Litterless Housing Systems in the Farrowing Area I

Project Overview and Housing Environment

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In the project presented here, three housing variants (conventional crate stall, opening crate stall, activity pen) for nursing sows featuring identical environmental conditions were compared over a period of several years. In addition, the objective was to study the effects of a temporally and quantitatively limited straw supply. This first contribution provides an overview of the project. In addition, the results of stall climate measurements and the evaluation of pen soiling will be presented.

The improved freedom of motion for the mother animals did not result in measurable effects on the stall climate. Small quantities of straw did not lead to any increase in the concentration of suspended dust in the stall air. In quantitative terms, the soiling of otherwise clean pen areas in the activity pens due to the increased mobility of the sows was insignificant.

Keywords

Piglet production, sow housing, farrowing area, housing systems

Introduction

In conventional animal housing, the litterless crate stall is standard in the housing of sows with piglets. The main goal during its development was the reduction of worktime- and space requirements [1]. In addition, the fixation of the mother sow was intended to reduce piglet losses [2]. Hence, animal protection in this housing system mainly means piglet protection. The behavioural needs of the sows, however, are not the focus of interest. Both restricting the freedom of movement and housing without litter must be reconsidered from the viewpoint of animal protection because they could affect the well-being and the health of the sows.

In current discussions, housing systems such as the crate stall are commented critically by many parts of society. Many consumers articulate their own ideas about animal-friendly, environmentally compatible farm animal housing. Agricultural policy is also calling conventional housing systems into question. In Sweden, the permanent housing of sows with piglets in piglet protection baskets has already been prohibited since 1988 [3]. The Swiss animal housing decree requires that as of 2007 farrowing pens be designed such that the sows can turn freely [4].

Given these developments, three housing variants for nursing sows providing identical environmental conditions were compared in the present study over a period of several years. The systems compared were a conventional crate stall, an opening crate stall, and an activity pen.

The primary objective was the evaluation of alternatives to the conventional crate stall which could meet with acceptance in practice even without massive pressure from the legislator. Additionally, the effects of a temporally and quantitatively limited straw supply were studied.

For the sake of the most comprehensive assessment possible of the studied housing variants and straw supply, parameters of breeding performance, animal health, animal behaviour, housing environment, and profitability were considered. This contribution will provide an overview of the project. Furthermore, the results of stall climate measurements and the evaluation of pen soiling will be presented. The following contribution will focus on ethological and pathological criteria as well as production data. Aspects of work management have already been described in reference [5].

Animals, Materials and Methods

Housing Technique and Examined Housing Variants

The studies were carried out on the experimental farm Relliehausen of the University of Göttingen. There, four compartments were newly constructed in an existing stall building at the end of 1998. Since first, the pen measurements were given due to the utilization of an existing building and, second, all pens were intended to feature identical measurements, there was virtually no leeway for planning with regard to the pen measurements. The feed passage was located in the middle of each compartment. On the right and the left side of the feed passage, three farrowing pens each measuring 2000 x 2500 mm were situated (**figure 1**).

Each compartment featured separately controllable pore canal ventilation (Fancom company, Panningen, NL). The outdoor air was admitted to the farrowing area through two fresh air openings at the beginning and the end of the central supply passage. Here, the air was able to be pre-heated by heating pipes. From this main passage, the fresh air reached the pore canals of the individual pens. The ventilation canals were situated above the feeding passage. In each compartment, an exhaust fan was vertically installed in the ceiling at the end of the feed passage. This fan was controlled depending on the stall temperature.

Since the profitability of a new housing technique is determined to a large extent by the amount of investment required for new construction or conversion, which, in turn, is dependent upon the unit numbers produced, standard parts from a stall equipment manufacturer (Laake company, Langen) were employed to equip the pens. For experimental reasons, the pens were also intended to be largely identical with regard to their equipment. Owing to these planning requirements, the pens only differed with regard to the fixation of the mother animal and details immediately derived from this feature, i.e. the height of the pen partition and the installation of piglet protection bars.

