"Animal well-being is understood as living in reasonable harmony with the environment, physically as well as psychologically, meaning that the environment must be of such quality that it is within the adaptability of the animal involved"

G. van Putten

PREFACE

This report was elaborated with the purpose to describe a pig social interaction trial carried at Research Centre for Pigs in Raalte, The Netherlands under the *Animal Sciences Group Wageningen, UR*. This thesis was a part of my studies in *CAH*, Dronten - Netherlands and in *UTAD*-Vila Real, Portugal.

This research was conducted with the aim of analyse the pig behaviour in their competition for the facilities, analysing as much as possible the drinking, feeding and rooting behaviours in different pen types, sizes and animal densities.

This thesis contains one first chapter that is a literature review about the subjects mentioned above and a second one describing the trial in Raalte, results and discussion. This thesis is finished with some conclusions according to the results obtained.

The target groups of this thesis are farmers, teachers and animal protection organizations. Furthermore this can be useful also for students or mere interested persons who would like to have some more information about this subject.

This thesis was written by Job Ferreira.

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…I hope not forgetting anyone, but if I am, my truthfully apologies…

CONTENTS

ABSTRACT

This experience was conducted to test and analyse the pig behaviour and welfare in their competition for the facilities (feeders, drinkers and rooting machines), analysing as much as possible the drinking, feeding and rooting behaviours in two different pen sizes (single/double) and animal densities.

Video observations during 3 months (January, February and March of 2007) were made in twelve pens with different number of animals to study behaviour measures in the different densities of 1.2, 1.8 and 2.4 m^2 per animal. The observations follow the fattening period until the days before the slaughter.

The results reached help to conclude that agonistic, interactive, inactive and sexual behaviours between pigs are generally higher in single pens, in the feeders and in the 1.2 density group.

The drinkers were the facility where less behaviour was detected. The feeders are the facility where pigs are generally more aggressive and the total number of aggressive interactions in the feeders is also affected by group size and number of hoppers. The rooting machine beside some significant agonistic behaviour observed, promotes the socialization between pigs, and consequently is a good device to decrease or avoid behaviours of frustration and stress.

The results reached in this trial are similar to other studies made before with growing pigs.

Key words: pigs; behaviour; competition; welfare; facilities; drinking; feeding; rooting; density; interactions.

GENERAL INTRODUCTION

In most European countries animal welfare is an issue of increasing importance. In individual countries and at EU level legislation is extending. It regards mostly minimum importance requirement. In production chain networks, additional conditions for animal welfare may be adopted, more than once strongly related to the image of the production. Improved welfare and perceptive qualities are intermingled then. Main welfare issues in pig husbandry have done with the discrepancy between the biology of the species and the type of environment, which is offered. These points to the following aspects to be considered with priority in most farms:

- Space and resting;
- Substrate for foraging, rooting and exploration;
- Climatic factors in the barn, with thermoregulation, air quality and floor factors as important components (management of these factors on the farm).

For pig producers a balanced approach in welfare evaluation and insight in alternative solutions are most relevant for the integration of welfare requirements in their systems (Metz and Backus, 1998).

We are living in a time that only the strong and able to compete survive. To be capable to face this condition, productions have to be pull for maximum levels and improvements have to be done all the time. The swine husbandry is an example and farmers are always growing and increasing their productivities trying to reach always the highest income. As long as the legislation allow (and this one is very restricted concerning animal per space, concentration, farm localization, environment) competitive farmers will continue to grow for a better satisfaction of market demands.

In recent years there has been increasing public concern in the comfort and welfare of farm livestock housed under so-called intensive husbandry conditions. In particular, the crowing imposed upon growing pigs under some systems has been subject to criticism. Bryant and Ewbank (1972) also developed studies with various species that shown that increasing population density, in generally is associated with the increase of the aggressions and anti-social behaviour.

The evaluation of animal comfort and well-being is one of the greatest challenges facing animal scientists and we might never get satisfactory answers to some of the

questions related to animal welfare issues (Hartsock and Curtis, 1983). The problem arises because the concept of welfare and different measures of welfare do not always co-vary. Indeed there is no easy way of knowing how much weight to give each of the various measures, nor at what level does a measure indicate poor welfare (reduce welfare is indicated by pathological measures such as broken bones, wounds, stomach ulcers and disease) (Beatti and Walker, 1995).

Having in account this problematic the *Animal Sciences Group of Wageningen UR*, has developed the project "*Pigs in ComfortClass*" in Raalte-The Netherlands. "*Pigs in ComfortClass*" is an innovative development and is the result of other radical approaches to cattle breeding systems. This project aim to satisfy the pig needs that have been mapped by means of a huge research data that was the result of years of investigations and it's purpose is to reach a housing system that is economically possible and with less costs and where the pig's welfare can be satisfied ("*Varkens in ComfortClass*", 2007).

This experience is based in the satisfaction of the ten most important needs of the pigs: satiety (food and drink), rest/relax, exploration, social contact, excretion/defecation, comfort behaviour, movement/locomotion, health, thermo comfort and security/protection. This thesis will analyse the pig behaviour and welfare in the competition for some of these elementary needs: feeding, drinking and playing/rooting in this husbandry system of production. These three actions are strongly associated with the satisfaction of the animal welfare because the majority of the aggressions and other undesirable behaviours happen during these activities (Morrison and Hemsworth, 2003). Analysing the behaviour in these three spilling, in different space allowance or animal densities will give an insight view about their behaviour and satisfaction of the needs and also check improvements that could be made to increase the welfare.

This thesis aim to reach more information and useful data, using traditional methods (direct observations and videos recorded of the animals time spending), that could be an important help in giving answers to issues as: effect on the behaviour of the facilities in different densities; competition between pigs concerning these facilities increase or decrease the welfare; this new husbandry system can convince farmers that these husbandry system and improves made are better for animal welfare; and/or competition for the facilities is a way for pigs live more actively and social, providing a life more mentally healthful.

PARTE A | LITERATURE REVIEW

1.1. Introduction to the subject

Nowadays we are surveillance to a completely and massive rise of the swine production sector, where producers are always trying to reach the nest level of efficiency in order to decrease their fix costs and get better profits. Concerning this challenging, the producers/farmers are staking in the enlargement of the size farms and/or increasing the number of animals per square meter. Besides the requirement of maintain the high productivity, the control of pig behaviour and animal welfare improvement are requirements that have to be fulfilled.

Until these days, the conventional production has been to grow the animals in small pens and in small groups, but at the present time and having in mind this aim of production increase, this option is a limiting factor that farmers are renouncing. By increasing the number of animals, farmers get so many advantages like higher monetary incomes, space savings, equipment reductions, easer mass standard management (as ear tattooing, vaccinations, teeth clipping, castrations or tail docking), that some other vital topics of the production management, as animal welfare or animal behaviour, are going, irresponsibly, for second plan ("*Varkens in ComfortClass"*, 2007). Furthermore, nowadays productivity has been improved through the use of high quality feed, genetic selection for pork traits and a decrease in the weaning age of piglets to 3-4 weeks to increase the number of litters per sow per year (Bolhuis, 2004).

Behaviour measurements are a difficult subject to analyse and reach conclusions but, when behaviour is used as a welfare measurement, two different animal responses could be observed. Firstly the behaviour observed may be the animal's actions to help it cope with the difficult situation or secondly it may be behaviour pathologies that have no beneficial effect and which can harm the perpetrator or others (Broom, 1991).

Today these issues are getting a vital importance in society and an outcoming restriction laws and legislations are punishing the unaccomplished farmers. Animal welfare is a key concern in society's unease about practices in intensive animal production and the rise of public debates about animal welfare vary widely. Consequently farmers focus on regular care based on habit and good intentions, scientists

focus on biological parameters, the public on icons like space, straw and outdoor access and animal protection organizations combine animal nature with maximal care.

1.2. Social organization, interactions and group size

Pigs are social species with strong tendency to form groups and live in a dynamic competition for food or access variable resources. The social organization of groups of pigs is known to include the establishment of a social hierarchy (Fraser, 1974; Jensen, 1980; Jensen and Wood- Gush, 1984). This social environment can be a source of social support and allow them to improve their capacity to cope with new environment demands. On the other hand, the instability, low predictability and low controllability of interactions with the other pigs of the group may lead to aversive situations (Bolhuis, 2004). Anyhow, for this social hierarchy function properly, the size of a group and the space allocated to it are very important (Jensen, 1982). The mixing of unfamiliar pigs of similar weight and age cause severe aggressions, more evident during the first day (Arey and Franklin, 1995), which is supposed be the formation of the hierarchy. The need that pigs of a group have to be capable of prompt recognition of each other is very important and still uncertain how the mechanics of recognition operate, however it is evident that different types of recognition exist. A form of face to face recognition appears to operate during an initial introductory period in the formation of the hierarchy. Sensory clues such as olfactory stimulations are probably involved in the maintenance of the social organization, moreover is evident that pigs in an established group are quickly able to recognize an/a unfamiliar/strange in the group. Visual and olfactory cues seem to be the principal differentiating features of pigs for each other (Frazer and Broom, 2001).

Conventional group size (10-30 animals), pigs show a dominance relationships which are built through aggressive behaviours (physical strength and fights) (Turner et al., 2004). In small group of pigs, the ability to individually recognise group members is very important for the working of the dominance hierarchy (Ewbank and Meese, 1971). Moreover, relative position in a dominance hierarchy becomes more important as resources become restricted. Hughes (1997) supposed that “animals in large groups (>50 animals) are more socially tolerant” which for Pagel and Dawkins (1997) contributes to the abandon of some attempts to establish social hierarchies. Greater availability of total

free space and feeding spaces also seems to eliminate the need for a dominance hierarchy (Hemsworth and Barnett, 2001).

It has been widely argued that aggression in pigs is due to the formation of a dominance hierarchy and higher levels of agonistic behaviour may be a result of the high incidence of social behaviour. The confirmation for this proposal comes from the observation that a pig being nosed by a pen mate would often retaliate by head thrusting the infringer pig. Such chronic aggression is evidence of poor welfare (Schaefer et al., 1990). Anyway, when the social hierarchy is established, which happens very easy and fast in a newly mixed group of pigs, is maintained by non-aggressive relations, low intensity aggressions and avoidance behaviour (Turner et al., 2004). Periodically, this dominance relationship must also be reinforced (more require in small groups) to "solidify the association between the identity of an animal and its dominance ability" (Bryant, 1972).

Effect of group size, stocking density and their interaction are subjects that are closely related. Rodenburg and Koene (2007) argued that "increasing the group size maintains or increases social support, whereas increasing the stocking density increases stress" and experiences made by Andersen et al. (2004) showed that more fights (in percentage) occurred after mixing groups of 6 and 12 pigs than groups of 24 pigs. Pig large groups were less aggressive to unfamiliar pigs than pigs from small groups, whereas they could still identify familiar pigs (Turner et al., 2001). This approach seems to be more advantageous to a pig in a large group than dominance relationships (Pagel and Dawkins, 1997; Anderson et al., 2004). Higher levels of cortisol founded in pigs housed in pairs than pigs housed in groups of 4or 8 with same space allowance per pig may proved that large group size can also reduce emotional stress (Takeda et al., 2003).

Bolhuis et al. (2005) trying to compare aggressiveness and fighting strategies in pigs found that pigs high resistant to fights (HR) showed more aggressive behaviour during the first hours after weaning and mixing but no dissimilarity in the achievement of the group social rank .On the other hand, in pigs with low resistance to struggles (LR), relationships were found between self-initiated fights and social rank. HR pigs showed high levels of violence in spite of of their success. Bolhuis (2005) concluded that this type of aggressive pigs "may cause problems in large groups, because they have difficulty in adapting their social strategy".

Turner et al. (2001) refer a clear reduction in the expression of aggressive behaviour by pigs in large group and concluded that aggressions did not increase by large group size (Turner et al., 2004); however pigs have the ability to discriminate between group members and pigs from other pens. The target group of the aggressions was primarily the foreign pigs which prove that pen mates were familiar with each other. They found also that, in large pens, pigs fight after mixing until reach a certain level of exhaustion or injury or they become more selective with whom they will fight. These authors concluded that different combinations of the social strategies are adopted by the pigs because in a large group there is a great variability in individual aggressiveness, for that reason behaviour on an individual pig should be study in large groups. In conclusion, there is reduction in the incidence and severity of aggressions by pigs previously housed in large groups, however these pigs were still able to discrimination among pen mates or alien animals. Turner et al. (2001) explain this contradiction by changes occurred in the social structure in pig small groups which could be caused by the inability of individual recognition or a strategy change.

The pig production conditions during the socialization period in early life, in particular space allowance, are crucial for develop pig social skills (Bolhuis et al., 2005). Moreover, in later life measures this could help to improve social stability and reduce social stress, as for instance, providing conditions that help the use of assessment as an alternative of fighting to resolve conflicts (Anderson et al., 2000; Jensen and Yngvesson, 1998).

Krohn et all (2000), with the aim of finding a method to evaluate the minimum welfare-acceptable floor space required for each group housed pig, distributed randomly in nine groups with six pigs in each at three different stocking densities: 0.27 m2 (0.84 x 1.95m) per pig, 0.44 m2 (1.08 x 2.45 m) per pig and 0.52 m2 (1.55 x 2.00 m) per pig, according to table 1.

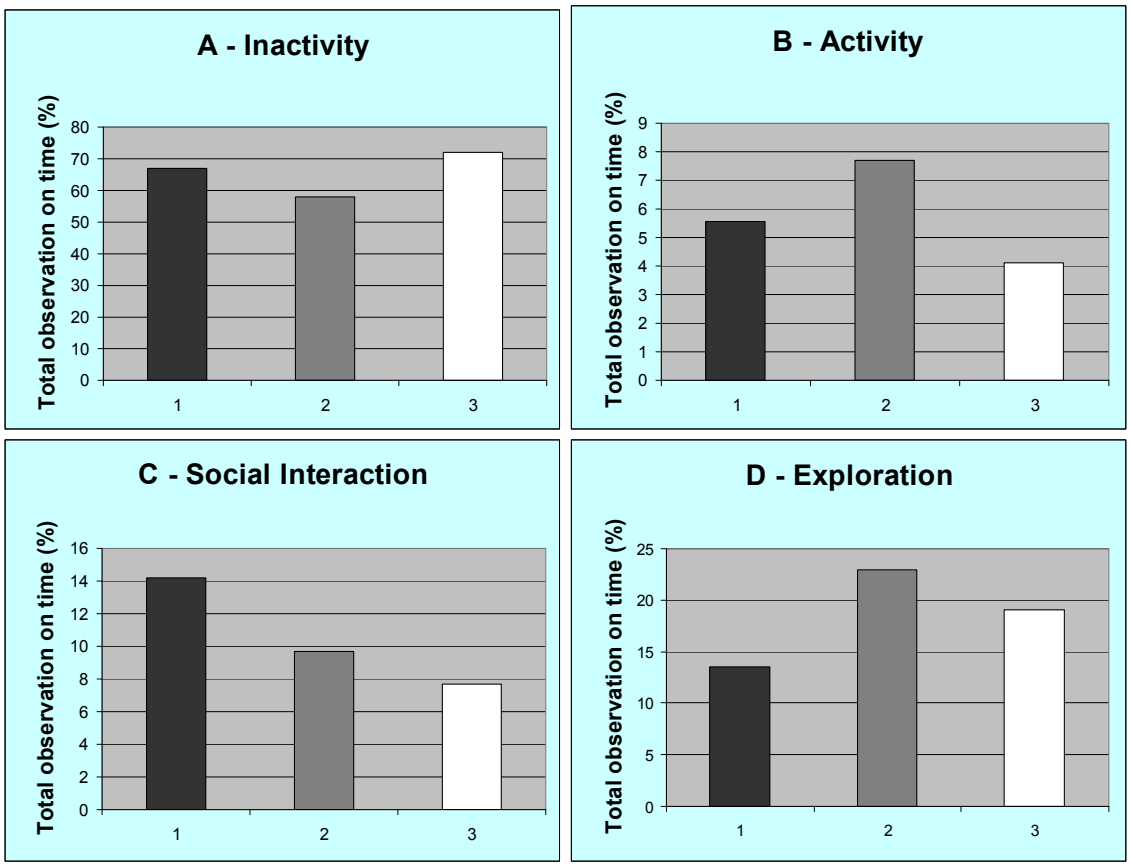
[1]**Table 1**
Experimental design: number of animals per group and per density.

