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Abstract

In nature pigs spend a large part of their active time foraging, a behaviour in which their snout plays a big role. In an intensive system pigs have an extremely limited possibily to perform natural behaviour such as foraging. The floors in intensive modern systems are often bare and the pigs are provided with a restricted amount of bedding material. Inability to perform natural behaviours may lead to stress and development of stereotypies and is an indicator that the animal has trouble handling the environment. The animal can for instance be less active and spend a lot of time motionless.

The objective of this study was to determine whether environmental enrichment in the form of a straw dispenser has any effect on the level of exploratory behaviour, activity and manipulation of penmates. The pen hygiene and amount of leftover straw were scored during the experiment to examine the effect a foraging tower had on hygiene and straw consumption. Enrichment was provided with a substrate dispenser (foraging tower) from which the pigs could pull straw through the bottom of the tube. An experiment was performed in three batches during a total of three weeks on growing pigs (< 35 kg) housed for commercial use. Nine groups per batch were exposed to one of three treatments: straw on floor (C); straw on floor and empty foraging tower (E); and straw on floor and straw in foraging tower (F). In each group, pig behaviour was observed through direct scan sampling of all pigs every 4 minutes during 2 hours on one day. A scan of all pigs in each pen was performed two times a day (8h00-9h00; 11h00-12h00).

The observed exploration had a total mean percentage of 26,3% (E), 26,4% (F) and 25,9% (C) during both observation sessions. Results showed a significant difference in activity level, exploration and manipulation of penmates, especially between group F and C. The activity level amongst all pigs were overall lower during the second (11h00-12h00) observation compared to the first. As the straw was distributed at 9h30 the growing pigs may have, by the second observation, fulfilled most of their rooting needs. Oral manipulation of penmates tended to occur significantly less often in group F compared to the other groups (E and C). The pen hygiene was not affected much by the different treatments which means that this kind of environmental enrichment is relatively compatible with the manure handling system used in the modern housing systems. The mean average of straw consumption in group F was 449 g/day compared to 353 g given on the floor in group E and C. Overall the F pigs had a higher amount of clean straw left on the first observation compared to the other groups.

Since there were no differences in behaviour between group E and C, the results suggest that the foraging tower *per se* did not stimulate activity or exploration in the pens. The stimuli should therefore have been the straw provided in the dispensers.

1. Introduction

1.1 Natural behaviour

The pig (*Sus scrofa*) is an omnivore which spends a large part of its active time foraging (Studnitz *et al.,* 2007). In nature it inhabits a large area and depends on seasonal sources of food for its survival (Studnitz *et al.,* 2007). Studnitz *et al.* (2007) point out that wild boars, hybrids and domestic pigs all have the ability to adapt their foraging strategy to the present situation. In a study by Gustafsson *et al.* (1999) it was found that domestic pigs and hybrids between wild boar and domestic pigs spend the same time foraging, although their strategies differ slightly. Domestic pigs seem to remain much longer in the same area while hybrids stay a short time and pass more barriers in the form of wooden hand-made obstacles (Gustafsson *et al.,* 1999). The same study showed that even though there were no barriers, the domestic pigs stayed in the same place which means that the domestication might have changed the behavioural repertoire towards a less costly strategy (Gustafsson *et al.,* 1999).

Considering that the pig is an omnivorous opportunist it is no wonder that the animals are very well adapted for exploratory behaviour (Arey, 1993). The pig explore the surroundings by rooting, sniffing, biting and chewing (Studnitz *et al.,* 2007). The snout plays a big part in this behaviour and it is mainly directed towards objects at floor level (Arey, 1993). The pigs are curious animals and therefore a part of the exploratory behaviour may be because of their curiosity (Studnitz *et al.,* 2007). The use of straw within conventional pig farming provides an opportunity to express these natural behaviours, but also promotes their performance (Arey, 1993). Straw is used because of its similarity to the substrate that the pigs would find in their natural environment (Arey, 1993). Regardless of their age the pigs explore bedding by sniffing and rooting, which displays the strong motivation to investigate with their snout (Arey, 1993). Arey and Franklin (1995) found that conventional housed pigs provided with straw have a higher activity level and spend less time lying down 1-5 days after mixing than those without straw ($P < 0.05$). During daylight hours pigs with access to straw spend approximately 26% of their time performing oral manipulation of straw material (Pearce, 1993).

1.2 Modern housing

The majority of growing pig in Europe are kept in pens with slatted floors and a good hygiene but to have an adequate enrichment in the pen whilst in an efficient way remove feaces and dirty straw seems to be a key problem (EFSA, 2005). The explorative behaviour is a natural behaviour that the animals have an extremely limited possibility to perform in the modern housing system (Arey, 1993). Bolhuis *et al.* (2005) concluded that the level of exploratory behaviour varied a great deal between pigs kept in barren and enriched pens (barren: 14,2-15,4%; enriched: 26,0-26,3%).

The floors in intensive systems are bare and uncomfortable, and straw reduces discomfort (Arey, 1993). The bedding also absorbs some of the faeces, which provides a better underlay and ensures a good foothold and health (Arey, 1993). Straw provides not only comfort for the pigs but also give the animals the possibility to control their temperatures and making them less vulnerable to changes in the barn-temperature (Fraser *et al.,* 1991). Growing pigs are either fed ad libitum or administered a certain amount of feed a few times a day during the fattening period (Studnitz *et al.,* 2007). Even when pigs are fed ad libitum, the need to perform exploratory behaviour are just as big as when the diet is resticted (Day *et al.,* 1995).

The use of straw in Europe is overall low which can jeopardize the welfare and natural behaviours of the pigs (Arey, 1993). The largest risk for tail-biting within a group of pigs are fully slatted floors and lack of suitible bedding material (EFSA, 2007). Straw is not very compatible with the manure handling system of this modern housing and could explain the low use (Arey, 1993). Improving the manure handling system so that it can manage a higher amount of bedding material or change to a more suitable substrate can be a solution to these problems and therefore improve animal welfare (Arey, 1993).

1.3 Straw as manipulative material

Use of enrichment creates opportunity for the pigs to perform behaviours that is of great help when expressing control over the environment (Van de Weerd *et al.,* 2006). Straw has been reported to improve the welfare of pigs, and serve not only as enrichment but also reduce negative behaviours directed towards other pigs (Day *et al.,* 2008). The same authors also states that the activity level and the behaviour diversity is greater when pigs are provided with straw. Growing pigs spend a lot of time with oral manipulation of bedding, interior and other penmates (Day *et al.,* 1995). Straw as bedding is widely used but can cause problems with the manure handling system and therefore the allowance is sometimes strictly limited (Jensen *et al.,* 2010). Jensen *et al.* (2010) consequently suggests that the use of silage would minimize this problem since it is more likely to be eaten by the pigs. Compared with chopped straw it is also preferable seeing that it allows the pigs to perform more explorative behaviour (Jensen *et al.,* 2010).