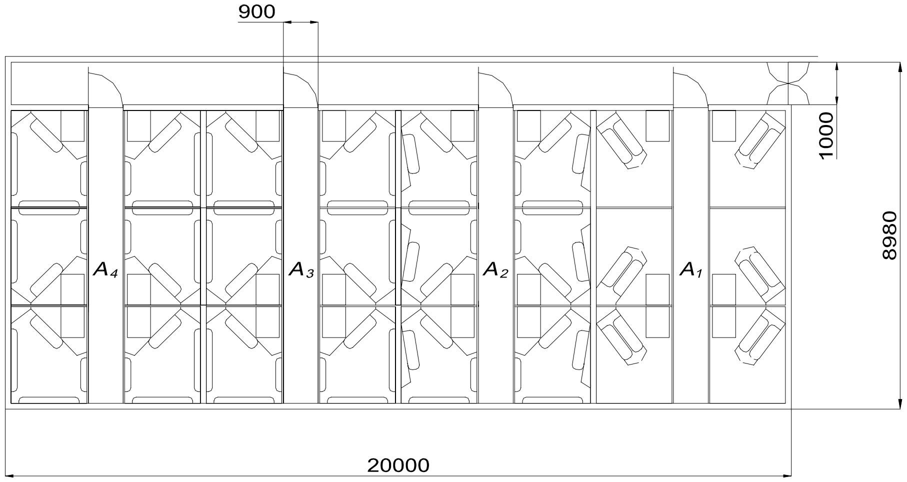

Figure 1: Ground plan of the farrowing area (measurements in mm).
A_1, conventional crate stall; A_2, opening crate stall; A_3, A_4, activity pens.

Within the compartments, there were no windows. Natural light only entered indirectly from the main supply passage through one window each in every compartment door. For illumination, five fluorescent lamps per compartment were installed (two lamps each over the right and left side and one lamp over the feed passage). At night, the fluorescent lamp over the feed passage stayed on for orientation lighting. At 7:00 a.m. and 5:00 p.m., illumination was changed from day to night lighting using a time switch.

The farrowing pens were equipped with fully perforated floors (MIK company, Marienhausen). Each pen featured a water-heated piglet resting area from the same manufacturer, which measured 600 x 800 mm. These heating elements were situated at the wall adjacent to the supply passage so that easy checks by the personnel were possible.

In detail, the housing variants were able to be characterized as follows:

In compartment 1, A_1, the pens were equipped with crate stalls common in practice, which featured diagonal stalling up with high trough installation (**figure 2**). In this housing system, the sow was fixed from the day of stalling-in until the day of stalling-out.

Stalling-up in compartment 2, A_2, was largely identical to A_1. After the castration of the piglets (on ca. the 10th day of their lives), the crate stall was opened. Both side wings were fixed in a folded-back position after the rear bars had been turned.

Stalling up in compartment 3, A_3, was an activity pen developed on the basis of a crate stall (**figure 3**). Of the original crate stall, a side wing was left, which was used to partition the piglet area off. By swivelling this grid and putting the rear bar in a different position, it was possible to fix the sow to the wall temporarily.

Stalling up in compartment 4, A_4, was similar to A_3. The only difference was that it was impossible to fix the sow.

Since the possibility of fixing a sow temporarily was not used in A_3 during the entire trial period, compartments A_3 and A_4 did not differ with regard to the housing system. A slight difference existed in the form of straw supply in the second phase of the trial, which will be discussed below.

Genetics and Feeding

In the trial period, approximately 140 productive sows and their offspring were kept on the experimental farm Relliehausen. The percentage of different genotypes in the sow herd is shown in **figure 4** The herd was supplemented through on-farm breeding. The purchasing of sperm was the only source of foreign genes.

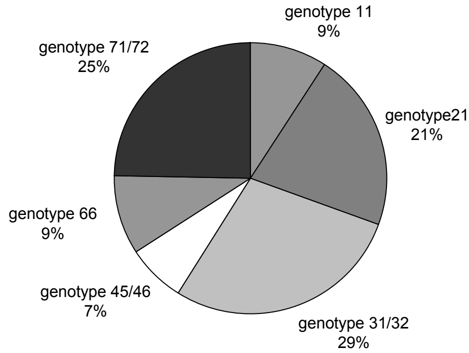

Figure 4: Percentage of the different genotypes of the sow herd of the experimental farm Relliehausen (status: May 2000).
11, German land race; 21, Large White x German land race; 31/32, German land race x Large White; 45/46, Hampshire x Pietrain; 66, Pietrain; 71, German saddleback x 21; 72, Coloured Bentheimer x 21.