	0,27m^2 per pig	0,44m^2 per pig	0,52 m^2 per pig
Group 1	6	6	6
Group 2	6	6	6
Group 3	6	6	6

[1] Scand. J. Lab. Animal SCi. Nº4. 2000. Vol. 27

Important to refer is that the highest density is almost identical to the European guidelines for farm pigs at 15 kg (Council of Europe, 1986) and the lowest density is close to the U.S. National Council's guidelines (National Research Council, 1996). Moreover, the pigs were fed twice a day and water was offered ad libitum. The outcome of this research shows no significant differences between the three housing densities and neither were there any behavioural differences between morning and afternoon observations (Fig. 1).

[2]**Figure 1.** Inactivity (A), active behaviour (B), social interaction (C) and exploration (D) as percentages of total observation time for the three densities (0,52 , 0,44 and 0,27 m2 per pig). Values are means for each density +SEM.



1-Low density
2-Intermedium density
3-High density.

There were no significant differences between the three densities observed concerning all behavioural categories. However, previous studies also showed that communication in groups are affected by high stocking densities (Ewbank and Bryant, 1972) and caused serious fights and other agonistic behaviours among the pigs (Bryant and Ewbank, 1974).

[2] Scand. J. Lab. Animal SCi. Nº4. 2000. Vol. 27

This study shows that aggression was observed so rarely that no conclusion could be made, and aggressions were jointed in the category for social interaction. For the pigs lying in direct physical contact with each other, no differences were found between the groups. The study also indicates that pigs do not feel aversion against being close together when resting, which corresponds with the results for social interaction. In general, the sitting/inactive behaviour is regarded as a cut-off behaviour as the pig tries to cope with the housing conditions (Pearce and Paterson, 1993). This study shows differences in the amount of sitting behaviour among the three densities. As far as group sizes are small enough, this study shows that pigs seems to be more affected by the environmental enrichment than the exact space within the ranges (Krohn et al., 2000).

1.3. Environment enrichment and space allowance

Animal production in modern systems frequently confines pigs in housing systems that did not allow the expression of their motivated behaviours. This conditioning can result in psychological distress and consequent abnormal behaviours as stereotypes and passiveness (Wood-Gush et al., 1983; Spinelli and Markowitz, 1985; Chamove, 1989; Wemelsfelder, 1990; Poole, 1992). A widely held assumption is that creating a naturalistic environment for animals will allow them to display their normal range of behaviour. Besides, an enrichment of an environment doesn't have to replicate nature but that the aim of enrichment should be to create an environment sophisticated enough to provide feedback (Grandin, 1989).

The term "environment enrichment" from a scientific point a view should only be applied to situations where environment changes have improve the performance of "strongly motivated specific behaviours or more complex behavioural repertoire" (Poole, 1992; Newberry, 1995). Anyway, Newberry (1995) defined environment enrichment as "the modification of a barren captive-environment to improve the biological functioning of animals", which allow them to perform their specific behaviour and choices. In addition, Weerd and Day (2008) defined successful enrichment when there is compliance of these four premises: "it should increase species-specific behaviours; it should maintain or improve levels of health; it should improve the economics of the production systems; and it should be practical to employ". These authors also

emphasize the importance of the possible bio-security risk when enrichment is moved between pens: "high standards of bio-security should be maintained and enrichment should be regularly cleaned and disinfected". Besides, the objects introduced for the enrichment shouldn't be able to be chewed and ingested (because they can cause obstructions problems) and they should be functional, easy to use and economic.

Enriching the environment with toys, substrates or others is a way to reduce aggression and improve welfare (Blackshaw et al., 1997; Morita et al., 1998), i.e., rearing environment has strong effects on both the central nervous system and pig behaviour, decreasing excitability and fighting (Grandin, 1989).

A study aiming to identify which factor, enrichment or space allowance, had more influence on pig behaviour, shows that when both increase, nosing and tail biting reduce. The results demonstrated also that there was less exploration of substrates and more inactivity in pigs under an enriched environment. On the other hand, pigs demonstrated more locomotory behaviour when given greater floor space in enriched pens. Duration of harmful social behaviour was greater in the barren that in the enriched environment and larger space allowance on its own did not encourage locomotory behaviour but only increased space allowance with enrichment (Beattie, 1996).

Other study made about exploratory behaviour had demonstrate that pigs, that are naturally exploratory animals, in barren pens, nosed the walls and the feeding equipment with much more frequency that the ones in enriched environments. In addiction, Horrell (1992) found that behaviour rubbing heads which involved nose to nose contact is a way of recognition and the increase of olfactory and visual cues with age is responsible for the decline of this behaviour. More investigations showed that shorter periods of time spent in exploratory behaviour by pigs in the barren environment were complimented by higher durations of harmful social behaviour. This statement supports the argument that pigs in the absence of substrates use pen mates as substitutes and this harmful social behaviour was composed mostly by persistent nosing and chewing of pen mates which led in some cases to cannibalism.

Pigs in large groups can have been suggested to more efficiently use space in crowded conditions as the free space available to all pigs is greater (McGlone and Newby, 1994). McGlone and Newby (1994) also hypothesized that space could be reduced in large groups without negatively affecting production. However, a study in a strawed system did not find such interaction (Turner et al., 2000), and studies in non-

bedded systems have not provided identical space allowances to both large and small groups (McGlone and Newby, 1994; Wolter et al., 2000). Some symptoms of chronic stress clearly indicate an animal welfare reduction. For instance, generally is accepted that injurious behaviours that damage the animal itself or its mates have negative implications for animal welfare (Wiepkema and Koolhaas, 1993). The increased aggression and increased manipulation of pen mates in barren housed pigs as compared to enriched housed pigs may lead to injuries and tail-biting, and it was consequently concluded that barren environmental conditions have negative implications for pig welfare, or increase risks for pig welfare (Beattie and Walker, 1995; Schouten, 1986). In addition, monitoring stress at farm level is important to help the farmer to make decisions to improve welfare, health and productivity and it is also important for certification of products. Moreover, it can be used to evaluate new or existing pig husbandry systems and changes in the legislation concerning the animal welfare.

A research made demonstrate that crowding pigs resulted in reduced overall productivity, with the greatest effect late in the study when pigs were most crowded. Space restriction has been associated with reduced gains (Brumm and Miller, 1996; Eisemann and Argenzio, 1999), reduced feed intake (Hanrahan, 1981), and reduced G:F (Brumm and NCR-89 Committee on Swine Management, 1996; Brumm and Miller, 1996), although effects on G:F have been variable. Crowded pigs were also observed eating less frequently than uncrowded pigs. The level of physical restriction imposed on pigs near the end of the study may have been responsible for hindering feeder access, as mobility was most restricted at that time. In addition, crowded pigs eat fewer meals and had greater latency to their next meal than uncrowded pigs, but only during the final observation period (more crowded). Concerning the behaviour of crowded pigs they were experiencing a greater level of stress than uncrowded pigs, as overall sitting and standing behaviours were unaffected by space restriction. The prevalence of tail biting, which is linked to intolerable levels of stress, (Schroder-Petersen et al., 2004) did not differ between the 2 space allowance treatments and results from the salivary cortisol and adrenal gland analyses, measures of acute and chronic stress, respectively, failed to demonstrate that crowded pigs experienced a greater level of stress than uncrowded pigs. Crowded pigs experienced more leg lesions than uncrowded pigs, but only during the final scoring period when they were most crowded. This study also hypothesized that a shift from lateral lying to the less space demanding ventral lying would occur in

crowded conditions. In contrast, the proportion of time pigs spent lying laterally did not differ among space treatments. The diurnal patterns of the two lying postures were dissimilar, with ventral lying following a pattern similar to that of active behaviours such as standing and eating, while lateral lying reflected an opposite pattern. This suggests that the two lying postures reflect different motivations, and as such they would not be substituted for each other as a means of space conservation. When housed in large groups, pigs spent less time sitting and lying ventrally than pigs housed in small groups, and more time lying laterally, which appears to be a more restful posture. This study shows that large group housing is not as detrimental to grow-finish pigs as once presumed (English et al., 1988). Effects on productivity are limited to the initial period of adaptation to the system. In contrast, effects of crowding are only evident at the end of the production period, and the two management factors appear to work independently of each other. There is little evidence that pigs in large groups are better able to adapt to space restriction than those in small.

Enrichment of the environment can stimulate behaviour patterns similar to that of pigs in semi-natural conditions (Beattie, 1995; Simonsen, 1990). Adding simple toys (Apple and Craig, 1992; Pearce and Paterson, 1993), unlike enrichment incorporated into design of the pen, cannot meet the three elements of complexity, unpredictability and responsiveness. The enrichment of the environment and the increasing space allowance result in nosing and tail biting behaviour decrease among growing pigs. Moreover, pigs in barren environments spent greater durations inactive than pigs kept in enriched environments. This inactivity in barren environments was dominated by the behaviour standing and/or sitting motionless and lying with eyes open. Wood-Gush and Beilharz (1992) suggested that such inactivity may protect the animal from the lack of stimulation. Alternatively, Schouten (1993) proposed that pigs in barren environments were constantly the recipients of harmful social behaviour by their pen mates, so he found that barren pigs unlike enriched pigs did not rest with their eyes closed but instead lay with their eyes open so that they could see any approaching pen mate. This proposal, that inactivity combined with alertness is a response to harmful social behaviour, is supported also by Beattie and Walker (1995): “pigs from barren environments performed more harmful social behaviour than their counterparts from enriched environments”. Previous studies have also shown that pigs kept in barren environments spend more time inactive (Wood-Gush and Beilharz, 1983; Pearce and Paterson, 1993) and it has been suggested that this

inactivity represents a "cut-off" strategy employed by pigs to distance themselves from stressful situations (Pearce et al., 1989). Inactive behaviour may also have resulted from a sense of learned helplessness which can develop when domestic animals are housed in sterile and unresponsive environments (Piggins and Phillips, 1998).

A research about the influence of environmental enrichment on welfare of growing pigs shows that pigs from enriched environments had higher cortisol responses which could have resulted from greater levels of behavioural activity. This could explain the higher maximum heart rates in pigs from enriched environments during the first minute of the study and during the period prior to the test when they were being driven towards the test arena. Enriched pigs also showed a greater number lesions to the endothelium of the heart may mean they had a more reactive sympathetic nervous system. In this study pigs from enriched environments were involved in less aggressive behaviour and less harmful social behaviour, such as persistent nosing and biting of pen mates, in the resident pen than pigs from barren environments. These results agree with previous research which shows that pigs engage in less pen mate-directed behaviour when provided with an alternative outlet for exploration in the form of substrates (Ruiterkamp, 1987; Arey, 1993). The lower level of environments was accompanied by higher levels of sitting, standing or lying inactive.

The differences shown between pigs from barren and enriched environments in their behavioural and physiological responses to stress may have a number of practical implications. As stated previously, the reduced levels of fear shown by pigs from enriched environments towards novel stimuli in the present study are also shown towards humans (Pearce et al., 1989), and this may account for the increase in handling difficulty previously reported for pigs from enriched environments (Beauttie et al., 1995; Geverink, 1998). Concluding this study, environmental enrichment appeared to improve the welfare of pigs by reducing harmful social and interactive behaviour in the resident pen, fear-related behaviour in the response to acute stress and adrenal weight at slaughter (Beattie and O' Connell et al., 2000). In addiction, the higher physiological responses to stress observed in pigs from enriched environments may have also implications for their meat quality, as high levels of stress at slaughter have been linked with the occurrence of pale, soft and exudative (PSE) pork (D' Souza et al., 1998).

Other research about this same subject, has demonstrate that pigs subjected to barren environmental conditions show more signs of chronic stress than pigs housed

under relatively enriched environmental conditions. It has been shown that barren housing conditions hamper the development of appropriate social behaviour as compared to more enriched housing conditions (e.g. Beattie et al., 1995a, 1996a; De Jonge et al., 1996; O'Connell and Beattie, 1999; Olsson et al., 1999; Schouten, 1986). Barren housed pigs performed more manipulative social behaviour (biting, nosing and massaging of pen mates) than enriched housed pigs, in the home pen as well as in the lorry during transport to the slaughterhouse. It has also been shown that barren housed pigs behave more aggressively and display more abnormal agonistic behaviour than enriched housed pigs (De Jonge et al., 1996; O'Connell and Beattie, 1999; Olsson et al., 1999; Schouten, 1986).

Environmental enrichment plays an important role in shaping the social behaviour of pigs. Barren housed pigs have more problems in the establishment of a dominance hierarchy than enriched housed pigs. The establishment of dominance hierarchies in barren housed pigs involves more aggression than in enriched housed pigs. These effects of rearing conditions on social behaviour are shown to be long-lasting, remaining into puberty and adulthood (De Jonge et al., 1996; O'Connell et al., 1999; Olsson et al., 1999). Avoidance behaviour in a novel environment is a kind of adaptive behaviour; therefore barren housed pigs show less adaptive behaviour than enriched housed pigs (Olsson et al., 1999).

Behavioural observations in the home pen and in a novel environment indeed showed that barren housing conditions may subject growing pigs to a situation of chronic stress as compared to more enriched housing conditions. Mixing of unfamiliar pigs is a stressor that has acute as well as long-term effects on behaviour, productivity and health (Ekkel, 1996; Friend et al., 1983; Graves et al., 1978). The same authors also found that "heart rates increased significantly in response to acute social stress". Social status seemed to affect the acute heart rate responses of pigs to social stress, because dominant pigs initially had lower heart rates during the resident-intruder test than subordinate pigs. The increased body temperature after mixing of pigs is caused by an increased (muscular) activity due to fighting in the first hours after mixing, as well as by psychological stress of longer duration. Therefore, it was concluded that body temperature may be a sensitive indicator of the long-term effects of social stress in pigs.