Materials that are complex, destructible and changeable provides the best stimuli for expressing exploration in the pen (Studnitz *et al.,* 2007). To occupy the pigs for a long period of time it is recommended that long straw is used instead of chopped straw (Bulens *et al.,* 2015). Bulens *et al.* (2015) also suggests that long straw seems to satisfy their need to perform exploratory- and chewing behaviours. Studies show that chopped straw is not a suitable material to fulfill the needs to perform rooting and exploratory behaviour and may therefore be redirected toward penmates (Day *et al.,* 2008). On the other hand, Day *et al.* (2008) found that when the pigs were provided with straw, irreplaceable of its length, the frequency of oral manipulation of other pigs were lower than with pigs kept in barren pens. According to a study by Bolhuis *et al.* (2005) the mean average of manipulation of penmates for pigs kept in barren environments is between 1,19-2,14% and in enriched environments it lies between 0,31 and 0,45%. It has been hypotesized that the materials that are most stimulating and let the pigs explore for the longest period of time are the ones that are most likely to prevent redirected behaviours (Studnitz *et al.,* 2007).

Jensen *et al.* (2010) reports that when giving pigs larger space allowance, they manipulated the bedding more than when kept in a smaller area. The authors concluded that this may be due to that more pigs are able to root simultaneously. That the enrichment can be used by a lot of pigs at the same time seems to be of high value and should be carefully thought about when choosing enrichment type (Jensen *et al.,* 2010). The enrichment should preferably be sufficient in order to maintain the explorative behaviour during the whole day to minimize redirected behaviours (Jensen *et al.,* 2010).

1.3.1 Presentation of straw

An enrichment should have the ability to occupy the pigs for some time and lower the frequency of abnormal behaviours shown (Scott *et al.,* 2007). There are many different

ways of presenting straw that may occupy the pigs for a longer time than straw distributed on the floor (Bulens *et al.,* 2015). A straw rack, a rack with openings that is placed on the wall or is hanged from the ceiling, is an example that was used in an experiment by Bulens *et al.* (2015) that resulted in a higher amount of straw used by the pigs compared with other enrichment types. The same authors concluded that the result mentioned above was due to the easy access to the straw (Bulens *et al.,* 2015). Strawblocks, hard packed straw in different shapes, is another enrichment that is effective and has a low straw loss through the slatted floor (Bulens *et al.,* 2015). Some types of enrichment, like the 'Funbar' (a narrow vertical dispenser filled with chopped straw) used in an experiment by Bulens *et al.* (2015), may however increase the frequency of abnormal behaviours (e.g belly-nosing) shown by the pigs. The enrichment type used in the present study is called a foraging tower and consists of a dispenser that releases straw when moved sideways. Novel objects overall seem to act as a cue to their exploratory motivational system and increasing the rate of visits to that particular area (Day *et al.,* 1995).

1.4 Stress and stereotypies

The modern housing, a combination of a limited space and shortage of bedding material, can cause development of stereotypies and stress due to inability to control the environment (Arey, 1993). Stereotypies are associated with negative welfare and when behaviours that are species-specific and strongly motivated are prohibited there is a high risk that the welfare could be compromised (Jensen & Toates, 1993). Stereotypies can be defined as repeated, invariable sequences of movements that does not serve any obvious purpose (Arey, 1993). An indicator that the animal has trouble handling the environment can for instance be that the animal is less active and spend a lot of time being motionless (Arey, 1993). The occurrence of oral activities directed towards other penmates in environments without bedding may be as a result of boredom and inability to perform certain natural behaviour, such as rooting (Arey, 1993).

The use of straw may promote activity and can reduce the abnormal behaviours of all ages of pigs (Arey, 1993). Provision of fresh straw also reduces and oral behaviour directed towards penmates and stimulate rooting in the bedding (Fraser *et al.,* 1991). When kept on strawbedding growing pigs were found manipulating penmates on average 5,0% of the total observed time (Scott *et al.,* 2007). In a study by Bulens *et al.* (2015) they conclude that even though some types of enrichment can promote welfare, some types have been observed to increase oral behaviours like belly-nosing. Belly-nosing is universally referred to as an indicator of stress and that the animal lacks enrichment and stimuli in the environment (Colson *et al.,* 2006). Colson *et al.* (2006) also points out that this behaviour can be a substitute to the eating behaviour and may be comforting and calming for the piglets to perform.

Stereotypies are undeniably an important factor when assessing the welfare of animals, and an environment that induce and increase performed stereotypies are normally not optimal for the animal (Mason & Latham, 2004). Although, several factors must be considered when assessing welfare, and not the stereotypy alone is enough to condemn the environment as poor (Mason & Latham, 2004). For example, when a stereotypy arises it is difficult to get rid of even if the animal is removed from the poor environment (Mason & Latham, 2004).

1.5 Legislation

Providing manipulative material to all ages of pigs is a requirement for all Members States of the European Union according to Council Directive 2008/120/EC of December 18, 2008 laying down minimum standards for the protection of pigs. The directive also states that the pens should correspond to the pigs´ need to explore and forage. Swedish regulations on farm animal husbandry, issued by the Swedish Board of Agriculture (SJVFS 2010:15, L 100) adds in a general advice to 3 chapter 7 § that the substrate should consist of rootable material that the can both stimulate and promote exploratory behaviour and chewing. SJVFS 2010:15, L 100 also regulates the weaning age which can not be under 4 weeks of age. At this time the pigets should have learnt to eat supplementary feed.

2. Aim and study question

The aim of this study was to investigate the effects of straw provided through a foraging tower on exploratory behaviour and activity level of growing pigs. The aim was also to test whether the foraging tower can satisfy the pigs´ need for exploratory behaviour better than straw distributed directly on the floor and how it affects pen hygiene. This might tell us how suitable this type of enrichment is in our intensive modern systems and if the pig welfare is positively affected by this.

The following questions were asked:

- How does the use of a foraging tower affect the explorative behaviour of growing pigs, compared to straw distributed on the floor?
- How does the use of a foraging tower affect the activity level of growing pigs, compared to straw distributed on the floor?
- How does the use of a foraging tower affect the level of manipulation of penmates, compared to straw distributed on the floor?
- How does the use of a foraging tower affect pen hygiene of growing pigs, compared to straw distributed on the floor?