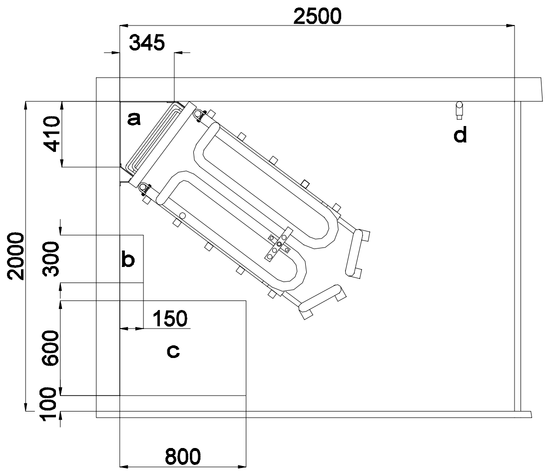

Figure 2: Ground plan of a pen in stall compartment A_1, conventional crate stall (measurements in mm).
a, feed trough with integrated drinker for the sow; b, automatic mash dispenser for the piglets; c, piglet resting area; d, piglet drinker.

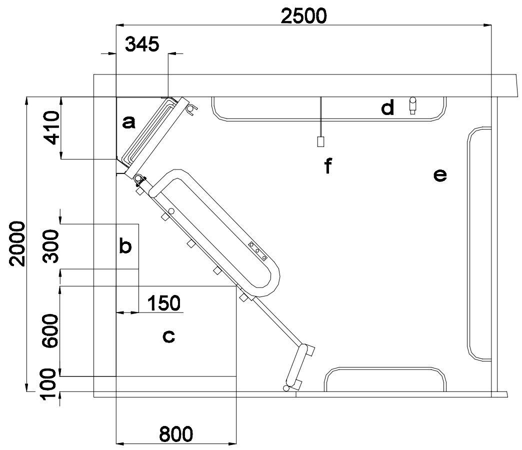

Figure 3: Ground plan of a pen in stall compartment A_3, activity pen with the possibility of fixing the sow (measurements in mm).
a, feed trough with integrated drinker for the sow; b, automatic mash dispenser for the piglets; c, piglet resting area; d, piglet drinker; e, protective bar for the piglets; f, fixing bar for the swivellable partition of the piglet area.

In the farrowing area, the sows were fed by hand. Figures 2 and 3 show the position of the troughs. At the beginning of the trial, the sows were fed twice a day. During the trial, storage feeders (Mannebeck company, Schüttorf) were installed. The storage containers were filled with feed once a day.

First, the sows got complete feed for nursing sows (Hemo company, Scheden, energy content 12.6 MJ ME; crude protein content 17%). Sow feed was switched in May 2001. As of this time, the sows got the complete feed Fertila L from the same manufacturer, whose indicated energy- and crude protein content was 13.4 MJ ME and 18% respectively.

As of the end of the first week of their lives, the piglets were offered piglet rearing feed (Hemo company, Scheden; energy content: 16.0 MJ ME; crude protein content 20.0%).

Herd Management

Before the sows were moved to the farrowing area, the young sows were kept in three-area pens, while the sows which had farrowed at least once were housed in a large group stall with automatic feed dispensers. Approximately one week before the calculated farrowing date, the sows were stalled out of the waiting stall, washed, and moved to the farrowing area. After a nursing period of about three weeks, the sows in the individual compartments were weaned simultaneously and moved to the mating centre.

When sows were stalled up in a compartment, all 6 pens were occupied. If it was impossible to stall up six late-pregnant sows at the same time, early-pregnant sows or nurses were stalled up in the empty pens.