Three experiments trying to analyse measurements and effects of crowding and fasting were conducted utilizing 120 growing-finishing pigs to correlate measures of

aggressive behaviour and determine the effect of restricted space allowance, fasting and straw bedding on porcine agonistic behaviour. The number and duration of bites correlated well with total aggression, which was measured as the sum of the number of attacks, replacements at the feeder and threats. Pigs that were fasted for 24 hours engaged in more biting activity than pigs fed *ad libitum* Straw bedding did not reduce biting behaviour among growing pigs that were fed *ad libitum* but tended to reduce agonistic behaviour among fasted pigs,. Neither a reduction in pen size nor addition of straw bedding at the time of mixing altered biting behaviour among finishing pigs fed *ad libitum*. The data demonstrate that inanition exacerbates aggressive biting behaviour when unfamiliar pigs are mixed, with the most biting occurring about 24 hours after withdrawal of feed. Results of two studies with growing and finishing swine fed ad *libitum* do not support the general recommendation of adding straw bedding when pigs are mixed to reduce aggressive behaviour (Kelley and McGlone et al., 1980).

Another important topic related with the environmental enrichment is the pig provision with straw to reduce the aggressive behaviour. Straw provides many benefits to pig: can improve their physical comfort and thermal comfort (provide them with warmth), supply them with entertainment, dietary fibre (they can eat it too) and an outlet for chewing and rooting behaviour (Weerd and Day, 2008) Groups of pigs that had previously been given straw, and pigs that had not, were divided into groups given no straw, very little straw, a substantial amount of straw, or deep straw. When the pigs that had previously had access to straw were moved to an enclosure without straw they were significantly more likely to bite each other than pigs that had never had any straw. Many pigs are given no straw or other bedding material, but instead are forced to live on bare concrete or slatted or perforated floors; this can lead to lameness or other injuries. Moreover, the lack of straw, combined with the overcrowding, prevents the pigs from performing their natural behaviours. In order to find an outlet for these frustrated instincts, they sometimes turn to the only other 'thing' in their pens – the tails of other pigs. However, even a small amount of straw helped to overcome aggressive behaviours. Regardless of their previous access to straw, the more straw the pigs were given the more time they spent rooting and ploughing, and the less time they spent biting, nosing, licking, or play-fighting one another. However, Weerd and Day (2008) reported that enrichment objects could potentially cause competition for fresh substrate such as straw.

Regarding the type of floor, solid floors (provided with bedding, such as straw) seem to be an improvement to pigs eat more and gain more weight. In addiction they tend to have fewer leg injuries, such as adventitious bursitis (Lyons et al., 1995; Mouttotou et al., 1998). Other type of floor as slatted floors (without beds) seem to frustrate the expression of "key behaviours such as exploration and foraging" (Weerd and Day, 2008), contributing more to leg injuries and other agonistic behaviours as ear and tail-biting (Lyons et al., 1995). Weerd and Day (2008) also emphasise the importance of the location of the enrichment in the pen, for instance a pig interacting with an enriched object in the lying area may cause disturbance of other pigs that are resting.

Studies examining the effect of different floor space allowances with or without enrichment showed that enrichment plays a greater role in determining pig behaviour than floor space allowance (Beattie and Walker et al., 1995). Moinard et al. (2003) as well found that slatted floors, limited feeder space, high stocking densities and large farm size increased the risk of tail biting. On the other hand availability of straw strongly reduced the risk of tail biting. [3]The "EU 2001 Pigs Directive" provides that as from 2003 pigs must be provide with sufficient straw or other similar material to enable them properly to carry out their natural exploratory and rooting behaviours and routine tail-docking is prohibited. Other authors defend that straw is not always the preferred substrate by pigs and are alternatives that pigs have a preference (Beattie et al., 1998; Weerd et al., 2008; Jensen et al., 2004).

Beattie et al. (1995) studied an alternative enriched-housing-system for pigs that was divided in five areas: bedded area with straw and a straw hopper, a sleeping area with an enclosed kennel with torn paper, a rooting area with peat and a fully slatted area with feeders and drinkers. Weerd and Day (2008), who studied this issue thoroughly, concluded that although the existence of strong behavioural indicators of improved welfare, alternative enriched systems didn't show any positive effects. Pig performances in these systems are similar (sometimes a little better) to the ones observed in barren systems. In addiction, alternative-housing systems are normally not realistic to manage in commercial practice and require high labour costs and consequent higher production costs.

[3] See Appendix 1

Enrichment that is used by pigs but has a negative effect on their health should be considered inappropriate, moreover if this enrichment influence factors such as animal performance (e.g. feed conversion efficiency and carcass quality) or meat quality, may be rejected under a commercial scale (Weerd and Day, 2008). On the other hand, there is an increased public demand for pork originated from these welfare-friendly systems hoping that meat from these systems has a better quality (Peeters et al., 2006). Despite this, there are knowledge gaps in the understanding of what substrates or objects improve pig lives. Neurobiological effects and brain parameters could be, in future, an important tool to achieve essential information about these issues.

1.4. Stereotypes and environment enrichment

Another important issue when pig behaviour is been study is the stereotypes. These behaviours are often described as abnormal behaviour in part because they arise under circumstances in which animals are thought to be bored or frustrated. Mason et al. (2007) establish that stereotypic behaviours are caused by: internal states induced by the confined environment that forces the animal to specific behavioural responses; and/or the environment creates a state of continued stress that affects behaviour resulting in nonstandard performances; and/or some bad experience or disturbance/disorder in the past or even during their infancy; or/and by endogenous effects (for instance, hormonal disorders) that consequently result in abnormal behaviours. The first cause above is normally called “frustration-induced stereotypic behaviours” (are driven directly by frustration, physical discomfort and fear) and the second and third “malfunction-induced stereotypic behaviours” (which are products of the central nervous system).

Some examples of stereotypes in pigs are pacing, bar, biting, vacuum chewing (chewing when nothing is present) or chain chewing. The concern over stereotypes is that these behaviours might serve as indicators of poor welfare so there have been recent studies to link stereotypic behaviour with stress. Stereotypes are also usually developed in situations characterized by restriction of movement (limited space) beyond the lack of stimulation.

Mason et al. (2007) refers that, even when stereotypic behaviours are helping pigs to cope with some harmful behaviours, it can't be taken as positive since they are only expressing that kind of behaviour because more natural activities are not possible.

Providing an appropriated enrichment, allowing pigs to interact or not with, seem to be a way to reduce the frequency of stereotypic behaviours. Enrichment is usually thought as the changes in structures and content enclosures, but other changes in pig husbandry can also be implemented (e.g. reduction in visitor noise or changes in keeper-animal interactions) that could reduce stereotypic behaviours. A good enrichment should allow pigs to perform activities that they prefer more than the stereotypic behaviours and offer them enhanced control (e.g. hide opportunities) and the benefits are evident: it tackles the roots of the issue and improve wellbeing by offering pigs favoured new behavioural opportunities (Mason et al., 2007).

Food restriction and poor welfare are the major factors that contribute to the development of stereotypic behaviour in pigs and sows. However, high fibre diets (Robert et al., 1997; Whittaker et al., 1998) and high-energy diets (Bergeron and Gonyou, 1997) have both been found to be effective in increasing satiety and reducing stereotypic behaviour (Brouns et al., 1997). In recent years, there has been growing evidence that stereotypes in pigs are specifically related to heightened feeding motivation due to feed restriction (Donaldson, 2004).

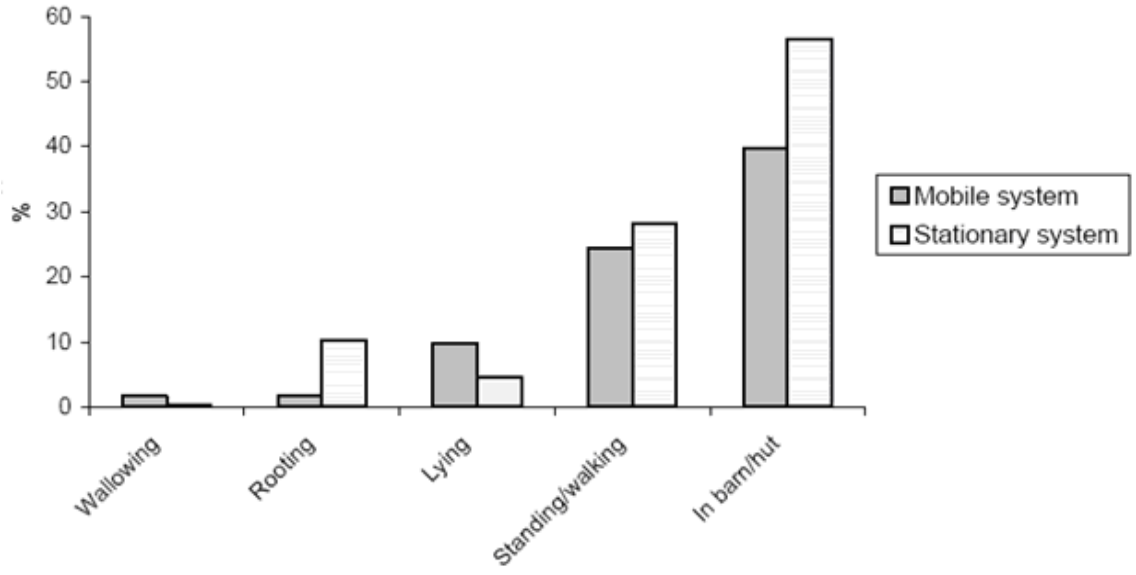
1.5. Locomotory behaviour

Concerning this environmental topic is also important to focus on the pig's locomotory behaviour that has been described as play behaviour (this suggestion is in agreement with the finding that locomotory behaviour decreased with age). Play behaviour was described in the past by Lawerence (1987) as a luxury activity which is only performed when all other needs are met, hence it is usually observed in young animals. Therefore it has been claimed that animals that play are in a good state of welfare. The inference is that pigs in barren environments were in poor welfare, measured by the lack of play behaviour and suggesting that all the needs of the young pig weren't being met.

Tests about leg lesions occurrences conducted among pigs housed in large groups show that pigs normally spent more time lying laterally than pigs in small groups, increasing the occurrence of skin abrasions and lameness. Another reason could be that pig large groups have more space available for running and the probability to get their feet caught in the slats increase (Street and Gonyou, 2007).

[4]Benfalk et al., (from the Swedish University of Agricultural Sciences) with the purpose of compares the behaviour of fattening pigs in two organic pig production, formed a mobile system and a stationary system. In the mobile system the pigs were kept on arable land and each pen contained a hut, feeding troughs, water, wallowing facilities and a grazing spot. Every year, pigs were transferred to a different plot of arable land. The group size of each pen was between 20 and 50 pigs. In the stationary system, the pigs were kept in a barn with access to an outdoor area. Pigs have feeding trough, water facilities and resting area with straw. The group size of each pen was 40 pigs. In each system, 5 groups of pigs were studied, for a total of 780 pigs. The pigs were studied at two different ages, approximately 15 and 20 weeks. The results reached were illustrated on Fig. 2.

[4]**Figure 2.** Proportions of general behaviours between systems (percent of total number of observations).



[4] http://orgprints.org/4313/04/4313-Benfalk_etal_4p_revised-ed.pdf

This study shows that pigs are more inactive in the mobile system. The stationary system has more percentage of lying animals and less percentage of walking and rooting pigs. In both, mobile and the stationary system, it was concluded that there was an irregular distribution of manure and urine in the pens. In the mobile system, the hotspots were in the hut area and in part of the drinking area, while in the stationary system, were in the concrete pad, in the wallowing area and in the first section of the transportation area. Also, in the mobile system, pigs avoided defecating around the feeding trough and in the hut. The concentration of defecations and urinations was higher in the hotspot areas in the stationary system.

Street and Gonyou (2007) hypothesized that a change from lateral lying to the less space ventral lying would take place in diverse motivations and so they wouldn't be substituted for each other "as a means of space conservation". They found that pigs housed in large groups spent less time sitting and lying ventrally and more time lying laterally (which is a more restful posture) than pig in small groups. Moreover, pigs almost never lie near crowded pen zones (for instance, feeders) maybe to avoid injuries or even fights. In low space allowances, sitting and standing motionless were observed more frequently and as referred before, this "could be a strategy for coping with the stress of crowding" (Pearce and Paterson, 1993). Generally, sitting and standing behaviours were unaffected by space restriction (Street and Gonyou, 2007).

1.6. Drinking behaviour

Other important subject concerning behaviour and welfare is the interaction and the degree of competition at the drinkers in growing pigs at different group sizes. The pattern of drinking behaviour in pigs and the influence of social factors, such as competition on this behaviour, have been poorly documented.

Fraser and Rushen (2001) believed that "competition between individuals arises due to the limitation, either in quantity, spatial distribution or temporal availability, of a resource such as food, water, space, or a mate". This competition between pigs almost always results in aggressions and in a consequent decrease of the welfare. In the past, Meese and Ewbank (1974) identified prioritising access to limited resources as a principal

reason for the emergence of dominance hierarchies, although this suggestion has been disputed later by other authors. A few years after, Schnebel and Griswold (1983) found that concentrated resource, which is easily defended, promotes frequent and intense aggression. During periods of competition, therefore, the ability of certain individuals to access resources may be compromised, as a result of their lower social rank or their poorer competitive ability. Consequently, under commercial conditions, provision of resources to a group of pigs must be adequate to allow every individual sufficient access, regardless of social status or competitive advantage or disadvantage.

The competition (in this case, drinking competition) between different members of a group, the priority may be based on a dominance hierarchy or on physical characteristics, such as weight. With the aim of investigate the effects of pig live weight on drinking behaviour and some patterns related, a study was developed using four replicates (2x2) of two group sizes (20 vs. 60) and two drinkers: pig ratios (1:10 vs. 1:20), using a total of 640 growing pigs. The drinking behaviour, skin lesion score and performance of nine focal pigs each of heavy, medium and light weight per pen were recorded. The outcome of this study prove that "the frequency of visits to the drinkers, drinking bout duration and daily drinking time were affected by group size and drinker allocation, but not by weight or the interaction of treatments and weight" (Turner and Sinclair et al., 2000) . The diurnal spread of drinking was similar for each of the four treatment combinations and each weight category. Moreover, these authors found that heavy pigs had the greatest number of lesions and light weight pigs the least; however this was not affected by the four treatment combinations. The treatments, in isolation, or in interaction with weight, did not affect performance. No treatment encouraged enough competition to compromise the drinking behaviour, social behaviour or performance of the lightest animals in the pen (Turner and Sinclair et al., 2000).