3. Material and methods

3.1 Animals and housing

The experimental subjects were 296 growing pigs (crosses of Duroc (50%) x Yorkshire (25%) x Swedish Landrace (25%)) in 27 different pens, 155 female and 141 male pigs. They were housed conventionally in a building section with 48 pens holding totally 540 growing pigs (<35 kg). During the 3 weeks of the trial the temperature in the building was on average 16,9 ºC, starting with 17,7 ºC and dropping to 15,5 ºC at the end of the rearing period. For 7-10 days at the beginning of the fattening period the pigs were given dry feed, followed by automatic liquid feeding three times a day during the rest of the rearing and finishing period. Each pen had unrestricted access to water through a nipple and they were fed at 5h00, 13h00 and 19h00. Dirty straw and feaces were removed from the solid floor every day before distribution of new straw.

Pigs were weaned at approximately 5 weeks of age, and were between 8 and 10 weeks old during the trail. At weaning the litters were mixed and sorted according to size. The pigs were housed in groups of 10-12 individuals in pens measuring 139x320 cm. The solid floor was of concrete and measured 139x240 cm. Each pen had a roof covering an area of about 168 cm^2 on the concrete part. The slatted area was 139x80 cm with bar intervals of 0,9 cm. At 11 weeks of age the growing pigs were moved to another building section and again sorted by size. At around 110 kg the pigs were sent to slaughter.

3.2 Enrichment and substrate

Long wheat straw, harvested on local fields during autumn 2015, was given daily to all experimental pens and to the whole section between 9h30 and 10h00. Amount of straw distributed to two of the experimental groups (C, E) was the same amount that the farmer ordinarily gives them. The straw was provided by hand and distributed on the solid floor in the pen. Six different samples of the distributed amount was taken during the three weeks that the experiment was conducted and the average weight was 353 g. A total of 50 randomely collected straws were measured and calculated avarage of straw length was 43,14 cm.

The enrichment method that was used was a foraging tower from Big Dutchman (Fig. 1) with the measurements 120x80x117 cm. The straw was brought into the dispenser from the top and could be rooted out by the pigs from the bottom. The dispenser had a volume of about 80 l (0,08 m^3) and could fit about 1890 g (an average of six samples) of straw.

Fig. 1. Straw dispenser which was filled from the top with straw.

3.3 Experimental procedure

The experiment was conducted during 3 weeks and was run in three batches, each batch consisting of nine pens of 10-12 pigs each. All batches included three experimental treatments, a control-group that received their substrate (353 g) on the floor (C), a group that was provided with an empty foraging tower and substrate (353 g) on the floor (E) and a group distributed substrate using a full foraging tower and recieved no straw on the floor

(F). As substrate all groups received uncut long straw daily at 9h30 and even though the dispenser had straw left it was filled to the top every day (F). The foraging tower was put into the box two days before behaviour observations started to give them the chance to get familiar with the object. It was also done to get a reliable result and so that the foraging tower hopefully had lost some of its novelty factor.

3.4 Data collection

The observations took place before distibution of new straw from 8h00 to 9h00 and about 1 h after straw distribution from 11h00 to 12h00, on one day in each group. Pig behaviour was recorded by direct instantaneous scan sampling every 4 min. The pen was scanned and the number of pigs standing was recorded. Among these standing individuals the number of pigs in mouth/snout in contact with straw, foraging tower, pen fittings/pen floor/feaces, another pig or inactive/other was recorded. Snout contact with other pigs was divided into belly-nosing (nursing behaviour practiced on a pen-mate) or all other type of contact with another pig.

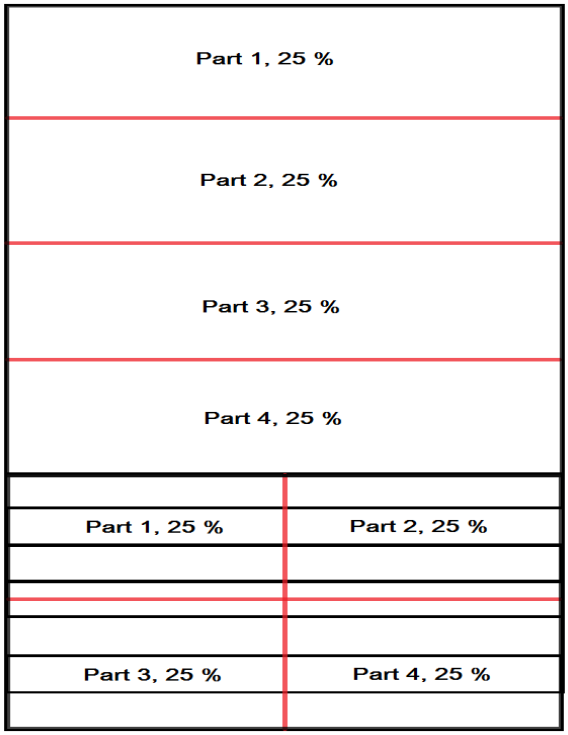

Fig. 2. Illustration of division of the pen. At the top; the solid floor that is divided into four horizontal parts. At the bottom; the slatted floor that is divided into four.

A scoring of pen hygiene and leftover straw were made every observation day at around 9h00. The scoring was done visually and all the pigs were present in the pen. The following catagorical scale was used: (0) less than 1 dl unsoiled straw left in the pen; (1) more than 1 dl and less than 1 l straw left; (2) more than 1 l and less than 10 l straw left; (3) more than 10 l unsoiled straw left in the pen. Scores of at least 2 was considered to indicate permanent access to straw in the pen.

The solid floor was divided into 4 parts (Fig. 2). Each part was scored separetely and the scores then added to get a total sum. At least 50 % of one area must be covered in feaces, dirty straw or being wet to be considered dirty and get 1 point. The solid floor could have a

maximum of 4 points, if all of the four parts were more than 50 % dirty, and a minimum of 0 points, if none of the parts are dirty. Also the slatted floor was divided into four parts (Fig. 2) and the points from scoring each part separtely were added together to get a daily sum. To get 1 point at least 50 % of that area of the slatted part should be blocked, which means that the slots should no longer be visible between the columns of the slatted floor. Scoring could be maximum 4 points, if all the four parts were at least 50 % blocked, and a minimum of 0 points if none of the parts was blocked.

Amount of straw left in the foraging tower was scored every day at around 9h00. Markings had been made on the inside of the dispenser at every 10 cm (Fig. 3). The scoring system shifting from a minimum of 0 points; completely empty, to a maximum of 10 points; dispenser full of straw (1890 g).

