs from synchronising that behaviour. But for a Comfort Class needs-fulfilment claim, and full size resting facilities with adequate floor quality is needed.

4.6. Proof of principle/the welfare claim from a technical perspective

The data gave no evidence of reduced welfare caused by lacking or limiting facilities. From this, however, it cannot be concluded that the animals were experiencing a good quality of life. On the other hand, the combination of the theory-based design and absence of negative welfare performance indicators is a strong argument for claiming that the facility brings good welfare. A direct comparison with welfare levels as realised in more conventional or alternatively improved (organic) is not possible. This is due to the set-up of the experiment, which was observational—context (the facilities tested) from which the results were derived.

4.7. Proof of principle/the welfare claim from a socio-technical perspective

For the Comfort Class initiative as a whole, the inability to demonstrate a clear cut animal welfare level (‘on a solid scientific basis’) is disappointing, but this was foreseen. Comfort Class is primarily a design based concept. And practical welfare-performance based indicators are scarce. For the process of animal welfare improvement (here using a clear cut needs based husbandry design), the demonstrative role is equally important as an unambiguous scientific result especially when considering that scientific results may be necessary, but probably never sufficient to attain closure on societally contested and constructed issues like animal welfare. Nevertheless, the presence of adequate facilities and absence of negative welfare indicators in the experimental facility do support the welfare claim of the Comfort Class concept. This was an important notion in the stakeholder communication. And the actors involved use this, albeit in a more generalised fashion: in most cases they do not restrict their reference to the results to the specific context (the facilities tested) from which the results were derived.

4.8. Methodological limitations

The nature of the present Proof of Principle study has some intrinsic shortcomings from a scientific standpoint. The work presented here does not fit in a classical scientific approach. A clear contrast treatment is not available, neither is a referenceable benchmark. Also, the number of independent experimental observations is small. Aside from some repeated measurement and time series analysis, statistical testing is impossible. This was foreseen and accepted by the scientists involved, and this is not a unique situation. Systems studies often suffer from limited numbers of independent observations or lack of ‘clean contrasts’, which results in problems in drawing statistically significant conclusions. Generally, this is due to limited resources and methodological constraints.

Had the tested Comfort Class facility been a draft husbandry system, this would have been a problem. However, the series of studies around the Comfort Class principle, starting with the PoP study, had no ambition of growing into a systems evaluation phase. The facility used was not a serious proposition for a real life system, but an experimental facility. The Comfort Class principle is a design principle, a concept rather than a set of requirements depicting a system. Thus, the experimental facility is just a designed combination of the requirements, allowing the exploratory test of the principle (as reported here) and allowing subsequent conduction of contrasting studies within that design (as reported in Vermeer, 2009 and Vermeer et al., in preparation). The parties involved repeatedly stressed this fact: even a poster was mounted in the facility stating “This is an experimental facility, not a blueprint for a housing system”.

For the sake of the increasing relevance of the work, the formulation of peer-reviewed (‘scientific’) conclusions was a prerequisite of the subsequent studies. The experiments following the Proof of Principle study performed in Batches III–VII, did obey the classical scientific habits and rules.

Results on production performance and animal health were not evaluated here, and stakeholder communication on them was minimised as far as possible. There are several reasons for this. The first is the limited size of the study. Especially on these practically relevant parameters, communication of soft figures may lead to false inferences. Also, the experimental context led to unusual situations such as high starter weights (due to late availability) and early experimental ending (due to reaching slaughter weight of the first pigs), leading to changes in stocking density. A more principal point is that the data on performance and health cannot be seen (and should not be used) as representative for any practical facility that is designed on the basis of the Comfort Class requirements. Strictly spoken, the performance and health results are not representative for regular exploitation of the facility as tested here, and should not be used here for the evaluation of the Comfort Class Principle based on the used facility.