Competition for access to resources, as drinkers, may be elevated in large group housing conditions. The sight of an individual engaged in drinking or feeding behaviour may encourage similar behaviour in another individual; a process knows as social facilitation. Furthermore, individuals have been described by Gonyou (1999) as expressing preferences for certain sections of certain drinker (or feeders). The existence of a larger number of pigs drinking or feeding at any instant and thus encouraging social facilitation and the possibility of an extreme number of animals preferring the same feeding point or drinker in large groups has been suggested by Spoolder et al. (1999), "as

potential sources of increased feeding or drinking competition in large group systems". Without evidence to the contrary, is possible that such mechanism may operate in large groups to elevate the demand for drinker access also.

The consequences of drinking behaviour over aggression and performance of the pen as a whole resulting from the restriction of drinker allocation from one drinker per 10 pigs to one drinker per 20 pigs for animal housed in groups of 20 and 60, have been reported by Turner et al. (1999). The findings of this experiment point out that, under the environmental conditions and feeding regime used in the experiment, the water intake, behaviour and performance of the pen as a whole were not compromised by the more restricted drinker allocation, large group size or the interaction of these two factors (Turner and Sinclair et al., 2000).

1.7. Feeding behaviour

Studies about the feeding behaviour and competition among the groups showed that the total numbers of aggressive interactions at the food hoppers are affected by group size interactions and number of hoppers. The number of aggressive interactions per pig is not affected by group size. In contrast, an increased familiarity (trough a reduction in group size) appeared to result in a relative reduction of more serious aggressive behaviour, but only when resources were not limiting. Aggression at the food primarily consisted of pushes or knocks from pigs which initiated an aggressive interaction. The frequency of biting to start an interaction was low, but considerably higher in groups offered one feeder space per 20 pigs compared to groups offered two feeder spaces. The increase presence of animals near the feeders inevitably leads to a higher level of social interactions. These studies did not found an interactive effect of group size and feeder space allowance on welfare parameters. This means that the initially greater level of aggression in large groups of pigs wasn't mitigated by the provision of extra hoppers. Feeder space availability by itself however did influence aggression at the feeder trough, and overall weight gain (Spoolder and Edwards et al., 1999).

Other researches made by Street and Gonyou (2007) show that crowed pigs eat less often than uncrowded pigs. Furthermore, during the final observation period, when pigs were more crowded, smaller amount meals eaten with greater latency to their next

meal, was observed among the crowded pigs. On the other hand, the proportion of time spent eating per day didn't vary between the different group sizes.

The effect of competition at feeding on specific categories of growing-finishing pigs was studied in order to provide an explanation for the increased variation in performance in high competitive feeding environments. Individual feed intake, feeding behaviour, performance and health were compared for relatively small, medium, and large pigs in pens of 16 animals. This study use pens with one or two dry feeders during a period of *ad libitum* eating followed by a period of restricted feeding. Some differences in feeding behaviour between the two levels of competition were seen for all categories of pigs, on the other hand, no difference in health was observed between pigs in the one- and two-feeder pens for any size category of pigs. In conclusion of this study, the inability of the small pigs to get access to feed in combination with overeating by the largest individuals caused the variation in performance seen within pens with a high level of competition at feeding (one feeder for 16 pigs). From a welfare point of view, feeding systems causing a high level of competition may be detrimental when considering all individual pigs in pens, even when it is possible to achieve acceptable production results (Georgsson and Svendsen, 2002).

Other research studying the effect of feeder space on pig grow performance from weaning to slaughter prove an increase in feeder-related aggression when growing pigs are provided a limited feeder space allocation (Spoolder et al., 1999). O'Connell et al., (2002) also reported that "pigs in pens with feeders that limited feed intake had an increased number of head thrusts and animal displacements at the feeder trough". Although pig behaviour was not considered in the study but observations of each pig at the end of the experience revealed no signs of increased injuries resulting from limiting feeder space (Wolter and Ellis et al., 2002). Furthermore, pigs with more pen space and eventually more total effective space result in pigs using space away from the feeder for other kind of behaviours (non-feeding behaviours). On the other hand, pigs in conventional pens have less pen space and thus they may use the pen space within 1 m of the feeder for non-feeding behaviours such as lying down or other social physical interactions. Complications in gaining and maintaining access to a feeder space in the conventional pens, due to limited pen space, may be responsible for the shorter but more frequent feeding events observed in these pigs.

The outcome of a research made in Canada, demonstrate that pigs in large groups eat fewer meals and had a greater latency to their next meal, but took longer to eat a meal. Thus, the proportion of time spent eating in a 24-hour period did not differ between the group sizes. Turner et al. (2002) reported a decrease in meals per day among lightweight pigs in large groups, but not in heavy animals. In this study, feeders in the large group pens were assembled together at one end of the pen, as opposed to being spread out equidistantly. Pigs may have experienced difficulty travelling through the large group to reach the feeders, but the data do not suggest that an increase in feeding behaviour (Spoolder et al., 1999) or an increase in competition at the feeder (Wolter and Ellis, 2002), as predicted for pigs housed in large groups, was occurring.

The frequency of feeding behaviour revealed that pigs in barren environments fed more frequently that pigs in enriched environments, however, overall they did not spend more time feeding. As both environments had the same feeder and the feeding space per pig was equal in both environments, theoretically the level of competition should have been identical. However, barren pigs had only two main outlets for any behaviour. These outlets are the manipulation of their feed or water nipple and the manipulation of their pen mates. The increase of the persistent nosing behaviour in barren environments supports the latter proposal that manipulation of pen mates is one outlet for behaviour in barren environments (Beattie and Walker et al., 1995). Moreover, studies by Morrow (1993) have shown that pigs in barren environments given another outlet for behaviour did reduce the frequency of feeding.

Pigs are omnivorous and domesticated pigs on pasture will spend 6-7 hours per day foraging (Hafez, 1975). However, pigs in conventional housing systems on concentrated diets may only spend 15 minutes per day feeding. Pigs usually drink two or three times as much water by weight as the dry feed they eating each day. However, feed restriction (Yang et al., 1981), high temperature and poor water quality may increase this ratio six times (Gardner et al., 1990).

A study made about the maintenance behaviours observed included feeding, drinking, defecation and urination. The results show that pigs avoid defecating and urinating near their feeding area and thus when given the opportunity, specific sites within the pen are chosen to urination and defecation by groups of pigs. This organised group eliminative behaviour is learnt throughout infancy (Fraser and Broom, 1998).

The scientific literature suggests that small, frequent feeding events throughout the day are more efficient for growth performance than larger less frequent feeding events. Large meals, eaten infrequently, lead to increased body fat deposition, decreased body protein and water, increased urinary nitrogen excretion and higher food to gain ratio than frequent small meals. Providing a substrate can help to increase the time that pigs spend exploring and decrease behaviour such as chewing on ears and tails of pen-mates. The result of nutritional studies and observations on feeding behaviour suggest that the feeding behaviour of pigs in large group systems may also contribute to the reported poorer growth performance observed in the industry setting (Morrison and Hemsworth et al., 2003).

1.8. Sexual behaviour

Mounting is described as a sexual behaviour and visual cues initiate this behaviour. While it is not unusual for entire males reared in groups to form stable homosexual relationships (Signore et al., 1975); Fraser and Broom, 1998), high levels of sexual behaviour amongst 21-week-old entire males housed in groups of 15 in a conventional system have been implicated in reduce feeding behaviour, feed intake and growth (Cronin et al., 2003). Cronin et al. (2003) also indicated that "mounting was usually associated with agonistic behaviour".

Cronin et al. (2003) showed that castration reduce social behaviour and increase feeding behaviour in housed finisher pigs. Researches made by this author comparing immune-castration with surgical castration revealed similar effect of both on the behaviour. In addiction, immune-castration brought clear profits to production as increased feed intake and faster growths: "immune-castration offers pork producers means to significantly improve feed intake and live weights heavier than entire males".

There are not many reports about the incidence of sexual behaviour by entire male growing pigs. Thus, the increase level of sexual behaviour by entire boars housed in large group systems may also contribute to lower incidences of feeding behaviour (Morrison and Hemsworth et al., 2003). Furthermore, Cronin et al. (2003) concluded that entire males in the latter period of the finisher stage of production were more unfocused from

feeding which led to a decrease of the feed intake and more time lost in social behaviours as aggressions and mounting.

In conclusion, castration increase feeding and decrease social behaviours which will bring benefits in production parameters as feed intake and growth rate, which consequently will improve welfare (reduce aggressions, mounting, injuries and carcass bruising) and meat quality (reduce DFD meat).

Summarizing briefly, this literature review suggest that social organization of groups of pigs require the establishment of a hierarchy and the size of the group and the space allocated to it are the most important in this organization. During the formation of the hierarchy severe aggressions and other agonistic behaviours may be observed among the groups, after those pigs of a group are capable of prompt recognition of each other and easily identify an unfamiliar pig. This literature as well suggests that perhaps animals in large groups are more socially tolerant and consequently abandon all attempts to establish social hierarchies.

Enriching the environment with toys, substrates or others is a way to reduce aggression and excitability and improve welfare; on the other hand, in barren environments more harmful social behaviour is observed. Furthermore, environment enriched with straw reduce pig aggressive behaviours and provide them many benefits including a life more active and social.

Stereotypic behaviour might serve as indicators of poor welfare and are usually associated with the lack of stimulation which makes the pigs bored or frustrated. Providing an appropriated enrichment and allow pigs to interact or not with, seem to be a way to reduce the frequency of stereotypic behaviours.

Locomotory behaviour, described as play behaviour, is measured as a luxury activity and is only performed when all other needs are met; other behaviours as sitting and standing, generally were unaffected by space restriction.

The different densities have an important role in the expression of pig behaviour, in particularly, in the expression of agonistic behaviours concerning the competition for water, food and rooting/explore. Drinker behaviour and performances of the pigs are not

compromised by the more restricted drinker allocation, large group size or the interaction of these two factors. Feeding behaviour and competition among the groups show that the total numbers of aggressive interactions at the food hoppers are affected by group size interactions and number of hoppers. The competition and frequency of visits to the drinkers and feeders are both not affected by weight or treatment interactions.

Finishing this chapter, table 2 resumes some of the most important statements, found by their authors, in the literature review.

Table 2
The table resumes some of the most important information of the literature review and their author.

Author	Social organization, interactions and group size
Arey and Franklin	"The mixing of unfamiliar pigs of similar weight and age cause severe aggressions, more evident during the first day"
Beattie and Walker et al.	"Enrichment plays a greater role in determining pig behaviour than floor space allowance"
Bolhuis	"High resistant pigs may cause problems in large groups, because they have difficulty in adapting their social strategy"
Broom	"…behaviour observed may be the animal's actions to help it cope with the difficult situation…"
Ewbank and Ewbank	"…communication in groups are affected by high stocking densities" "High stocking densities affected the communication in the group and caused more serious fights among the pigs"
Ewbank and Meese	"In small group of pigs, the ability to individually recognise group members is very important for the working of the dominance hierarchy"
Frazer and Broom	"Visual and olfactory cues seem to be the principal differentiating features of pigs for each other"
Grandin	"… Creating a naturalistic environment for animals will allow them to display their normal range of behaviour"
Hemsworth and Barnett	"Greater availability of total free space and feeding spaces also seems to eliminate the need for a dominance hierarchy"
Hughes	"Animals in large groups are more socially tolerant"
Jensen	"For this social hierarchy function properly, the size of a group and the space allocated to it are very important"
Jensen and Wood- Gush	"Pigs are social species with strong tendency to form groups and live in a dynamic competition for food or access variable resources"
Krohn et al.	"…pigs seems to be more affected by the environmental enrichment than the exact space within the ranges"
McGlone and Curtis	"In pigs, providing shelter after mixing did help to reduce aggression"

Mendl et al.	"The strategy to cope with a low social status might be more important than the actual position in the hierarchy"
Pagel and Dawkins	"Pigs in large group… abandon all attempts to establish social hierarchies…"
Pearce and Paterson	"… pigs do not feel aversion against being close together when resting"
Schaefer et al.	"… higher levels of agonistic behaviour may be a result of the high incidence of social behaviour …"
Spoolder and Edwards et al.	"The number of aggressive interactions per pig is not affected by group size. In contrast, an increased familiarity (trough a reduction in group size) appeared to result in a relative reduction of more serious aggressive behaviour, but only when resources were not limiting"
Street and Gonyou	"There is little evidence that pigs in large groups are better able to adapt to space restriction than those in small"
Turner et al.	"Aggressive behaviour was not elevated by a large group size"

Author	**Environment enrichment and space allowance**
Beattie and Walker et al.	"… when enrichment and space allowance increase, nosing and tail biting reduce…"
	"Enrichment played a greater role in determining pig behaviour than floor space allowance". "…Larger space allowance… did not encourage locomotory behaviour but only increased space allowance with enrichment..."
	"… the increased aggression and increased manipulation of pen mates in barren housed pigs as compared to enriched housed pigs may lead to injuries and tail-biting…"
	"Barren environmental conditions have negative implications for pig welfare, or increase risks for pig welfare"
	"Sitting and standing behaviours are unaffected by space restriction…."
	"Barren housing conditions hamper the development of appropriate social behaviour as compared to more enriched housing conditions…"
Blackshaw et al., Morita et al.	"… enriching the environment with toys or substrates … has been found to reduce aggression…"
Brumm and Miller	"Space restriction has been associated with reduced gains … reduced feed intake and reduced G:F…."
Day Jel	"Providing pigs with straw reduce aggressive behaviour… provide physical comfort and thermal comfort, provide them with entertainment, they can eat it too (dietary fibre) and an outlet for chewing and rooting behaviour…"
De Jonge et al.	"It has been shown that environmental enrichment plays a role in shaping the social behaviour of pigs"
English et al.	"Effects of crowding are only evident at the end of the production period…"
	"Pigs in large groups are better able to adapt to space restriction than those in small…"
	"Large-group housing is not as detrimental to grow finish pigs as once presumed"
Ekkel	"Mixing of unfamiliar pigs is a severe stressor that has acute as well as long-term effects on behaviour, productivity and health"
	"… social status seemed to affect the acute heart rate responses of pigs to social stress, because dominant pigs initially had lower heart rates during the resident-intruder test than subordinate pigs"