Trial Period and Straw Supply

The trial began with work management studies in the period from 13 April 1999 until 14 October 1999 [5; 6]. All other trial questions were researched in the period from 20 April 2000 until 25 April 2002. This period was divided into two trial phases, V_I and V_{II}. Like in the work management studies, no straw was used during V_I. In V_{II}, the sows were offered straw for a limited period of time in order to allow them to exhibit nest building behaviour. In spring 2001, the changeover from V_I to V_{II} was carried out differently compartment-wise. While most parameters were measured during the entire trial period, the ethological parameters are available for six periods per compartment and trial phase.

For straw supply, straw racks (**figure 5**) were attached to the crate stall in A_1 and A_2 and the grid adjacent to the piglet resting area in A_3 two days before the calculated farrowing date. Approximately two days after birth, these racks were removed from the pen. In A_4, metal sheets were fitted under the trough during the entire trial phase V_{II}. On these sheets, straw was able to be offered on the floor.

Independent of the form of straw supply, each sow received 500 g of straw two days before the calculated farrowing date. Two days after birth, the straw which remained in the rack or on the metal sheet was removed and weighed back.

Stall Climate Measurements

At the beginning of the trial, relative humidity and air temperature in the stall were continuously measured using one combination of a sensor and a data logger (Tinytag or Tinytag Plus, Gemini Data Loggers company, UK) each per compartment and parameter. As of July 2000, hygrothermo sensors (TFG80H, Ahlborn company, Holzkirchen) were installed in the compartments. A measuring instrument (Therm 5500-3) from the same manufacturer was used for signal transformation and –recording.

All mentioned sensors were installed at a height of 2000 mm. The arrangement of the sensors over the compartment area is shown in Figure 6.

The exhaust air volume flows of the individual compartments were calculated based on the ventilation rate indicated by the ventilation computer. For this purpose, the percentage of the maximum ventilation rate was read at the ventilation computer (Fancom company, Panningen, NL) every day at 9:00 a.m. Based on these data, the current air volume flow was calculated according to information provided by the manufacturer. An experimental examination of the actual conditions did not take place.

Ammonia concentration was measured three times a week with the aid of a PAC III E gas measuring instrument (Dräger company, Lübeck). The measurement was carried out at 12 points in each compartment (**figure 6**).

The suspended dust content of the air in the compartments was measured in the middle of their feed passages at a height of 1500 mm using the aid of a TEOM 1400 a dust measuring instrument (Rupprecht & Patashnick Company, Albany, NY). The examinations required for the present study were carried out using a sampling head which does not pre-separate certain particle sizes and only prevents very large particles, such as straw, from being sucked in.

Only one instrument was available for these measurements. This instrument was used to measure total suspended particulate matter (TSP) concentration in the stall air of the individual compartments regularly and quasi-continuously during the first nursing week. The 30 min average values of these measurements were stored and evaluated.