4.9. The Comfort Class process

The Comfort Class initiative (development and adoption of the concept and its introduction in practice led by stakeholders)
is rather a socio-technical innovation than a substantial technical development. The real innovation is not so much the (technical) combination of facilities. The innovation ambition and the results were plural and of heterogeneous character. First, it comprised the deliberate choice to refrain from natural conditions as the ultimate reference, but to refer to the animal needs only. Secondly, the choice to focus on the animal well being and explicitly separate this from other human values in animal welfare (De Greef et al., 2006) attracted stakeholders, ignited discussion and provided clarity. Above all, the adoption of the concrete welfare concept by the consortium of the major Dutch farmers’ organisation and the major Dutch animal protection organisation affected the way the welfare debate is structured within the pig sector in the Netherlands. For the farmers involved, animal welfare was converted from ‘implementing a legally enforced set of extra requirements’ to a ‘design process with the key goal to harmonise husbandry facilities with economic possibilities’.

In this way, the (technical) degree of ‘proof’ of good welfare is less important. From a scientific point of view, such a ‘proof’ is highly desirable but virtually impossible, as the available set of welfare indicators is too narrow and too imprecise for a possible demonstration of the nowadays rather nuanced contrasts between (improved) conventional circumstances and the needs-based design as tested here. In conventional practice, the number of skin lesions or scratches is low as well. And the observed activity patterns as shown are rather robust. Nevertheless, from an animal science point of view, especially the results on synchronisation are relevant. The (already known) full degree of synchronisation in lying behaviour and its observed low level in food intake behaviour are valuable both for our view on the pig group dynamics and for formulating requirements. And, not in the least, these concepts (synchronisation and lying behaviour) facilitate a change of minds with farmers and designers towards more animal oriented design.

4.10. Reflection on the role of empirical study in the process

The arguments above describing the innovation process as a whole may suggest that the empirical study in the Comfort Class facility was not essential. This is not the case. The leading parties had a rather positivistic view on the role of experimentation, and great trust in science to be unequivocally able to deliver objective truth. Their trust in ‘clear science’ was high, despite the warnings that the studies would not give hard evidence. Secondly, apart from the explicit trust in science and the inevitable requirement to measure, a communication argument also played a role. The steering representatives believed that experimentation by scientists would contribute to communication with their own home base (member farmers and NGO-supporters, respectively) with more authority.

4.11. Reflection on the methodology

The initial animal oriented design project that initiated the study presented here, as well as the experiences with the subsequent steps, has laid important foundations for a more elaborate approach called Reflexive Interactive Design (RIO, in Dutch). RIO is an approach for doing reflexive modernisation (Bos and Grin, 2008), i.e. the attempt to modernise our ways of production and consumption without repeating the mistakes of first modernisation (Beck et al., 1994), that is increasingly confronted with its self-generated risks and side effects. In RIO reflexive modernisation is seen as a prerequisite for sustainable development, which is by definition a multidimensional challenge of both technical and social nature. Piece-meal engineering, based on step-by-step improvements on one dimension at a time, will likely generate new undesired side effects on other dimensions of sustainability. RIO is described in more detail in papers that deal with projects that followed Comfort Class, such as Houden van Hennen on laying hen husbandry (Bos, 2008; Groot Koerkamp and Bos, 2008) and Cow Power on dairy husbandry (Bos et al., 2009b) as well as more methodical papers (Bos and Groot Koerkamp, 2009; Bos et al., 2011). Key characteristics of RIO are already visible in the sequence of projects described here: 1. a focus on needs (instead of solutions), 2. a reflexive attitude to basic assumptions, beliefs and standard technologies and practices in the current production system, 3. an interactive setup that enables learning and enhances reflexivity of a range of stakeholders involved, 4. a focus on engaged design instead of distantivated analysis, 5. the choice for structured design, and 6. a keen eye on the power of niche experiments to create space at the regime level for practices that break with entrenched practices. In this approach, the present Comfort Class case is the most developed in sandwiching experimental scientific work within interactive innovation and design activities. It has contributed to a better understanding how design and design processes facilitate the governance of system innovations by heterogeneous groups of stakeholders (Bos et al., 2011).