Grandin	"Small amounts of environmental enrichment, also suspended objects or small amounts of contact with a person in the pen, decrease excitability and fighting"
	"A widely held assumption is that creating a naturalistic environment for animals will allow them to display their normal range of behaviour"
	"…rearing environment has strong effects on both the central nervous system and pig's behaviour, decreasing excitability and fighting"
Kelley and McGlone	"Neither a reduction in pen size nor addition of straw bedding at the time of mixing altered biting behaviour among finishing pigs fed *ad libitum*"
	"Inanition exacerbates aggressive biting behaviour when unfamiliar pigs are mixed, with the most biting occurring about 24 hours after withdrawal of feed"
Lyons et al., Mouttotou et al.	"Pigs kept on solid floors and provided with bedding, such as straw, have been found to eat more and gain more weight ..."
	"Slatted floors and a lack of bedding have been found to contribute the most to leg injuries..."
McGlone and Newby	"Space could be reduced in large groups without negatively affecting production"
Moinard et al.	"…availability of straw strongly reduced the risk of tail biting"
	"…slatted floors, limited feeder space, high stocking densities and large farm size increased the risk of tail biting"
Olsson et al.	"Avoidance behaviour in a novel environment is a kind of adaptive behaviour; therefore barren housed pigs show less adaptive behaviour than enriched housed pigs"
Pearce and Paterson	"Both, enrichment of the environment and increasing space allowance, result in a reduction in nosing and tail biting behaviour among growing pigs"
	"Pigs in barren environments spent greater durations inactive than pigs kept in enriched environments…"
	"Inactivity represents a "cut-off" strategy employed by pigs to distance themselves from stressful situations"
Schouten	"Pigs in barren environments were constantly the recipients of harmful social behaviour by their pen mates."
	"Inactivity combined with alertness is a response to harmful social behaviour"
Schroder-Petersen et al.	"The prevalence of tail biting, which has also been linked to intolerable levels of stress did not vary between two different space allowances…"
	"… a shift from lateral lying to the less space demanding ventral lying would occur in crowded conditions…"
Street and Gonyou	"Generally, sitting and standing behaviours were unaffected by space restriction"
Weerd and Day	…high standards of bio-security should be maintained and enrichment should be regularly cleaned and disinfected"
	"…the objects introduced for the enrichment shouldn't be able to be chewed and ingested…and they should be functional, easy to use and economic"
	"Straw provides many benefits to pig: can improve their physical comfort and thermal comfort(…) supply them with entertainment, dietary fibre (…) and an outlet for chewing and rooting behaviour"
	"…the more straw the pigs were given the more time they spent rooting and ploughing and the less time they spent biting, nosing, licking, or play-fighting one another"

Author	Drinking behaviour
Gonyou	"The sight of an individual engaged in drinking or feeding behaviour may encourage similar behaviour in another individual … a process knows as social facilitation…"
	"Pigs express preferences for certain sections of certain drinker (or feeder)…"
Spoolder et al.	"… large groups of pigs increase competition in the drinking area"
Turner et al.	"The consequences for drinking behaviour, over aggression and performance of the pen as a whole … resulting from the restriction of drinker allocation from one drinker per 10 pigs to one drinker per 20 pigs for animal housed in groups of 20 and 60"
Turner and Sinclair et al.	"The frequency of visits to the drinkers, drinking bout duration and daily drinking time were affected by group size…"
	"… drinker allocation and lesion score correlated poorly with the parameters of drinking behaviour"
	"Water intake, behaviour and performance of the pen as a whole were not compromised by the more restricted drinker allocation, large group size or the interaction of these two factors"

Author	Feeding behaviour
Fraser and Broom	"…pigs avoid defecating and urinating near their feeding area"
	"…feeding behaviour of pigs in large group systems may also contribute to the reported poorer growth performance observed in the industry setting"
Georgsson and Svendsen	"The inability of the small pigs to get access to feed in combination with overeating by the largest individuals caused the variation in performance seen within pens with a high level of competition at feeding (one feeder for 16 pigs)…"
Gonyou	"…crowed pigs eat less often than uncrowded pigs"
	"…when pigs were more crowded, smaller amount meals eaten with greater latency to their next meal, was observed among the crowded pigs"
	"…the proportion of time spent eating per day didn't vary between the different group sizes"
Hemsworth and Barnett	"… the greater availability of resources such as total free space, availability of feeding places and preferred lying areas may eliminate the need for a dominance hierarchy … which functions to control aggression when resources are limited…"
Morrison and Hemsworth et al.	"The frequency of feeding behaviour revealed that pigs in barren environments fed more frequently that pigs in enriched environments, however, overall they did not spend more time feeding…"
	"The result of nutritional studies and observations on feeding behaviour suggest that the feeding behaviour of pigs … may also contribute to the reported poorer growth performance observed in the industry setting..."
Morrow	"Pigs in barren environments given another outlet for behaviour did reduce the frequency of feeding…"
	"… frequent feeding events throughout the day are more efficient for growth performance than larger less frequent feeding events…"
O'Connell et al	"Pigs in pens with feeders that limited feed intake had an increased number of head thrusts and animal displacements at the feeder trough…"
Spoolder	"… there is an increase in feeder-related aggression when growing pigs are provided a limited feeder space allocation"

Spoolder and Edwards et al.	"The aggression at the feeder showed that the total numbers of aggressive interactions at the food hoppers are affected by group size interactions and number of hoppers…"
	"The initially greater level of aggression in large groups of pigs was not mitigated by the provision of extra hoppers…"
	"Feeder space availability by itself however did influence aggression at the feeder trough, and overall weight gain…"
Turner et al.	"Pigs in large groups eat fewer meals and had a greater latency to their next meal, but took longer to eat a meal "
	"… a decrease in meals per day among lightweight pigs in large groups was observed, but not in heavy animals…"
Wolter and Ellis et al.	"… no signs of increased injuries resulting from limiting feeder-trough space were observed"
	"Pigs with more pen space and ultimately more total effective space result in pigs using space away from the feeder for non-feeding behaviours"
	"Pigs in conventional pens have less pen space and … they may use the pen space within 1 m of the feeder for non-feeding behaviours … such as lying down or social tactile interactions"

PART B | THE TRIAL

2.1. General Information

The project "*Pigs in ComfortClass*" is a pilot project without pattern concerning the satisfaction of the pig needs and welfare that was implemented on 26th of April (2006) and will be developed during the coming 3 years.

LTO Pig Producers Professional Group and *Animal Protection* in close cooperation with the *Animal Science Group of Wageningen UR* (The Netherlands), join their strengths and challenged to reach a housing system where the welfare is guaranteed with smallest economic costs (pig needs has main point are described below, in Table 3). The costs of the entire building are 25% lower than regular buildings[5]; as a result, this project aims to satisfy interests of both, farmers and animals.

The behaviour of the pigs is followed 24 hours per day with cameras to monitor if effectively the pig needs are been satisfied and also for data collection.

This project is under the biological farming which consequently brings changes on the farm management [6]. The animals in "*Pigs in ComfortClass*" are castrated with tails and fed *ad libitum*. Both sexes are present in all pens and the breed used in this trial is a Dutch commercial cross between:

Sow: Dutch standard cross *Large White* x *Landrace*

X

Boar: *Pietrain*

The pigs were kept more or less 3 months on the *ComfortClass* building in the fattening period. On the 15th of December of 2006 they had 9 weeks old. The first animals were removed to slaughter at 18 March of 2007.

[5] See Appendix 3 (Dutch space regulations for pigs).
[6] To know more about organic livestock farming and regulations consult Appendix 2.

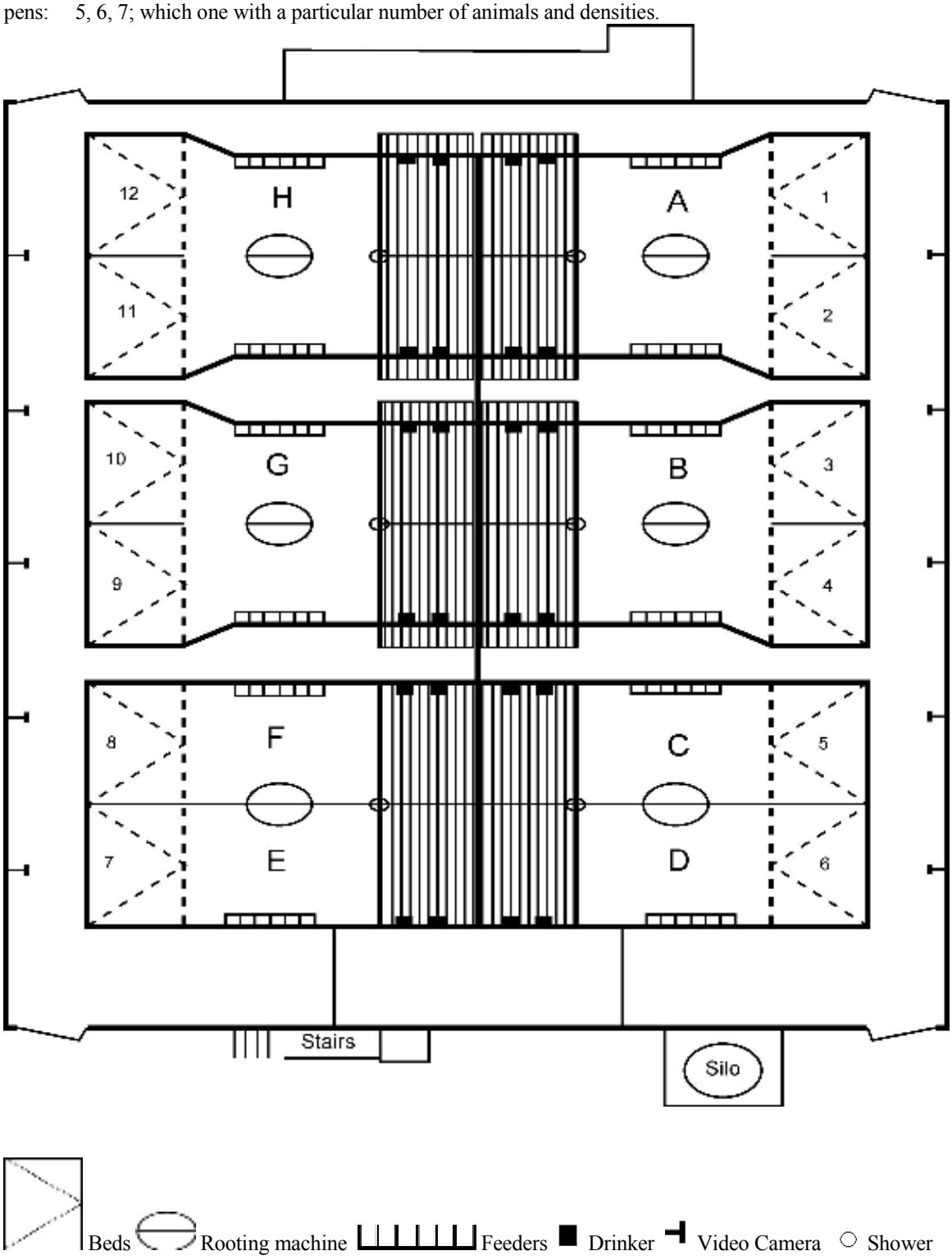
Table 3. The satisfaction of the 10 most important needs in "*Pigs in ComfortClass*" is the mainly intention of the entire project. These needs have been mapped by means of a huge research data that was the result of years of investigations.

Need	Description: pig wants...	Term	Choice in the stable in Raalte
Satiety	Quietly and indefinitely they can eat and drink in the company of other pigs.	**Food and drink**	2 drink sources and 6 feed boxes per 12 pigs. *Ad libitum*.
Relax/rest	A large part of the time, a pig can lie down with the others.	**Relax/rest**	Space sufficiently for all, with straw in the floor for clarity and comfort.
Exploration	With other pigs exploring the surroundings and rooting.	**To explore**	Exploration of the space in the different pen sizes. Presence of a rooting machine.
Social contact	Not only as a social animal.	**Together**	All activities can be done together. Social contact between animals.
Excretion	Normally they defecate and urinate in a particular spot (they are "toilet trained animals").	**To defecate**	Clear defecation zone, sufficiently separated from the others facilities.
Comfort behaviour	Inherent to which animal.	**Itself care**	The animals seem glad and well-cared-for.
Locomotive behaviour	Sufficient movement.	**Movement**	Much space: 1.5 – 2 m^2 /animal. Separated function areas.
Health	No inconvenience experience of sickness.	**Healthy**	Healthy materials. Good care. Good stable provides less mutual damage.
Thermo comfort	Not too warm or too cold. The pigs can regulate their temperature easily.	**Comfortable**	Natural ventilation. Several climate areas, among other things (straw). Water spray for hot days (shower).
Security	Security to eat, drink and to be able to withdraw.	**Safe/ Protection**	Good equipment and as result: less aggression and lesions.

2.2. Material and Methods

2.2.1. General Structures

Figure 3. The room lay out with 12 pens. The figure shows double pens: 1, 2, 3, 4, 9, 10, 11 and 12; single pens: 5, 6, 7; which one with a particular number of animals and densities.



A – 36 pigs; **B** – 24 Pigs; **C** – 24 pigs; **D** – 18 pigs; **E** – 12 pigs; **F** – 18 pigs; **G** – 36 pigs; **H** – 48 pigs.

This *ComfortClass* building has 30 meters of length and 20 of width. The ridge height (from the ground) is 6, 75 meters. The ventilation of the building is natural[7]. The structure is composed by 12 pens (singular or double, according to Figure 3), which one with a different number of animals, making the total of 216 pigs. This structure provides the study in different animal densities and in different pen sizes as is illustrated in Table 4.

Table 4. Relation between the three different densities with the number of animals and pen type in the project "*Pigs in ComfortClass.*"

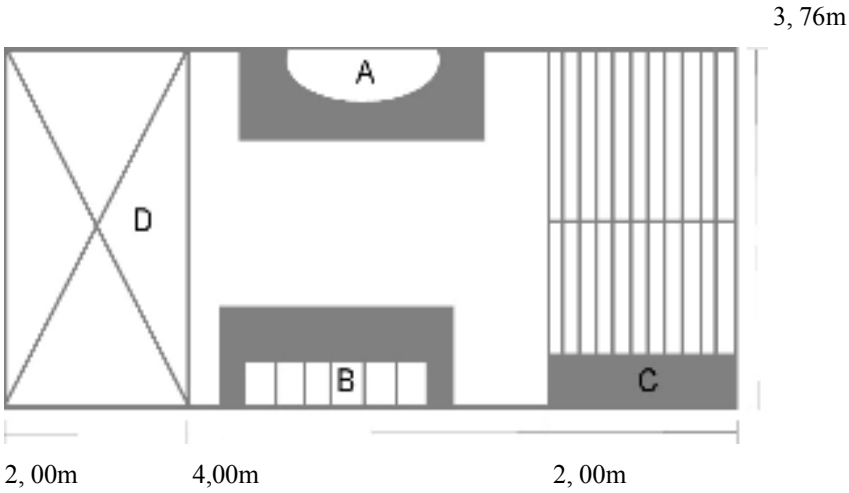
Pen Type	Number of Pigs	Density (m2/animal)	Pen Number
Single	12	2,4	7
Single	18	1,8	8 and 6
Single	24	1,2	5
Double	24	2,4	3 + 4
Double	36	1,8	1 + 2 and 9 + 10
Double	48	1,2	11 + 12

The density of 2,4m^2 per animal is the one theoretical required, the 1,2 m^2 is the one slight above the future EU standard (1 m^2) and the 1,8 m^2 density is one in the between.