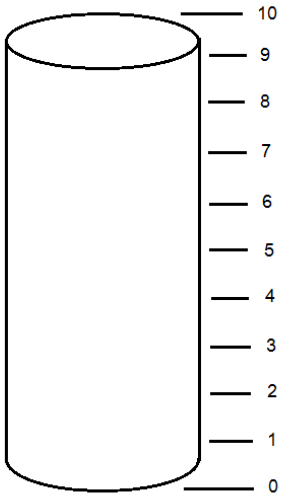

Fig. 3. Illustration of scoring system for straw left in foraging tower.

3.5 Data analysis

The collected data were compiled in Word Excel and two-sample t-tests were performed in Minitab to analyse if the mean differed between the treatment groups. Activity level, exploratory behaviour and manipulation of penmates was compared between groups E, F and C. The selected behaviours were divided into three groups; (1) exploratory, (2) manipulation of penmates and (3) inactive and an average for each box and observation time (8h00-9h00/11h00-12h00) were calculated. Also the total percentage average of activity was calculated in which all the observed behaviours except 'inactivity/other behaviours' was calculated. 'Snout in contact with straw', 'foraging tower' and 'fitting/floor/feaces' was counted as (1) exploratory behaviour and 'snout in contact with other pig' and 'belly-nosing' belonged to (2) manipulation of penmates.

The quantity and percentage for each score was calculated to see the distibution of scores and which group that tended to have the best pen hygiene for the solid and the slatted floor. To enable testing in Minitab and to perform a Chi-Square-test, were the expected value was compared to the actual value and se if this could be generalized for a larger population of growing pigs, the hygiene for each pen was scored as 0 or 1. If the solid/slatted floor remained clean (0) during the whole experiment it received a total score of 0, if not it was scored as 1.

4. Result

4.1 Activity level

The mean percentage of activity level between the treatment groups was not affected by the different ways to distribute straw at the first observation session 8h00-9h00 (Tab. 1). At the second observation session the mean percentage showed there was clearer difference in activity level between group F (17,7%) and groups E (25,5%) and C (24,9%). No significant statistical difference between groups E and C was found, neither at the first observation at 8h00-9h00 (P=0,97) or at 11h00-12h00 (P=0,90). There was a tendency to a significant difference at 8h00-9h00 (P=0,077) between groups F and C and a clear difference at 11h00-12h00 (P=<0,001). The activity level during the morning observation (8h00-9h00) was almost two times higher than the second daily observation at the middle of the day (11h00-12h00) (Fig. 4). The total mean percentage of activity level during both observation session are 35,1% (E), 32,6% (F) and 35,0% (C).

Table 1. Mean value, median and standard deviation of mean value of activity in the three treatment groups (C (straw on floor), E (empty foraging tower and straw on floor) and F (full foraging tower and no straw on floor)) at the two different observation sessions (8h00-9h00 and 11h00-12h00).

	8h00-9h00			11h00-12h00		
Group	**Mean**	**Median**	**StDev**	**Mean**	**Median**	**StDev**
C	0,450	0,455	0,257	0,249	0,091	0,293
E	0,450	0,455	0,287	0,251	0,091	0,292
F	0,475	0,455	0,274	0,177	0,091	0,222

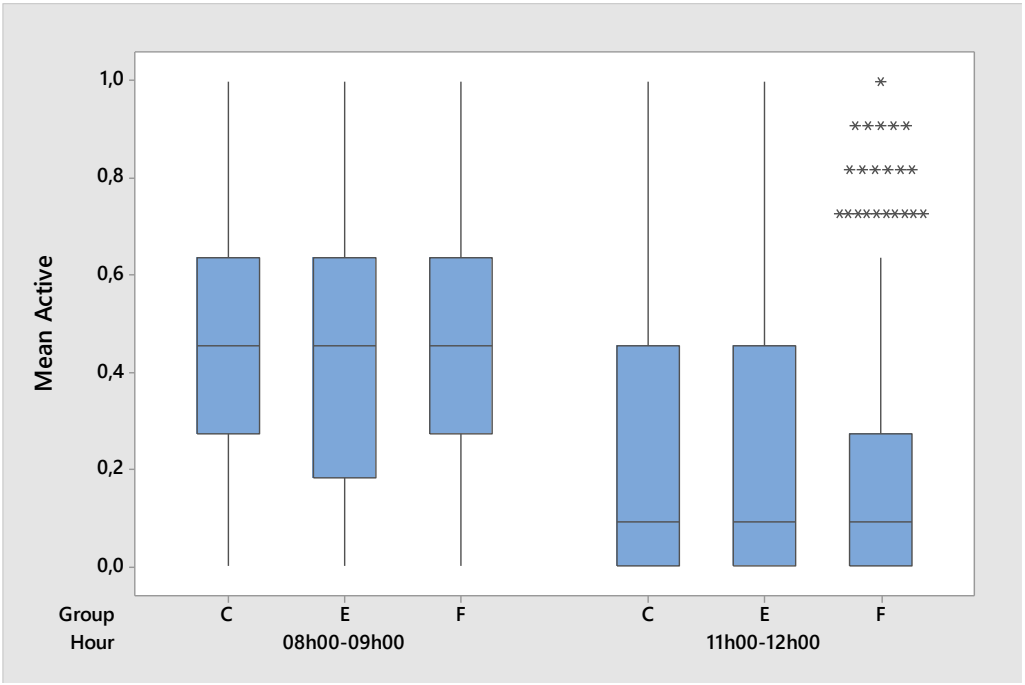

Fig. 4. Boxplot of mean of active time divided into treatment groups and observation sessions. The outliners (*) are observations that lies an abnormal distance from the other observed values.

4.2 Exploratory behaviour

No significal difference in exploratory behaviour was found between groups E and C, neither at 8h00-9h00 (p=0,407) nor 11h00-12h00 (P=0,873). Between groups F and C there was on the other hand a difference at both observation sessions shown by a P-value of <0,001 at both times. Table 2 shows a variation of mean values between the three groups (E, F and C) at the second observing session (11h00-12h00). The mean percentage average of exploratory behaviour amongst the pigs in all groups plummets during the second observation (Fig. 5). The observed exploration had a total mean percentage of 26,3% (E), 26,4% (F) and 25,9% (C) during both observation sessions.

Table 2. Mean value, median and standard deviation of mean value of exploratory behaviour in the three treatment groups (C (straw on floor), E (empty foraging tower and straw on floor) and F (full foraging tower and no straw on floor)) at the two different observing sessions (8h00-9h00; 11h00-12h00).