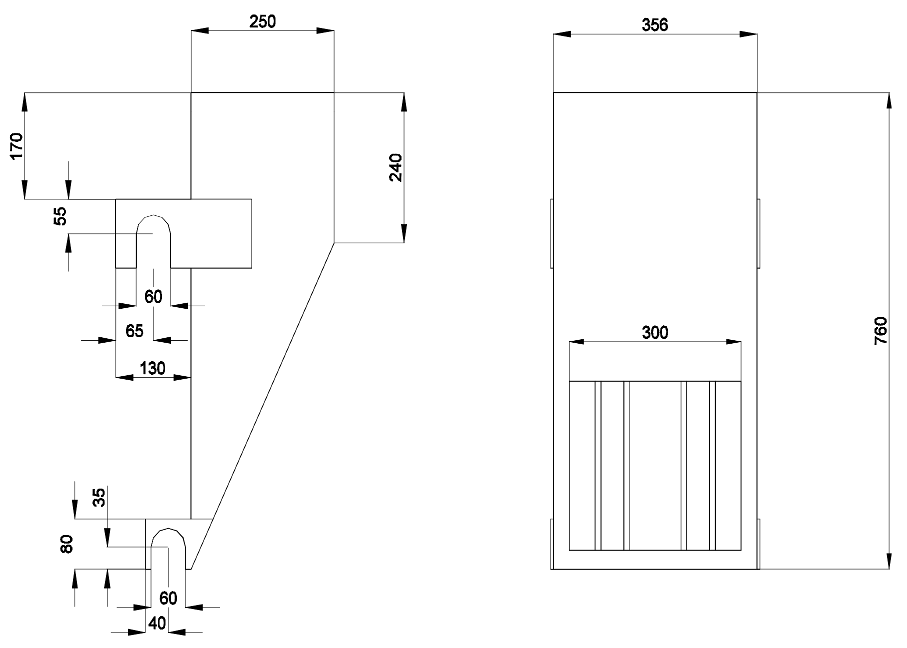

Figure 5: Lateral (left) and front view of a straw rack (measurements in mm).

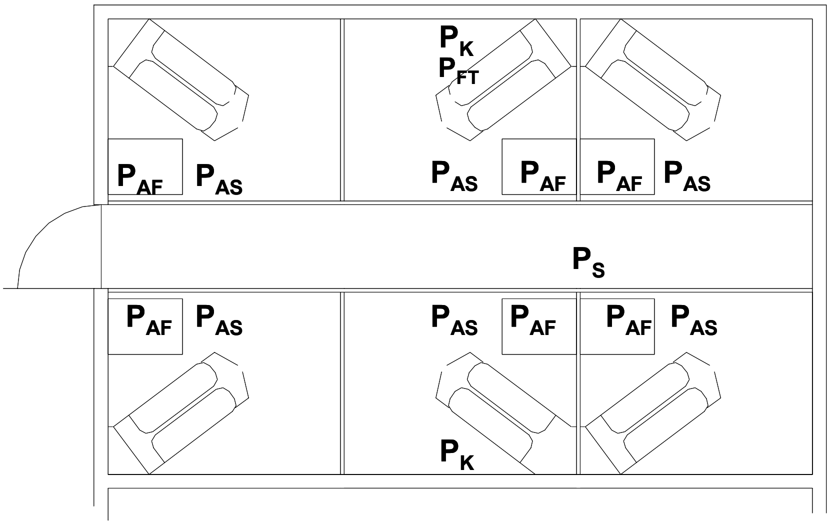

Figure 6: Measuring points for the registration of the housing environment and positions of the video cameras shown using compartment A_1 (conventional crate stall) as an example.
P_{AF} and P_{AS}, measurement of ammonia concentration at the height of the piglets´ or the sows´ heads; P_{FT}, measurement of humidity and air temperature; P_K and P_S, position of a video camera and the dust measuring instrument.

Assessment of Pen Soiling

For the assessment of pen soiling, the pens were divided into four main areas of the same size, which met in the middle of the pen (cf. table 3). In each of these areas, four sub-areas were distinguished. Pen soiling was evaluated once per week. According to subjective discretion, the individual areas were divided into five classes ranging from clean to very heavily soiled. For clarity´s sake, soiling was converted into percent. This parameter, which is termed soiling degree in the present study, was based on the soiled area and the subjective mark given to describe the soiling.

Data Evaluation

No detailed statistical analysis of the parameters air temperature, relative humidity, and air volume flow was carried out. The suspended dust concentrations were analysed based on a set of extended data as compared with reference [7] according to the method described there. NH_3 concentrations in the stall air and pen soiling were evaluated with the aid of the procedures glm and npar1way of the statistics package SAS.

Results and Discussion

Stall Climate

Table 1 lists the continuously measured stall climate data. With regard to temperature and relative humidity, differences between the compartments were small. Over the average of the trial years, stall temperature was lowest in compartment A_1. Even there, however, temperature was within the performance-oriented optimal range according to reference [8].

With regard to the airborne dust, the situations in A_1 and A_2 were similar. In comparison, the measurement values were lower in A_3 and significantly higher in A_4. By means of analysis of variance, no significant influence of the trial compartments on dust concentration could be established. Therefore, the present study does not provide any indication that more possibilities of activity for sows with piglets lead to increased dust formation in the stall compartment under the given housing conditions.

Reference [7] had already shown that the number of weaned piglets as another measure of animal activity and the occurrence of particles (e.g. faeces, skin, hair) did not significantly influence dust concentration under the given conditions.