The number of feeders is 2 per pen and has the space capacity to feed, at the same time, 6 pigs (in normal conditions). Which pen has also 2 individual drinkers, one rooting machine and one shower to be used in hot days[8]. The zone normally used for excretion (grids/slatted floor) is made by reinforced concrete with cracks[8]. The pen layout with all the components is illustrated below on Figure 4.

[7] See appendix 5
[8] See appendix 6

Figure 4. Pen layout with the different function areas and the observation areas (eat, drink, play and rest).



A- Rotting machine zone
B- Feeder zone
C- Drinker zone;
D- Rest zone (beds).

The total pen size is 30, 08m^2 (3, 76 x 8, 00 m). The slatted floor has 7, 52m^2 (3, 76m x 2, 00m) of total space and is elevated around 10 cm from the rest of the floor to facilitate the cleaning process. The remove system of the manure and urine is under the slatted floor. The solid floor has15, 04m^2 (3, 76m x 4, 00m) of total space and is covered with straw which provide comfort, clearness and helps to regulate temperature special in cold months.

The beds have 7, 52m^2 (3, 76m x 2, 00m) of total space and capacity for all the animals of the pen. They are closed with plastic curtains that help to maintain a warm temperature inside. Is a structure very simple which allow fast and easy cleans[9].

2.2.2. Method

In order to reach trustworthiness conclusions, several observations and data have to be collected. In the beginner and to make an approach to the farm reality and pig behaviours, some direct observations were made in order to improve the interpretation of the recorded videos (that aren't always very clear and understandable).

[9] See appendix 6

This research is related to 3 months of video recordings, starting at 1st of January and ending at 1st of April (2007). The days of observations are 7 days in January (5th, 9th, 13th, 15th, 17th, 23rd , 25th and 28th); 12 days in February (5th, 7th, 9th, 11th, 13th, 15th, 17th, 19th, 21st, 23rd, 25th and 28th); and 6 days in March (1st, 5th, 9th, 13th, 15th and 17th) of 2007, making the total of 312 hours observed. The observations are made at the hours that, in average, pigs are more active and vigorous, which is between 16.00h and 17.00h.

The study areas are the ones in Figure 4 (A, B and C) which is more or less 0,5m for both sides and 1m for the front of which facilities (having in accounted the posterior part of the pig's body).

After analysing a conventional ethogram[11] and regarding the availability of time, the data were collected according to Table 5.

Table 5. Simple ethogram followed in the research with the basic behaviours observed.

Day:
Hours: 16.00h – 17.00h
Pen:
Camera:

Behaviour	Feeders	Drinkers	Rooting Machine
Aggressive behaviour/fight (1)			
Tail bite (2)			
Ear bite (3)			
Other bite (3)			
Mount (5)			
Smell genital (6)			
Sit/ lay (active) (7)			
Sit/ lay (inactive) (8)			
Explore/rooting (9)			
Contact nose/nose (10)			
Contact nose/body (11)			

[11] See appendix 4.

After having the data, they were grouped in different topic behaviours: Agonistic behaviour: (1), (2), (3) and (4); Sexual behaviour: (5) and (6); Inactive behaviour: (6) and (7); and Interactive behaviour (9), (10) and (11).

All the data were treated first numerically (averages and percentages) to give a general outlook about the information collected and secondly submitted to a statistical analysis.

2.2.2.1. Numerical treatment

Regarding the numerical treatment the data were divided per number of animal of which pen having in account the list of the removed animals[12].

2.2.2.2. Statistical analysis

The statistical behaviour analysis (agonistic, interactive, inactive and sexual behaviours) was performed using JMP software (v. 5.01; SAS Inst., Inc., Cary, NC, USA). The behavioural data (number of occurrences per hour) was analysed using the GLM procedures to determine the influence of pen, facility and density on pig behaviour following the model[13]:

$$Y_{ijkl} = \mu + P_i + S_j + D_k + (PS)_{ij} + (PD)_{ik} + (FD)_{jk} + (PFD)_{ijk} + \varepsilon_{ijkl}$$

μ is the overall mean,
P_i is the fixed effect of the pen type(i = 1,2),
F_j is the fixed effect of facility (j = 1, 2, 3),
D_k is the fixed effect of density (k = 1, 2, 3),
$(PF)_{ij}$ = the fixed effect of the interaction between P_i and F_j,
$(PD)_{ik}$ = the fixed effect of the interaction between P_i and D_k,
$(FD)_{jk}$ = the fixed effect of the interaction between F_j and D_k,
$(PFD)_{ijk}$ = the fixed effect of the interaction between P_i, F_j and D_k,
ε_{ijkl} is the random error.

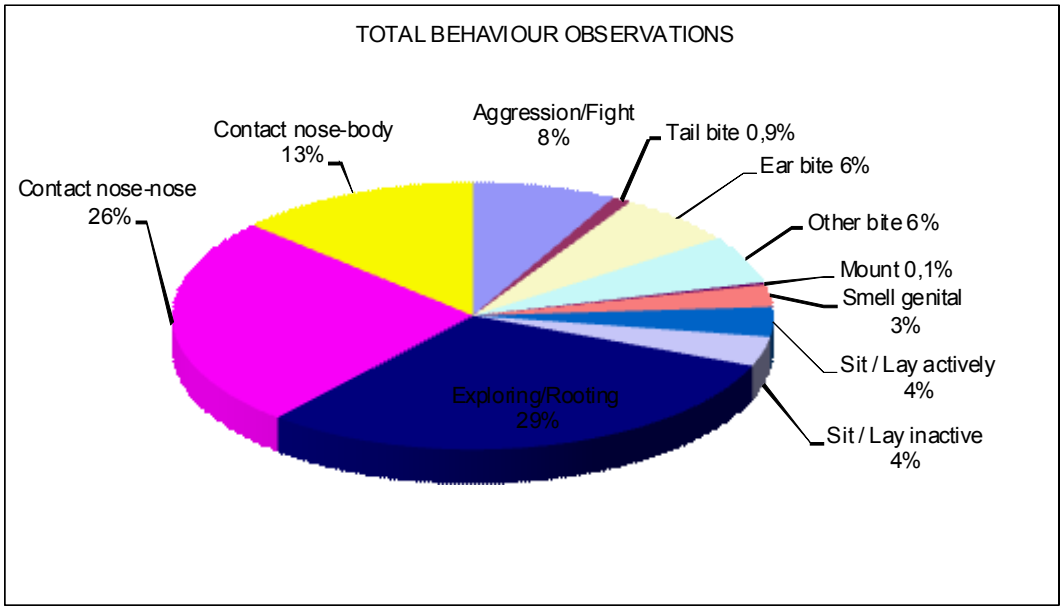
[12] See appendix 7.
[13] Least square means were computed and tested for differences using the Tukey-Kramer test.

3.1. Results and Discussion

3.1.1. Descriptive analysis

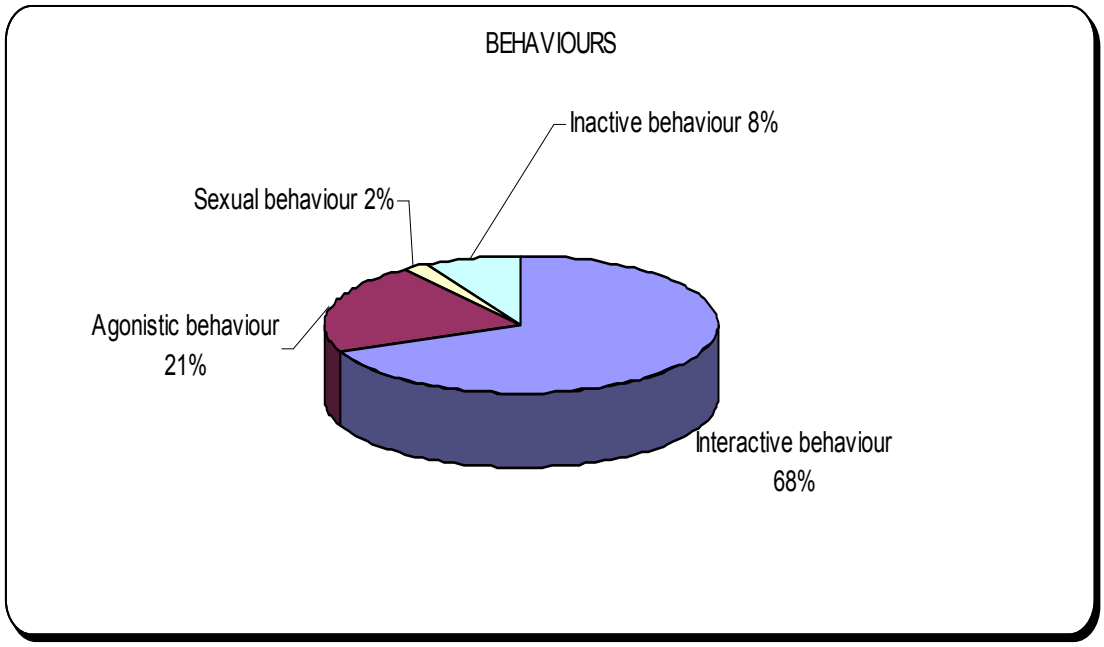
The general results obtained in Figure 5 shown that 68% of the total observations in this trial are related with interactive behaviours ("contacts" and exploring/rooting"), on the competition for food, water and/or explore/play. These results confirm pig as a social animal (Beattie and Walker, 1995) and support the proposal of the vital importance that enriched environments have regarding pig interactions and socializations on the welfare achievement (De Jonge et al., 1996). Regarding the agonistic behaviour is important to take a look to the low rate of the "tail bite" (0,9%), (indicator of frustration, stress or annoyance) which may be a very good sign of the fulfilment of the animal needs in this *ComfortClass* husbandry system (Beattie and Walker, 1995). Relating to the same undesirable behaviour, results show a moderated average of the "aggression/fight" (8%) and a similar and small standard between "other bites" and "ear bites" (6%). The sexual behaviour in this trial was the one with lower rates, like it was expected: "smell genital" with 3% of the total behaviours observed and a even low percentage of "mount" behaviours" (0,1%). This trial shows also the same small percentage (4%) between "sit/lay actively" and "sit/lay inactively", which supports the researches made by Street and Gonyou (2007) about the preference that pigs have to lay or rest in other places less crowded, far from the feeders, drinkers or toys, to avoid injuries or aggressive behaviours.

Figure 5. The graphic illustrate the general results of the 26 days behaviour observations.



Analysing Figure 6 concerning sexual (2%) and inactive (8%) behaviours, the results do not have a significant expression/tendency relatively to the other two behaviours in the figure. This low sexual behaviour, more specifically "mount", could be a good indicator of pig wellbeing because this is normally associated with agonistic behaviour (Cronin et al., 2003); however these results are limited to the surveillance zones. The agonistic behaviour in this experience is 21% which can be considered significant regarding the total of the behaviours analysed. This significant agonistic behaviour will deserve a deep analyse ahead, in the statistical analysis.

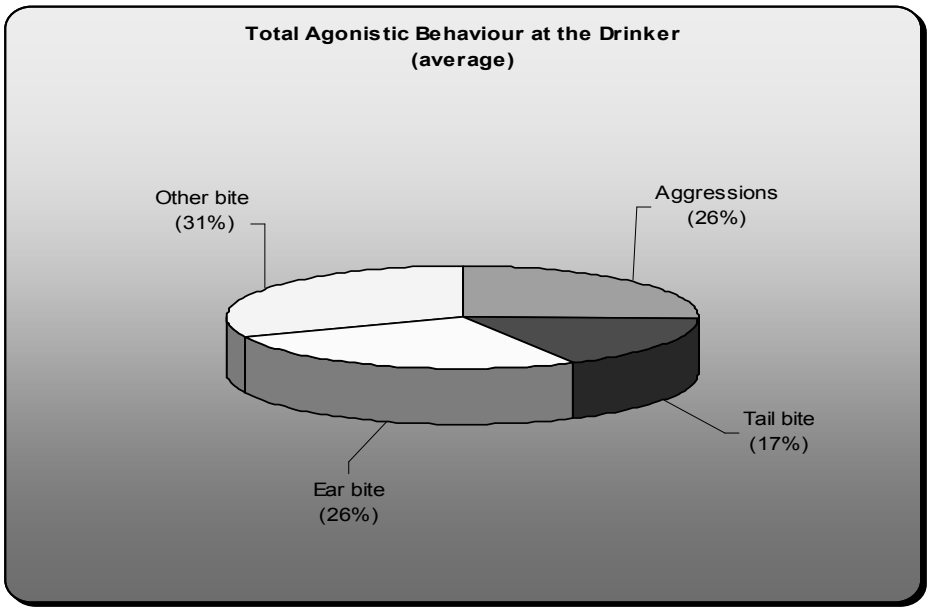
Figure 6. The graphic illustrate the results obtained, grouped in different types of behaviour (relation between the agonistic, interactive, inactive and sexual behaviours).



Regarding the agonistic behaviour is important also take a look how this conduct is distributed among the three facilities (Figure 7, 8 and 9). The results at the drinkers, feeders and rooting machines are a slightly different between them. Moreover, this behaviour difference may help to recognize where pigs are more aggressive.

The results from the total agonistic behaviour at the drinker are shown in Figure 7.

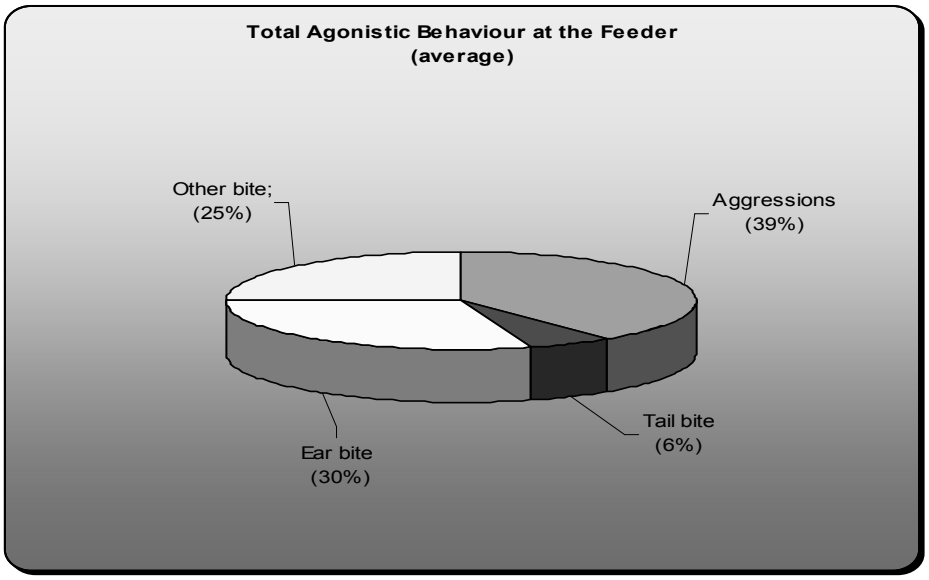
Figure 7. The graphic illustrate the data collected of the total agonistic behaviours at the drinkers in all the 12 pens - numerically treatment (averages).