	8h00-9h00			11h00-12h00		
Group	**Mean**	**Median**	**StDev**	**Mean**	**Median**	**StDev**
C	0,330	0,364	0,216	0,188	0,091	0,244
E	0,340	0,364	0,242	0,190	0,091	0,246
F	0,393	0,364	0,247	0,135	0,000	0,188

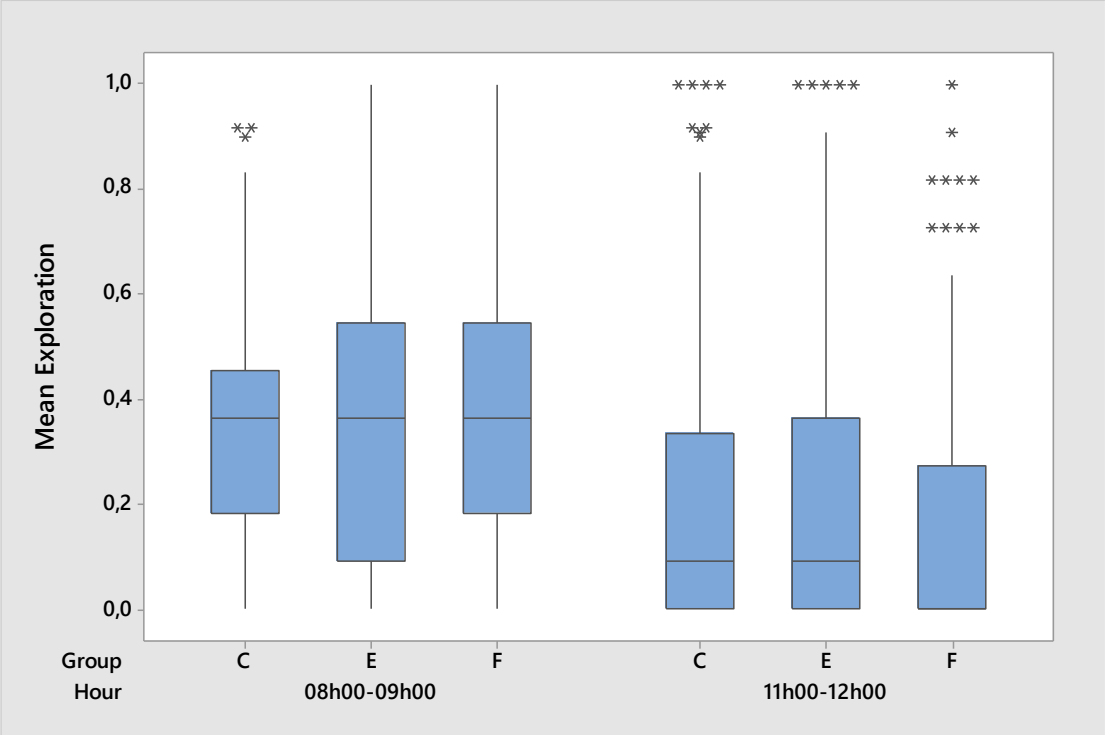

Fig. 5. Boxplot of mean of exploratory behaviour divided into treatment groups and observation sessions. The outliners (*) are observations that lies an abnormal distance from the other observed values.

4.3 Manipulation of penmates

The mean average percentage of manipulation of penmates during both observing sessions is overall lower in group F compared to E and C (Tab. 3). In groups E and C no significal difference were discovered at neither 8h00 (P=0,079) or at 11h00 (P=0,977). Between

group F and C the results revealed a significal statistic difference both at 8h00-9h00 (P=<0,001) and 11h00-12h00 (P=<0,001). Group F tended to perform less oral manipulation of penmates than the other groups at both observations (Tab. 3). Overall the manipulation of other penmates decreased from the first to the second observation (Fig. 6).

The frequency of the behaviour belly-nosing did not differ between the three treatment groups at neither the first (8h00) or second (11h00) observation. The mean average of each group varied between a minimum of 1,53% and a maximum of 1,98% and t-test did not show any significant difference between the the groups. The mean percentage of performed belly-nosing during both observation sessions were 1,78% (E), 1,55% (F) and 1,83% (C).

Table 3. Mean value, median and standard deviation of mean average of manipulation of penmates in the three treatment groups (C (straw on floor), E (empty foraging tower and straw on floor) and F (full foraging tower and no straw on floor)) at the two different observation sessions (8h00-9h00; 11h00-12h00)).

	8h00-9h00			11h00-12h00		
Group	**Mean**	**Median**	**StDev**	**Mean**	**Median**	**StDev**
C	0,120	0,091	0,113	0,060	0,000	0,097
E	0,110	0,091	0,097	0,060	0,000	0,097
F	0,082	0,091	0,099	0,041	0,000	0,079

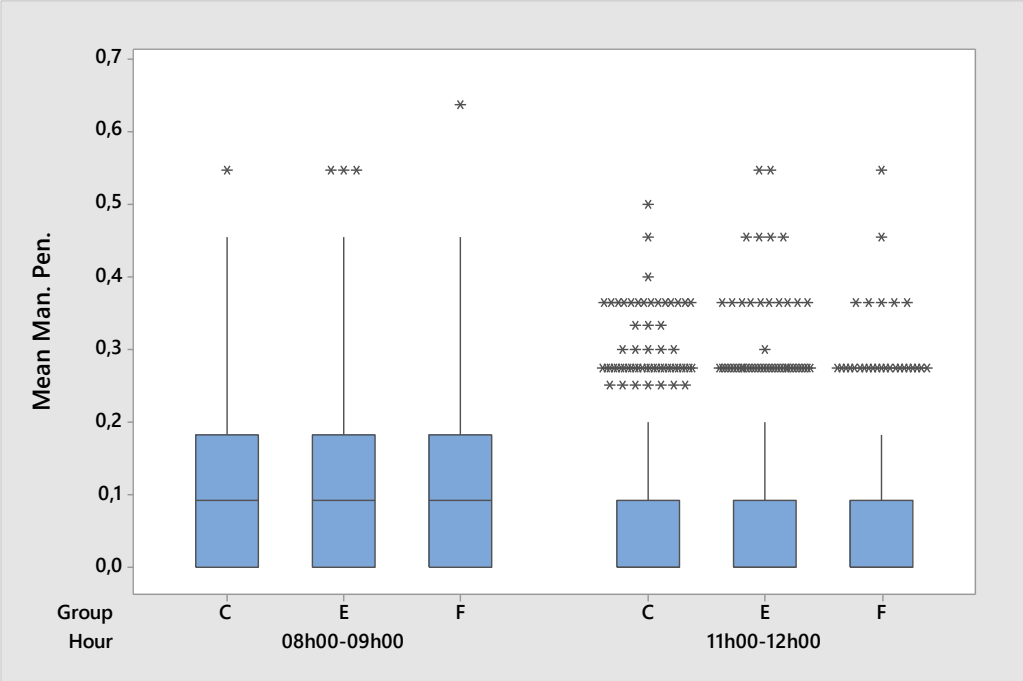

Fig. 6. Boxplot of mean of manipulation of penmates divided into treatment groups and observation sessions. The outliners (*) are observations that lies an abnormal distance from the other observed values.