The time of measurement exerted a considerable influence on the measurement result. After farrowing, a permanent increase in suspended dust concentration in the stall air was able to be observed in 36 out of 46 measuring periods. This observation does not concern the comparison of the housing variants and has already been discussed in [7] on the basis of a preliminary data basis.

No directed difference could be distinguished between the trial phases with and without the provision of straw as nest construction material. The fact that offering straw to the sows did not influence dust concentration can be explained as a result of the extremely small quantity.

Since the air volume flow was measured only once per day and the dust measuring instrument had to be moved regularly, only 102, 78, 86, and 72 simultaneous observations of the air volume flow and the suspended dust content of the stall air are available for the compartments A_1, A_2, A_3, and A_4 respectively. **Figure 7** shows that no directed relation between the mentioned parameters was able to be determined.

The low ammonia concentrations in the stall air (**table 2**) emphasize the favourable experimental conditions. Even though the influence of the stall compartment on this parameter was highly significant, it does not express any directed differences between the housing variants as shown by the small differences in the table.

Table 1: Temperature, relative humidity, and total suspended particulate matter in the stall air as a function of the housing variant (V_I and V_{II}).

		compartment			
		A_1	A_2	A_3	A_4
air temperature [°C] 1)	Avg	18.5	20.7	20.7	19.8
	±	2.8	2.8	2.4	2.4
relative humidity [%] 1)	Avg	54.9	60.7	49.5	59.7
	±	12.5	6.3	11.2	8.4
airborne dust [µg m^{-3}] 2)	Avg	317.8	330.1	262.3	392.1
	±	96.1	80.8	53.3	317.7

V_I, trial phase I, no straw supply; V_{II}, trial phase II, straw supply in order to allow for nest construction behaviour; A_1, compartment 1, conventional crate stall, A_2, compartment 2, opening crate stall; A_3 and A_4 compartment 3 and compartment 4, activity pens; avg, arithmetic mean; ±, standard deviation.
1) The mentioned parameters were measured parallel in all compartments. Only the results of measurements taken while the individual compartment was occupied are shown here.
n = 19654, 19286, 16674, and 18489 for the compartments A_1, A_2, A_3, and A_4.
2) In the compartments, the mentioned parameters were measured with a time shift. Only measurement values taken post-partum were used for calculation. The mean values and standard deviations shown were calculated based on a set of data in which each measuring period is only represented by its mean value (cf. [7]). n = 13, 11, 12, and 10 for compartments A_1, A_2, A_3, and A_4.

Pen Soiling

Table 3 shows pen soiling. In all four examined compartments, the soiling degree of the entire pen area was below 10%. In this respect, differences between the individual compartments were small. Non-parametric analysis of variance, however, showed the influence of the housing variant to be significant.

The differentiation of the soiling of the entire pen area into the individual sub-areas shows that area 4 (the pen area adjacent to the feed passage) in the crate stall variants A_1 and A_2 and area 2 (the pen area adjacent to the wall) in the activity pens (A_3 and A_4) were worst affected.

In trial phase V_{II} (straw supply), the pens were less soiled than in trial phase V_I (no straw supply). However, it must be emphasized here that the set-up of the trial does not enable the factors measuring period on the one hand and straw supply on the other hand to be statistically separated.

In addition to the housing variant and the trial phase, the age of the litter was proven to exert a significant influence on pen soiling. In all housing variants, the highest soiling degree was registered in the first week post-partum.

Conclusions

The improved possibilities of activity for the mother animals did not result in measurable effects on the stall climate. Small straw quantities did not increase suspended dust concentration in the stall air.

The increased mobility of the sows in the activity pens led to the soiling of otherwise clean pen areas (e.g. the trough area), which, however, was of little importance at least under quantitative aspects.