In the drinkers the "other bites" are higher (31%) than the "ear bites" and "aggressions/fights" (both 26%). Important to note that is in the drinker where the "tail bites" have more expression (17%). This may be explain because the drinkers are the facility with lower total behaviour interactions and animal occupation (Turner and Sinclair, 2000) and due this fact when a tail bite happens, increase the relative results in the total average of the observations. In general, the two drinker sources are adequate and enough in all pens; the agonistic behaviour observed was not due to insufficient drinkers but because some punctual high incidence of social behaviours (Schafer et al., 1990).

These behaviour results observed in the feeders are illustrated at figure 8.

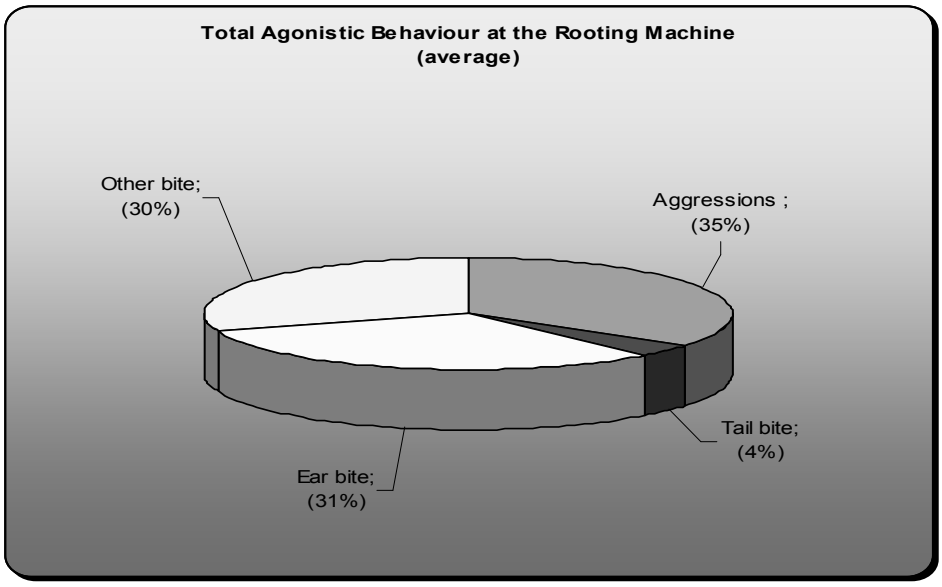
Figure 8. The graphic illustrate the data collected of the total agonistic behaviours at the feeders in all the 12 pens - numerically treatment (averages).



"Aggression/fight" at the feeder is the most significant behaviour (39%), followed by the "ear bites" (30%), "other bites" (25%) and "tail bites" (6%). The feeders show a significant agonistic behaviour that could be a sign of inappropriate number of feed spaces in some pens. The pigs that can be accommodated per feeder space affects the relative feeder cost per pig and the number of pigs per pen (Gonyou and Lou, 2000) and consequently have a negative impact on the animal welfare.

Relating to the rooting machine the results are similar but with lower agonistic behaviours that in the feeders, as shown in Figure 9.

Figure 9. The graphic illustrate the data collected of the total agonistic behaviours at the rooting machines in all the 12 pens - numerically treatment (averages).



In the rooting machine the behaviour more observed is also the "aggression/fight" (35%) followed by "ear bites" and "other bites" (30% and 31%, respectively). "Tail bites" have the lower expression of all these behaviours (4%).

Resuming, these three last graphics show that the agonistic behaviour is on average higher in the feeders than in the rooting machine and generally lower in the drinkers. Pigs are socializing in the rooting machine, having a lot of contacts, rooting and playing, which is in the line with what De Jonge et al. (1996) found concerning the important role that environment enriched plays in the shape of the social behaviour of the pigs. Therefore this socialization is very important to reduce apathy which was never a synonym of welfare (Beattie and O' Connell, 2000). In addiction, the number of drinkers seems to be appropriated and sufficient in all the pens. Respecting to the feeders, the same could not be confirmed in all pens with this numerical treatment.

3.1.2. Agonistic, interactive, inactive and sexual behaviours

The behavioural data (number of occurrences per hour per pig) to determine the influence of pen, facility and density on pig behaviour is divided in 4 tables of results. The first one, the influence of these effects regarding the agonistic behaviour is shown on Table 6.

Table 6. Influence of pen type, facility and animal density effects on the pig agonistic behaviours (hear bite, tail bite, aggressions/fights and other bites – occurrences h-1 pig-1).

	Agonistic behaviours			
	Hear bites	Tail bites	Aggressions/ Fights	Other bites
Pen type				
Sg	0,123 (0,005) [a]	0,017 (0,002) [a]	0,163 (0,007) [a]	0,133 (0,005) [a]
Db	0,075 (0,004) [b]	0,013 (0,001) [a]	0,086 (0,005) [b]	0,062 (0,004) [b]
Facilty				
D	0,014 (0,005) [a]	0,003 (0,002) [c]	0,015 (0,007) [c]	0,020 (0,006) [b]
F	0,149 (0,005) [a]	0,028 (0,002) [a]	0,196 (0,007) [a]	0,132 (0,006) [a]
RM	0,135 (0,006) [a]	0,015 (0,002) [b]	0,163 (0,008) [b]	0,141 (0,006) [a]
Density				
1.2	0,114 (0,006) [a]	0,022 (0,002)[a]	0,139 (0,008) [a]	0,111 (0,006) [a]
1.8	0,097 (0,004) [b]	0,016 (0,002) [a]	0,122 (0,006) [ab]	0,083 (0,005) [ab]
2.4	0,087 (0,006) [b]	0,007 (0,002) [b]	0,112 (0,008) [b]	0,099 (0,006) [b]
Probability				
Pen type	<. 0001	0,213	<. 0001	<. 0001
Facility	<. 0001	<. 0001	<. 0001	<. 0001
Density	0,004	<. 0001	0,051	0,002
Pen type*Facility	<. 0001	0,067	<. 0001	<. 0001
Pen Type*Density	0,003	0,645	0,379	<. 0001
Facility* Density	0,010	0,002	<. 0001	<. 0001
Pen type*Facility*Density	0,007	0,865	<. 0001	<. 0001

Sg - Single; Db – Double
D – Drinkers; F – Feeders; RM – Rooting machines
Density (m^2/animal)
Values given in brackets are the standard error
[a,b,c] For each behaviour within a effect, means without a common superscript letter differ ($P < 0.05$)

According to the results in Table 6 all agonistic behaviours are affected by pen, facility and density (P between 0.05 to 0.0001) except for the behaviour "tail bites", which is not affected by the facility (P=0.213). Overall, the agonistic behaviours are more intense in single pen type, in the feeder and in the animal density of 1.2 m^2. These findings were reported by others (Randolph et al., 1981; Nielsen et al., 1995; Hyun et al., 1998; Schrøder-Petersen and Simonsen, 2001; Bracke et al., 2004; Rodenburg and Koene, 2007). High density has been shown to increase aggression behaviours in growing pigs (Bryant and Ewbank, 1972; Randolph et al., 1981, Turner et al., 2001). Through the results pigs in high densities have more necessity to compete for food, water and rooting because they have less access to these facilities (less space allowance), consequently fights and aggressions are more frequent, which is in line with what Beattie and Walker (1998) referred. The agonistic behaviour is a welfare problem with consequences on pig performances. Actually there is scientific information which shows the agonistic behaviour impact in growth rate and feed efficiency (Nielsen et al., 1995; Ayo et al., 1998).

Generally the feeder is the facility where the agonistic behaviours were higher (0.028 to 0.196 occurrences h-1 pig-1). However the agonistic behaviours exhibits in the rooting machine were also high. The agonistic behaviours "hear bites" and "other bites" for both facilities were very close. According to results, is in the feeder that the agonistic behaviour earns more expression, which was also founded by Spoolder and Edwards (1999) when they reported that aggressive interactions at the feeders are affected by group size interactions and number of hoppers.

Concerning the drinkers, the agonistic behaviours were always less frequent ($P<0.05$) comparing with the others facilities. These results are in accordance with other authors (Spoolder and Edwards, 1999; Wellock et al., 2003). What Spoolder and Edwards (1999) reported about large groups of pigs increasing the competition in the drinking area is not confirmed in this trial. Regarding the results can be confirmed what Turner and Sinclair et al. (2000) reported, about the behaviour and performance of the pen as a whole were not compromised by animal large group size. Moreover, the finding made by Gonyou (1999) concerning the pigs preference for certain sections of certain drinker is also not confirmed in this research.

Respecting to group dimension (double or single), pigs are engaged more ($P<0.001$) frequently in the agonistic behaviours in the single pens. The exception is for

"tail bites" which shows no difference (P=0.213) between group dimensions. This is in accordance with studies made in pigs and other species: "when the group increases the agonistic behaviour decrease" (Hughes et al., 1997; Turner et al., 2001; Andersen et al., 2004) and "animals in large groups are more socially tolerant" (Hughes, 1997).

As stated by Turner et al. (2001) "this change in aggressive behaviour may have been an overt consequence of an alteration in the strategy of group social organisation, which in turn may have been brought about by a deficit in individual recognition ability required for the maintenance of a dominance hierarchy structure of organisation". In addition, when the dimension group is minimum the agonistic behaviour more associated is the "aggressions/fights" (0.163 occurrences h-1 pig-1) and "tail bites" the lowest (0.017 occurrences h-1 pig-1).

The conjugation of the three effects (Pen type*Facility*Density) earns a very higher association concerning "aggression/fights" and "other bites", which is an important fact to have in account because this type of aggressive behaviour is an indicator of poor welfare or can be linked to intolerable levels of stress (Schroder-Petersen et al., 2004).

Resuming, the drinkers are the facility where less agonistic behaviours were detected, so the number and disposition in all pens are sufficient and does not represent an obstacle to welfare. These findings are in conformity with Turner et al. (1999) that shown that the water intake, behaviour and performance of the pen as a whole were not compromised by large group size. On the other hand, we are analysing data from January, February and March where the temperature is lower. In hot months the results may not be the same. The feeders are the facility where the animals are more aggressive and the total number of aggressive interactions at the food hoppers is affected by group size interactions and number of hoppers (Spoolder and Edwards, 1999). This aggressive behaviour in high density pens is very evident. Alternatively, in those pens the solution could pass by increasing the number of feeders per pen or maybe the use of circular feeders on the middle of the pen (Gonyou and Lou, 2000). The rooting machine is an important step to implement in pig husbandry. This statement can be proved by the animal affluence to this facility and the quantity of social interactions developed in it. Besides the occurrence of several aggressions and bites, this facility represents an important move to the satisfaction of the pig's welfare (Ruiterkamp, 1987 and Arey, 1993). This is more evident in pens with lower densities because pigs are not able to develop as many social interactions as crowded pigs, so they canalize their behaviours to

the rooting machine like an instrument to fight against apathy and decrease and/or avoid frustrated behaviours or stress (stereotype behaviours). Generally, animal density increases the agonistic behaviours (Bryant & Ewbank, 1972).The results show also that all the four agonistic behaviours are higher in single than in double pens but this difference is small concerning "tail bites".

Concerning the influence of pen, facility and density on the interactive behaviours, the results are shown on Table 7.

Table 7. Influence of pen type, facility and animal density effects on the pig interactive behaviours (explore/rooting, contact nose/nose and contact nose/body – occurrences h-1 pig-1).

	Interactive behaviours		
	Explore/rooting	Contact nose/nose	Contact nose/body
Pen type			
Sg	0,563 (0,015) [a]	0,520 (0,012) [a]	0,276 (0,006) [a]
Db	0,386 (0,010) [b]	0,298 (0,009) [b]	0,147 (0,008) [b]
Facilty			
D	0,099 (0,015) [b]	0,224 (0,013) [c]	0,072 (0,008) [a]
F	0,101 (0,015) [b]	0,404 (0,013) [b]	0,252 (0,008) [b]
RM	0,122 (0,016) [a]	0,598 (0,013) [a]	0,311 (0,009) [c]
Density			
1.2	0,487 (0,016) [a]	0,425 (0,014)[a]	0,243 (0,009) [a]
1.8	0,474 (0,012) [a]	0,408 (0,010) [a]	0,204 (0,007) [b]
2.4	0,463 (0,017) [a]	0,393 (0,014) [a]	0,188 (0,009) [b]
Probability			
Pen type	<. 0001	<. 0001	<. 0001
Facility	<. 0001	<. 0001	<. 0001
Density	0,600	0,251	<. 0001
Pen type*Facility	<. 0001	<. 0001	<. 0001
Pen Type*Density	0,136	0,434	0,006
Facility* Density	0,940	0,766	0,914
Pen type*Facility*Density	0,292	0,115	0,661

Sg - Single; Db – Double
D – Drinkers; F – Feeders; RM – Rooting machines
Density (m^2/animal)
Values given in brackets are the standard error
[a,b,c] For each behaviour within a effect, means without a common superscript letter differ ($P < 0.05$)

These results show that the interactive behaviours are affected by pen type and facility (P<0.001) and the density also affect the "contact nose/body" behaviour (P<0.001). On the other hand, density does not have a significant effect on

"explore/rooting" and "contact nose/nose" behaviours (P=0.600 and P=0.251, respectively). This truth can be explained by the socialization and relations between animals near these facilities and this socialization increase with density. Important to note the role of the rooting machine on the facilitation of the interactive behaviours "nose/nose" and "nose/body" (0,598 and 0,311 occurrences h-1 pig-1, respectively) which confirm the importance that enriched housing conditions have in the development of appropriate social behaviour (Beattie and Walker et al., 1995). These results in this enriched housing system shows that pigs are more active, showing more play and explorative behaviours which is in accordance with other studies made (Beattie et al, 1996; Fraser et al., (2001); Lyons et al., 1995).

There is no interaction between facility*density and interactive behaviours, which is high concerning "explore and rooting" behaviour (P=0,940), the "contact nose/body" (P=0,914) and also the "contact nose/nose" (P=0,766). There is also no interaction between pen type*facility*density and "contact nose/body" (P=0,661). Moreover, is important to refer the higher interactive behaviours interaction with single pens comparing with double ones, as Beattie and Walker (1998) referred.

These results show that pigs in this husbandry system were very interactive and this may be an excellent evidence about the importance of the enriched environment, providing a life more mentally healthy and, consequently, an improve on the welfare.

Concerning the influence of pen, facility and density on the inactive behaviours, the results are shown on Table 8.

Table 8. Influence of pen type, facility and animal density effects on the pig inactive behaviours (sit/lay actively and sit/lay inactively – occurrences h-1 pig-1).