4.4 Pen hygiene

In total, the score most registered on the slatted floor was 0 (no part blocked) (92,6%), which means that the pen hygiene within all groups was good (Tab. 4). There were very little difference between the groups. In group C the only score registered was 0. Scoring of the solid floor showed on the opposite that group E and F recieved a lower score, but still

there was a very small difference between the three groups (Tab. 5). The solid floor had overall a good hygiene within all groups and the score 0 (no part dirty) was registered 97,0% of the total registration count.

To make it possible to perform a Chi-Square test the scores were divided into two groups; 0 or 1. There was a significant statistical connection found when scoring the slatted floor (X^2= 6,05; P=0,049). No difference was observed of hygiene on the solid floor (X^2= 3,61; P=0,165).

Table 4. Distibution of hygiene scores (%) on the slatted floors within each treatment group (C, E and F) (0: No part dirty; 1: one part more than 50% blocked; 2: two parts more than 50% blocked; 3: three parts more than 50% blocked and 4: all parts more than 50% blocked).

		0	**1**	**2**	**3**	**4**	**All**
C	*N*	45	0	0	0	0	45
	%	100,0%	0,0%	0,0%	0,0%	0,0%	100,0%
E	*N*	41	4	0	0	0	45
	%	91,1%	8,9%	0,0%	0,0%	0,0%	100,0%
F	*N*	39	4	2	0	0	45
	%	86,7%	8,9%	4,4%	0,0%	0,0%	100,0%
All	*N*	125	8	2	0	0	135
	%	92,6%	5,9%	1,5%	0,0%	0,0%	100,0%

Tab. 5. Distribution of hygiene scores (%) on solid floor within each treatment group (C, E and F) (0: No part dirty; 1: one part more than 50% dirty; 2: two parts more than 50% dirty; 3: three parts more than 50% dirty and 4: all parts more than 50% dirty).

		0	**1**	**2**	**3**	**4**	**All**
C	*N*	42	3	0	0	0	45
	%	93,3%	6,7%	0,0%	0,0%	0,0%	100,0%
E	*N*	45	0	0	0	0	45
	%	100,0%	0,0%	0,0%	0,0%	0,0%	100,0%
F	*N*	44	1	0	0	0	45
	%	97,8%	2,2%	0,0%	0,0%	0,0%	100,0%
All	*N*	131	4	0	0	0	135
	%	97,0%	3,0%	0,0%	0,0%	0,0%	100,0%

4.5 Leftover straw

The score 0 (≤1 dl straw left) was the score most registered in group C and in group E the score 0 and 1 (between 1 dl and 1 l straw left) were equally distributed (Tab. 6). In Table 6 it can also be seen that within group F score 1 was registered most of the time and thereafter the score 2 (between 1 l and 10 l straw left) and 0. The distribution between scores differed significantly between treatment groups (Chi-square=16.38; P<0,001).

Table 6. The number and percentage of times each score (**0**: ≤1 dl; **1**: 1 dl to 1 l; **2**: 1 l to 10 l; **3**: ≥10 l) of leftover straw was registered in total and in each treatment group (C (straw on floor), E (empty foraging tower and straw on floor) and F (full foraging tower and no straw on floor)).

		0	**1**	**2**	**3**	**All**
C	*N*	29	12	4	0	45
	%	64,4%	26,7%	8,9%	0,0%	100,0%
E	*N*	21	21	3	0	45
	%	46,7%	46,7%	6,7%	0,0%	100,0%
F	*N*	10	20	11	4	45
	%	22,2%	44,4%	24,4%	8,9%	100,0%
All	*N*	60	53	18	4	135
	%	44,4%	39,3%	13,3%	3,0%	100,0%

The mean average of straw left in the foraging tower was 1441 g, which means that the pigs in group F consumed on average 449 g per day. During the experiment the pigs consumed a maximum of 1134 g straw per day and a minimum of 189 g per day.

5. Discussion

The purpose of this study was to evaluate which effect a foraging tower had on the level of oral manipulation of penmates, exploratory behaviour and activity of growing pigs in a conventional housing system. Investigations were also made to see if this kind of environmental enrichment affects the pen hygiene and how much straw was consumed by the pigs. Overall the results from the study showed that this kind of environmental enrichment partially stimulates activity and exploration even though there was a decrease in activity during the second observation session (11h00-12h00). To get a clearer picture I would have liked to have at least three observation sessions each day, and from this see how the activity level changes also during the afternoon. I was planing to perform a pilot study, but the delivery of the foraging towers was delayed and I therefore had no time for this. Otherwise it would have been helpful to see how much the activity differed between the observation sessions and taking that into consideration when deciding on time for my observations.

5.1 Activity level

The availability of environment enrichment in the form of a straw dispenser strongly influenced the activity level of the pigs. These result contradicts with a previous study by Fraser *et al.* (1991) in which no difference in activity was found between groups provided straw on the floor and from a straw rack. Straw provides occupation for the pigs and promoting activity (Arey, 1993) and as results (mean of both obs. sessions) from this study shows the pigs were active during approximately a third of the observation time (E: 35,0%; F: 32,6%; C: 35,0%).

The level of activity were highest in group F during the first daily observation but it switched and during the second observation the control group (C) had the highest activity level. It may depend on the earlier distribution of straw and that the most urgent need to root is fulfilled at the time of the second observing session. In the total mean percentage during both observation sessions group F had a lower level of activity because of the inactivity during the second observation were the majority of pigs were lying down. All types of activity (exploratory and manipulation of penmates) were overall lower in all groups during the second observation session (11h00-12h00). It may have been due to the

pigs´ normal daily routine. Because of the substantial difference in activity level between these sessions it could have been informative to add one or two more observation sessions to see if the level of activity increased again or kept decreasing during the day.