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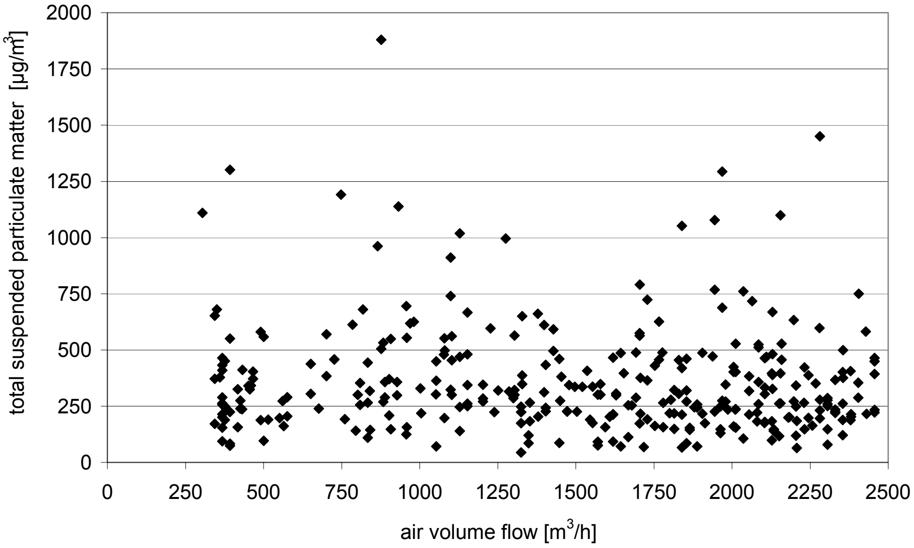

Figure 7: Correlation between air volume flow and total suspended particulate matter in the stall air measured simultaneously in the same compartment (n=338).

Table 2: Air volume flow and ammonia concentration in the stall air [1)] as a function of the housing variant (V_I and V_{II}).

		compartment			
		A_1	A_2	A_3	A_4
air volume flow [$m^3\ h^{-1}$]	Avg	1274.8	1459.9	1908.9	1579.7
	±	687.8	632.1	422.4	584.7
NH_3 concentration, sow [2)] [ppm]	Avg	5.6	7.9	6.7	7.7
	±	1.6	4.0	3.5	3.0
NH_3 concentration, piglets [3)] [ppm]	Avg	6.3	8.2	7.1	8.2
	±	2.0	4.6	3.6	3.5
NH_3 concentration, total [ppm]	Avg	6.0	8.0	6.9	8.0
	±	1.8	4.2	3.4	3.2

V_I trial phase I, no straw supply; V_{II} trial phase II, straw supply in order to allow for nest construction behaviour; A_1, compartment 1, conventional crate stall; A_2, compartment 2, opening crate stall, A_3 and A_4, compartment 3 and compartment 4, activity pens; Avg, arithmetic average; ± standard deviation; conc., concentration
1) Only results of those measurements are shown for which simultaneously collected information about the NH_3 concentration of the stall air and the air volume flow is available. n = 35, 28, 29, and 27 for compartments A_1, A_2, A_3, and A_4.
2) Measuring point, height of the sow´s head, ca. 800 mm above the ground.
3) Measuring point, height of the piglets´ heads, ca. 300 mm above the ground.

Table 3: Soiling degree [1)] of the individual pen areas as a function of the housing variant (V_I and V_{II}).

		stall compartment			
pen area		A_1	A_2	A_3	A_4
trough area [2)]	Avg	1.4	1.8	4.8	5.0
	±	4.6	4.7	9.0	8.1
stall wall area [2)]	Avg	11.0	12.3	17.6	18.7
	±	10.4	9.3	9.6	10.0
piglet resting area [2)]	Avg	0.7	0.9	2.4	1.7
	±	4.4	4.2	6.8	5.7
feed passage area [2)]	Avg	19.3	15.9	10.4	10.7
	±	10.5	10.8	10.3	9.6
total pen area	Avg	8.1	7.7	8.8	9.0
	±	5.4	4.3	5.5	4.7

V_I, trial phase I, no straw supply; V_{II} trial phase II, straw supply in order to allow for nest construction behaviour; A_1, compartment 1, conventional crate stall; A_2 compartment 2, opening crate stall; A_3 and A_4, compartment 3 and compartment 4, activity pens; Avg, arithmetic average, ± standard deviation.
1) Subjectively registered pen soiling [%]
2) ca. 25% of the pen area.

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