	Inactive behaviours	
	Sit/lay actively	Sit/lay inactively
Pen type		
Sg	0,079 (0,003) [a]	0,055 (0,003) [a]
Db	0,036 (0,002) [b]	0,031 (0,002) [b]
Facilty		
D	0,007 (0,004) [c]	0,002 (0,003) [c]
F	0,092 (0,004) [a]	0,062 (0,003) [a]
RM	0,072 (0,004) [b]	0,046 (0,003) [b]
Density		
1.2	0,067 (0,004) [a]	0,050 (0,045) [a]
1.8	0,060 (0,003) [a]	0,041 (0,002) [b]
2.4	0,046 (0,004) [b]	0,037 (0,003) [b]
Probability		
Pen type	<. 0001	<. 0001
Facility	<. 0001	<. 0001
Density	0,000	0,101
Pen type*Facility	<. 0001	<. 0001
Pen Type*Density	0,213	0,792
Facility* Density	0,000	0,161
Pen type*Facility*Density	0,035	0,895

Sg - Single; Db – Double
D – Drinkers; F – Feeders; RM – Rooting machines
Density (m^2/animal)
Values given in brackets are the standard error
[a,b,c] For each behaviour within a effect, means without a common superscript letter differ ($P < 0.05$)

The results for "sit/lay actively" and "sit/lay inactively" behaviors show that all effects studied are affect by these behaviors (P<0.001) except the density for "sit/lay inactively" (P=0.101). In general, inactive behaviours are more frequent (P<0.05) in single pens, near the feeder and in the 1.2 density group. These results also contest that sitting and standing behaviours were unaffected by space restriction, reported by Street and Gonyou (2007).

There are no relation between pen type*density and pen type*facility*density with "sit lay/inactively" behaviour (P=0,792 and P=0,895 respectively). Accordingly, agonistic behaviour increase with density so this could be an important proof to support Pearce and Paterson (1993) statements when they established that inactivity represents a "cut-off" strategy employed by pigs to distance themselves from stressful situations. The

verification that larger space allowance did not encourage locomotory behaviour supposed by Beattie and Walker et al. (1996) is also confirmed in this trial. Single pens show a higher relation with this kind of behaviour than double pens. Furthermore, the feeders have a higher interaction with this behaviour than the other two facilities. Drinkers are not a preferred area for pigs to rest because this behaviour is observed very rarely (0,007 and 0,002 occurrences h-1 pig-1, respectively). When pigs are resting (sit/lay) near the facilities areas, they usually are more active than inactive because as these are the most frequented places, they need to preserve a certain state of alert. Furthermore, this alertness combined with inactivity, should be taken in account because as Schouten (1986) reported, can be a response to harmful social behaviour.

The sexual behaviour results, the last type of behaviour treated, are illustrate in table 9.

Table 9. Influence of pen type, facility and animal density effects on the pig sexual behaviours (mount and smell genital – occurrences h-1 pig-1).

	Sexual behaviours	
	Mount	Smell Genital
Pen type		
Sg	0,006 (0,001) [a]	0,055 (0,003) [a]
Db	0,004 (0,001) [a]	0,031 (0,002) [b]
Facilty		
D	0,001 (0,001) [b]	0,002 (0,003) [c]
F	0,007 (0,001) [a]	0,062 (0,003) [a]
RM	0,006 (0,001) [a]	0,046 (0,003) [b]
Density		
1.2	0,005 (0,001) [a]	0,050 (0,045) [a]
1.8	0,005 (0,001) [a]	0,041 (0,002) [b]
2.4	0,004 (0,001) [a]	0,037 (0,003) [b]
Probability		
Pen type	0,0675	<. 0001
Facility	<. 0001	<. 0001
Density	0,632	0,004
Pen type*Facility	0,590	0,0001
Pen Type*Density	0,197	0,001
Facility* Density	0,497	0,004
Pen type*Facility*Density	0,236	0,003

Sg - Single; Db – Double
D – Drinkers; F – Feeders; RM – Rooting machines
Density (m^2/animal)
Values given in brackets are the standard error
[a,b,c] For each behaviour within a effect, means without a common superscript letter differ ($P < 0.05$)

The behaviour “mount” is only affected (P<0.001) by the facility. Curiously, this behaviour shows almost the same occurrence in the feeder and in the rooting machine (0,007 and 0,006, respectively) which as Cronin et al. (2003) referred maybe usually associated with agonistic behaviour. The low frequency of this behaviour could be related with castration of males. Pigs in this kind of production (even in biological production) are normally castrated so sexual behaviour is not seen very often, only some not many smells genital and even some few attempts to mount.

Regarding “smell genital” behaviour, this one is affected by all the different effects analysed. This behaviour is higher in single pens (0,055) and in the feeders (0,062). Concerning the “mount” behaviour, single pens show a little higher (0,006) relation than in double pens (0,004) and also the feeders have a higher relation than the other two facilities (0,007). Peculiarly, the “mount” behaviour do not follow the same pattern of the most previously discussed behaviours, is the only one with same relation between the two different 1.2 and 1.8 density groups (0,005). No relation was found between sexual behaviour and lower incidences of feeding behaviour (Morrison and Hemsworth, 2003).

CONCLUSION

This project goal was to analyse the pig behaviour in their competition for the facilities, analysing as much as possible the drinking, feeding and rooting behaviours in the different pen sizes, types and animal densities. As Broom (1991) referred, behaviour measurements are a difficult subject to analyse and reach conclusions.

In general the studied behaviours (agonistic, interactive, inactive and sexual behaviours) are affected by pen type, facility and density. Usually pigs in single pens, in the feeders and in the 1.2 m^2 density group, exhibit those behaviours more frequently. Furthermore, the results reached in this trial are similar to other studies made before with growing pigs.

Analysing all these behaviour results, I think ComfortClass husbandry system can easily convince farmers and animal protection organizations about the improvements made regarding welfare, labour and costs in equipment and buildings. Therefore, farmers are able to know how much space and money can be saved in accommodations and labour and animal protection organizations can see in this project an important step for the accomplishment of the pig needs and welfare. In my opinion, and with the right animal density, this project represents definitively an important step for the satisfaction of both concerns achieving important welfare issues needed for the satisfaction of this sector. On the other hand, the technical results can be lower than general intensive productions but under the EU regulations and having in mind that welfare will be an imperative issue in the next few years, an overlook in this subject matter could help farmers in their future orientations. Moreover, the results reached can be an important help to further studies.

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APPENDIX

APPENDIX 1

EU 2001 Pigs Directive

Since January 2003, the provision of appropriate environmental enrichment to pigs of all ages has been mandatory across the European Union (EU) (Directives 2001/88/EC and 2001/93/EC). The Directives state that: 'To enable proper investigation and manipulation activities, all pigs must have permanent access to a sufficient quantity of material such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such which does not adversely affect the health of the animals'.

[14]APPENDIX 2

Regulations for organic livestock farming in EU

In the European countries, the EEC-Regulation No 1804/1999, supplementing regulation Nº 2092/91 on organic production, has been passed and become law in August 2000. As shortly described in Sundrum (2001), Jakobsen & Hermansen (2001) and Padel et al. (2000), the EECRegulation provides a standard that involves the right to label food as organic. It includes specifications for housing conditions, animal nutrition, and animal breeding, as well as animal care, disease prevention, and veterinary treatment, and will create a framework for organic livestock production and labelling products in all European countries on an equal, legal base. An important key principle is to rely mainly on the management of internal farm resources rather than on external input and, in relation to health management, to rely on prevention measures rather than on medical treatment.
As regards feed, this intends to ensure quality production rather than to maximize production, while meeting the nutritional requirements of the livestock at various stages of their development.
Livestock must be fed on organically produced feeding stuffs, preferably from the farm itself. A limited proportion of conventional feeding stuffs is permitted within a transitional period expiring on 24 August 2005. It is specifically requested that
• The feeding of young mammals must be based on natural milk, preferably maternal milk, for a minimum period depending on the species.
• Roughage, fresh or dried fodder, or silage must be added to the daily ration for pigs.
• Only feed materials listed in Annex II of Council Regulation No 1804/1999, whether conventionally or organically produced, can be used (a positive list). Furthermore, conventional feed materials of agricultural origin can be used only if they are produced or prepared without the use of chemical solvents. This implies that e.g. soybean meal, the most common protein source in animal nutrition, cannot be used in organic feed.
• Antibiotics, coccidiostats, medical substances, growth promoters, or any other substance intended to stimulate growth or production are not allowed in animal feeding.
• No feed components may have been produced with the use of genetically modified organisms (GMOs) or GMO derivatives.
• Vitamins authorised for conventional animal production under Directive 70/524/EEC should be derived from raw materials occurring naturally in foodstuffs. Synthetic vitamins identical to natural vitamin can, however, be used for monogastric animals.
The legislation for organic livestock production aims at providing environmental conditions, which allow animals to perform their natural movements and behaviour. Management methods must not interfere with animals' body parts, meaning that e.g. tail docking is not allowed. However, castration is allowed to reduce aggressions in pens and during transport and to ensure product quality.
The minimal standards in relation to animal welfare are primarily focussed on locomotion areas, floor characteristics and husbandry practices. Dry litter as well as group penning is prescribed for all farm animals. Tethering farm animals is not acceptable. The indoor area is supplemented by an outdoor area that must be at least 75% of the indoor area.

[14] Development of organic pig production systems [online],[Read 2007-05-22]

The main minimum requirements for organic pig production are shown in the next tables:

Organic pig production – minimum requirements Item Requirement

Item	Requirement
General	
- Age at weaning	40 days (DK: 49 days)
- Feed	Less than 20% non-organic feed – from 2005 100% organic feed Access to roughage or rooting material
- Use of drugs	No preventive medical treatment of animals Medical treatment only after instruction and diagnose by a veterinarian Subsequent treatment with therapeutic drugs - only by a veterinarian 2 times longer retention time than required by veterinary authorities Log of all veterinary treatment and use of disease control agents
- Treatment	No tail docking and teeth clipping (or grinding)
Indoor housing	
- Outdoor yard	Max. 50% covered with roof
- Gestation sows	Group-housed
- Lactating sows	Loose
- Weaners	Flat-deck pens not allowed.
- All categories	Free access to roughage Clean and dry litter in lying area Each lying zone must accommodate all animals in pen
Outdoor housing	Access to grazing area at least 150 days from 15 April – 1 November (Except for weaners and finishers) Access to shelter, shade and cooling facilities Clean and dry litter in lying area

Organic pig production - space requirements

Space requirements (buildings)	Indoor space, Sqm/animal	Solid floor space indoor, sqm./animal	Outdoor yard space, sqm./animal
Boars	6.0	3.0	8.8
Lactating sows	7.5	3.75	2.5
Gestation sows	2.5	1.25	1.9
Weaners 40 days – 30 kg	0.6	0.3	0.4
Finishers 30-50 kg	0.8	0.4	0.6
Finishers 50-85 kg	1.1	0.55	0.8
Finishers 85-110 kg	1.3	0.65	1.0

[15]APPENDIX 3

Dutch impose strict regulations (Pat Tuite, Drogheda)

(:::) Weaners to 30kg require 0.4m^2 floor area with at least 0.12m^2 solid.
Finishers over 85kg require 1m^2 floor area and at least 0.3m^3 solid.
These grower floor areas are approx. 50% higher than the requirements of E.U. Directive 91/630.
The Dutch are especially concerned with ammonia emissions. The Green Label Production system

[15] Pig Newsletter [online], [Read 2007-05-22]

requires a 50% reduction in ammonia emissions from pig buildings. This is achieved mainly by reducing the exposed surface area of the manure and/or by washing the exhaust air.

Group housing in Holland (Eva Lewis, Teagasc, Moorepark)

I spent the last two weeks of February 2002 in Holland visiting commercial and research farms operating group housing systems for pregnant sows.

Holland is operating under strict welfare regulations known as `Varkensbesluit'. The `Varkensbesluit' lays down minimum requirements for pig housing and welfare and comes into force on 1st January 2008. Sows and gilts must be housed in groups with **2.25m^2 total area (of which 1.30m^2 is solid) per individual**.

[16]APPENDIX 4

The ethogram used for studying the pigs:
Lying: The pig lies down, either on its belly or on one side
Lying alone: The pig lies on the floor without any physical contact to other pigs
Lying together: The pig lies on the floor and is in physical contact with at least one other pig
Sitting: The pig sits on its tail with its forelegs stretched nudez the body
Standing: The pig stands on all four legs. Standing passive: The pig stands without any activity
Standing active: The pig stands while moving its head to investigate the surroundings or performing sham chewing
Movement: The pig walks or runs around the pen
Drinking: The pig drinks water from the water-cup
Elimination: The pig defecates or urinates
Comfort behaviour: The pig rubs its body against the inventory, stretches or yawns.
Exploration: The pig makes horizontal movements of the head over the floor or bars, sniffs the floor or bars
Inventory manipulation: The pig licks, manipulates, sniffs or bites the inventory of the pen, e.g. bars and chains
Play: The pig jumps in the air or runs back and forth in the pen doing buckjumps
Social interaction: The pig sniffs, bites or massages another pig in the pen or performs homosexual mounting
Aggression: The pig pushes, bites or fights withanother pig from the pen.
Other behaviour: The pig performs in a way not mentioned above

The pooled behavioural categories:
Inactivity: Lying alone + lying together + sitting + standing passive
Active behaviour: Standing active + movement + comfort behaviour + play + drinking + elimination
Social behaviour: Social interaction + aggression
Exploration: Exploration + inventory manipulation

[17]APPENDIX 5

Pigs do not have functional sweat glands, so pigs cool themselves using water or mud during hot weather. They also use mud as a form of sunscreen to protect their skin from sunburn.

Mud also provides protection against flies and parasites.

[16] A preliminary study of the impact of stocking density on the behaviour of group housed [Online],[Read 2007-05-23.
[17] Pig.Com [Online], [Read 2007-05-21]

APPENDIX 6

Picture 1 - Pens (general view)

Picture 2 - Natural ventilation system

Picture 3 - Feeders

Picture 4 - Drinkers

5 - Rooting machine

Picture 6 - Slatted floor

Picture 7 - Shower

Picture 8 - Beds (inside view)

Picture 9 - Beds (fontal view)

APPENDIX 7

List of removed animals

Date	Pen	Animal	Cause
10/1/2007	6	229	Very crippled
11/1/2007	11-12	931	Umbilical point crack (to sick pen)
1/2/2007	11-12	428	Lung problems
4/2/2007	8	781	Circo
6/2/2007	8	750	Circo
11/2/2007	3-4	418	Heart problems
12/2/2007	9-10	14	Paralysed (20/2 euthanized)
28/2/2007	11/12	309	Lung problems
2/3/2007	1-2	471	Unknown
8/3/2007	9-10	260	Circo
9/3/2007	11-12	751	Circo
	11-12	950	Circo
	11-12	729	Little one/small pig (to sick pen)
	8	269	Little one/small pig (to sick pen)
19/3/2007	8	458	Paralysed (21/3 euthanized)
27/3/2007	11-12	479	Tail biting (to sick pen)
	11-12	469	Tail biting (to sick pen)