5.2 Exploratory behaviour

Pigs in their natural environment dedicate the greatest part of their active time foraging (Studnitz et al., 2007). The pigs spent a substantial amount of their time exploring the environment and substrate (Tab. 2). It was shown that the level of explorative behaviour was affected by treatment method and a significal difference was found between groups F and C (P=<0,001). At the first observation F pigs displayed a higher level of explorative behaviour (F: 39,3%; C: 33,0%) and at the second observation results were the opposite (F: 13,5%; C: 18,8%). This result may indicate that group C at the first observation lacks substrate to root in whilst group F have the possibility to root out more fresh straw from the dispenser. The total level of exploratory behaviour during the both observing sessions was 25,9% (C) and 26,4% (F) which corresponds with findings by Pearce (1993) that concluded that pigs provided with straw spent about 26% of their time exploring the pen during daylight hours.

Gustafsson *et al.* (1999) meant that wild types (hybrids) of pigs and domesticated pigs spend the same amount of time foraging, although their strategies differ slightly. This would mean that the need to perform these behaviours is equally as big for both pig types. To enable this it is important that the environment promotes exploration, and this could be done by providing straw and other types of enrichment (Van der Weerd *et al.,* 2006; Day *et al.,* 2008). Gustafsson *et al.* (1999) did not use wild boars in the study, which means that the crossbreads foraging pattern may not exactly resemble those of a pure wild boar and could therefore be a source of error and make it difficult to compare these different populations. Despite of this it is interesting to see the adaptabilty and the switch in stategy, which give the pigs a greater control of their behaviours. Good animal welfare should imply the possibility to perform natural behaviours and access to the resouces that promote those behaviours. This study may be of help when choosing a suitible enrichment method for growing pigs to improve welfare and give the pigs a possibility to express important natural behaviours such as exploration.

5.3 Manipulation of penmates

Overall the F pigs tended to display a lower level of penmate manipulation which may be because of the occupation of the foraging tower. This coheres with studies by Van der Waard *et al.* (2006) saying that pigs with around-the-clock access to straw displays lower levels of this kind of manipulation. When kept on straw bedding the manipulation of penmates was observed 5% of the total observation time (Scott *et al.,* 2007), which corresponds with findings in this study where the mean average of oral manipulation lies between 6% (F) and 9,% (C). As mentioned above the pigs naturally forage during a large amount of their active time (Studnitz *et al.,* 2007), in which chewing and rooting are a big part. It seems logical that when there is no bedding left to use the behaviour is redirected towards other objects, for example other pigs in the pen. Certain other enrichment methods have been proven to increase the number of performed abnormal behaviours (Bulens *et al.,* 2015). This study showed a decrease of these which means that this kind of enrichment can be beneficial to the welfare of growing pigs.

The frequency of belly-nosing was very low (observed in less than 2% of the observations) in all groups at both observation sessions. Gardner *et al.* (2001) investigated how belly-nosing developed post-weaning and saw a significal change over time. The behaviour peaked at day 10 post-weaning (2,2%) (Gardner *et al.,* 2001). Due to the time constraints, I chose not to analyse the difference of belly-nosing, or any other behaviour, shown over time, but I did get a total percentage of performed belly-nosing; 1,8% (E), 1,6% (F) and 1,8% (C). There are many factors to consider, the pigs were mixed at weaning which could have had impact on the oral manipulation of penmates, since some of these were of aggressive nature (e.g biting). The results could have differed if the groups were not mixed according to size, but that is just speculations and would have to be further investigated to be determined with certainty.

5.4 Pen hygiene and leftover straw

The pen hygiene on the solid floor was not affected by treatment, but I did get a significant value when processing the scores of hygiene on the slatted floor (P=0,049). Results showed that the pen hygiene overall was good, irrespective of the treatment the group recieved. This suggests that this kind of environment enrichment is somewhat compatible with the manure removal system used in modern systems. This could enable a greater use of straw for pigs throughout the whole production chain.

On average the pigs in group F had a larger proportion of straw left on the floor after 24 h. None of the groups reached the fixed limit of 2 points which was considered to indicate a permanent access of straw. Although, group F had the possibility to root out more straw during the whole day (24 h), which the other groups had no possibility to do. Considering the results, my interpretation is that group C and E did not recieve enough straw to occupy the whole group during 24 h. My suggestion is that if no environmental enrichment (that distributes straw during a longer period) is used, a larger amount of straw should be given to the pigs more than once daily. This should be done to satisfy their need to root during the entire day and night, not just temporary, which leads to several possitive effects, like decreasing the level of manipulation of penmates (Studnitz *et al.,* 2007).

The mean of consumed straw in group F was 449 g/day, which is a somewhat larger amount than the other groups daily recieved. My belief is that it in the beginning was hard for the pigs to root out the straw because of the length of the straw. To increase straw use in the beginning of the rearing period it could be an idea to try chopped straw instead of long straw, and investigate how well that would fulfill their need to perform natural behaviours. The opening between the bottom plate and the dispenser could be adjusted which means that this enrichment can be suitible for both growing- and finishing pigs. Also different substrates and different lenghts of the substrate could be used which means that this enrichment type is adaptable for different types and ages of pigs.

5.5 Methods of behaviour observation

The scan sampling method are used to collect a large amount of data from relatively large groups (Lehner, 1979) and it was chosen to this study because of the large amount of animals and behaviour states that would be observed. It is common to use 2 to 5-minute intervals between scans when investigating activity levels at group level (Bolhuis *et al.,* 2005). In this study an interval of 4 minutes was used, during which it is possible that certain important behaviours are missed and therefore not registrered. That interval were chosen to have enough time for counting all standing pigs in each pen and register which

object the snout is touching. This time was the right amount for this type of study and the number of pens observed. To get more reliable results it would have been desirable to expand the study and increase the number of litters.

It could have affected the pigs that a human observer was present and recorded behaviours at the observation sessions. In particular during the first days of observation I noticed that the pigs were a little bit nervous and jumpy. To avoid this kind of stress it may be possible to use cameras that record continuously during the entire day. This would also allow the observer to record all behaviours at exactly the time they were performed.

5.6 Consequences for the farmer

One foraging tower from Big Dutchman costs 320 EUR, which means that it would be costly to install one in each pen in a section or in a whole building. However, if the foraging tower is placed stategically in the pen it could be easily reached from the middle aisle, which could reduce the farmers´ workload quite a bit. The foraging towers do not have to be refilled every day since they can hold a large amount of straw. To optimize use and reduce the cost the foraging tower could also be placed between two pens. However, this could require some reconstructions which obviously leads to more costs. If the building was to be reconstructed or a new building would be built, enrichment method should be considered at an early stage to minimize costs, later rebuilding and unnecessary work for the farmer. As the results from this study show, the oral manipulation of other penmates were overall lower when pigs were provided with a foraging tower. It can be assumed that if the level of pig manipulation is reduced, the number of wounds and lesions of the pigs would also be reduced as a result, which consequently would lead to a lower medication use and both less work and money invested by the farmer. More studies would have to be performed to clarify the effect of foraging towers on the number of skin lesions and wounds found on growing pigs. Can it be used to reduce these kinds of injuries and will it lead to a more profitable business?