4.12. Contribution to sustainability?

A key element in sustainable development for the regular commodity oriented pork chain is to both (re-)establish a societal ‘licence to produce’ and at the same time to find a way to deal with the economic consequences associated with the changes in practices related to meeting societal demands. The Comfort Class initiative contributed to both of these. The project played a role in the change of the attitude of farmers towards animal welfare. Instead of opposing welfare improvements (classical: stressing that farmers can’t afford them), they took the opportunity to study the opportunities for meeting requirements. Especially through involvement of the media, the project served as a means to expose farmers’ initiatives for enhanced animal welfare.

The second effect on sustainable development is related to the final orientation the project took. The retail was challenged, and the NGO involved offered its hall mark for better animal welfare for initiatives. Result is that by the mid of 2011, about a million Dutch pigs will be produced in enhanced animal welfare conditions. The contingency that all supermarkets may exchange all regular pork for pork with a welfare claim (like the major Dutch supermarket formula announced in 2010 for their share), implies two gains in sustainability. It comprises an increase in quality of life for millions of pigs and implies a step aside away from the global pork commodity system. The latter is a step towards a
systems innovation for the seemingly inert production chain (Greef and Casabianca, 2009).

5. Conclusions

The stakeholder led Proof of Principle study to verify the Comfort Class claim produced mixed results. Scientifically, the study offered support (but not unambiguous proof) for the hypothesis, that the Comfort Class level results in a good quality of life for pigs, especially based on the absence of observed welfare infringements. A strict scientific confirmation of the concept’s (quite ambitious) claim is both philosophically and experimentally difficult (if not impossible). Practically, the study improved trust in the concept amongst stakeholders involved and the willingness to further translate this into practice.

Results supported the theoretical expectations of required space, with indications that the degree of synchronisation may reduce the calculated space requirement. The observation of synchronisation and clustering behaviour (addressed for resting and eating) was fruitful in demonstrating and quantifying the habits of the pigs involved and the opportunities in meeting the underlying needs. For behaviours that are not fully synchronised, the idea of subgroup formation influenced the calculated level of requirements. In the present work, no evidence of the existence of substantial sub-groups was found; neither in the synchronisation of eating behaviour, nor in the clustering of laying behaviour.

The integration of stakeholder process and animal science experimental work proved to be successful in the development of the innovation route from science to practice. The current Comfort Class case acted as a well received starter of a series of comparable interactive innovation routes, and of the development of the RIO (Reflexive Interactive Design)-methodology.

5.1. Animal welfare implications

The Comfort Class approach provides a scientifically informed foundation to incorporate animal needs in the design of animal production systems. The results of the study reported here provide empirical support for the associated welfare claim. The results on synchronisation and clustering yield opportunities to reduce the theoretically derived requirements for space and number of facilities (e.g. feeding places) towards levels that are practically more feasible. This innovation route facilitates market initiatives for pork production systems with increased animal welfare. Current developments illustrate that they are coming within reach, even for commodity based systems such as in the Netherlands.

5.2. Systems innovation implications

The Comfort Class experiment may lead to a so called system innovation: an encompassing set of changes in an existing (production) system, that implies profound changes not only at the technical level, but also at the social and institutional level. Important indicators for this are the changes in the relations between generally opposing parties that collaborated in the experiment, and the change in the way animal welfare is conceived of since the introduction of the Comfort Class concept.

The pilot facility is a (technical) novelty in itself, but its system innovative potential resides more in its non-technical features. It is a tangible material realisation of a specific conception of animal welfare that enables different stakeholders to collaborate in new ways, it has become a yard stick for improved animal welfare for fattening pigs in the Netherlands, and it has proven to inspire farmers to take measures on their own farms beyond expectations. Thus, whilst the underlying knowledge and technology are important, and the scientific scrutiny of its merits is highly functional, the dominant role of the facility is non-technical, including the accompanying process that led to it.

Conflict of interest

“The work reported in this manuscript is not being considered for scientific publication elsewhere. The authors declare that there are no conflicts of interest related to this manuscript or the study that is reported in it”.

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