5.7 Further research

There are already a vast amount of research on how activity level and manipulation of penmates are affected by environmental enrichment, although in these studies straw is often used as enrichment itself. How environment enrichment in the form of foraging towers affects the behaviour of growing pigs is not very well-documented and more research must be done to show possible effects. To get a deeper understanding of the effect of straw as enrichment and which presentation of straw is preferred among the pigs it could be of value to compare different enrichment objects. To see how the pigs interact with the enrichment object continuous observations would have to be made. The enrichment can provide opportunity for the pigs to perform natural behaviours and therefore improving the animal welfare (Van de Weerd *et al.,* 2006). To determine if this is the case with this type of enrichment (foraging tower) more research must be made to ensure that it does not induce aggression and abnormal behaviours like certain other enrichment types (Bulens *et al.,* 2015). Experiments involving different types and lengths of substrate presented by a foraging tower would be of interest to see if the pigs consume more or less straw depending on these factors. This could be used to see which kind of substrate is preferred and most suitable (in a foraging tower) for growing and finishing pigs.

To get a clearer picture of how a foraging tower is affecting the activity level, not only during the morning (8h00-12h00), it could be possible to use cameras that record during

both night and day. This would show which time of the day the resources are mostly used. The overall activity was very low during the second observation session (11h00-12h00) and it would have been of interest to see the change during the day. At which time of the day does the activity level peak and is there a significal difference between pigs provided straw on the floor and from a foraging tower.

According to my own experiences of pig production the pigs that are given the lowest amount of straw are finishing pigs. Finishing pigs, just like every other pigs, have needs to express natural behaviours such as rooting and chewing (Studnitz *et al.*, 2007). The first thought was to perform this experiment on finishing pigs, but because of the light weight of the foraging towers and that they could not be drilled into the floor I was required to study smaller pigs. It would therefore be of interest to see how foraging towers affect the activity level of finishing pigs. As they are stronger and bigger, they would probably consume a larger quantity of substrate. Performing a study to see if a foraging tower can provide occupation for the entire day would therefore be of value. This would not only provide stimulation but also result in less work for the farmer as this would only have to be filled once every day or every other day depening on the consumption. The consumption of straw from a foraging tower would have to be investigated to show how to optimize use of the enrichment and facilitate the farmers´ conditions.

6. Conclusion

The pen hygiene was not affected by the different treatments; the pens were relatively clean. The mean average of straw consumption in group F was 449 g/day and overall the F pigs had a larger amount of clean straw left compared to the other groups (E and C). Activity level, exploration and manipulation of penmates differed between the treatments, especially between group F and C. Group F showed a higher level of activity and exploration during the first observation session (8h00-9h00) and a lower level during the second observation session (11h00-12h00) compared to the other groups. At both observations group F showed a lower level of penmate manipulation, which indicates that the treatment the groups recieved had an impact on the selected behaviours. Exploratory behaviour and manipulation of penmates were overall less frequent in all groups during the second observation session (11h00-12h00) than during the first (8h00-9h00). Since there were no differences in the studied behaviours between group E and C, the foraging tower *per se* did not seem stimulate activity or exploration in the pens. The stimuli should therefore have been the straw provided in the dispensers.

7. Populärvetenskaplig sammanfattning

Det har gjorts många studier på hur halm påverkar bland annat exploration, aktivitet och oral manipulering av andra grisar. Många av dem undersöker hur dessa beteenden påverkas av mängd tilldelad halm och vad som skiljer sig mellan grisar hållna i karga, tomma boxar och de som får tillgång till strömaterial. Syftet med studien var att undersöka effekten på aktivitet, exploration och oral manipulering då man miljöberikar boxen hos tillväxtgrisar i konventionell produktion. Jag ville också ta reda på om denna berikningsmetod är kompatibel med det gödselsystem som idag används och om det kan erbjuda sysselsättning under en längre tid än vad halm distributerad på golvet kan göra. De berikades med en halmautomat som bestod av ett rör fyllt med långstråig halm som kunde bökas ut av grisarna i botten på behållaren.

Grisen spenderar naturligt en stor del av dess aktiva tid på att böka, tugga och undersöka. Dessa beteenden är mycket viktiga och trynet och munnen spelar en stor roll i dessa. Beteenden som ovan nämnda har grisen en mycket begränsad möjlighet att utföra i den moderna intensiva hållning vi i dagens läge till stor del använder oss av. Oförmåga att utföra naturliga beteenden kan orsaka stress och leda till en utveckling av stereotypier som tyder på att djuret har problem att hantera miljön det lever i. En indikator på stress orsakad av miljön kan exempelvis vara att djuret blir mer inaktiv och spenderar stora delar av den naturliga aktiva tiden med att ligga/sitta/stå orörlig.

Studien utfördes i 3 omgångar bestående av 9 boxar (10-12/box) med tillväxtgrisar i varje omgång. Varje box tilldelades en av tre behandlingar (E: tom halmautomat, halm på golvet; F: full halmautomat, ingen halm på golvet; C: ingen halmautomat, halm på golvet). Halmautomaten sattes in två dagar innan beteendeobservationerna startade för att minska förekomsten av beteenden riktade mot den endast på grund av att den utgjorde ett nytt och spännande objekt i boxen. Beteendeobservationer gjordes två gånger om dagen (8:00-9:00; 11:00-12:00) då antal stående (aktiva) grisar registrerades och kategoriserades i olika grupper beroende på vilket objekt som trynet/munnen vidrörde.

Grisarna i grupp F konsumerade i medeltal 449 g/dag och hade överlag en högre andel ren halm kvar jämfört med grupp E och C. Boxhygienen hos de olika grupperna skiljde sig inte särskilt mycket, utan boxarna hos alla grupper höll sig relativt rena under hela försöket. Det fanns en signifikant skillnad i beteende mellan grupp F och C, i både aktivitet- och explorationsnivå, vilket betyder att halmautomaten hade en inverkan och ökade dessa nivåer. Alla typer av aktivitet var överlag låg under den andra observationstimmen, och grupp F hade då en lägre aktivitet- och explorationsnivå än de andra grupperna, vilket var det omvända jämfört med den första observationstimmen. Inga skillnader i aktivitet mellan grupp E och C kunde påvisas, vilket tyder på att halmautomaten i sig inte stimulerade till aktivitet eller exploration.

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