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Cooling pig stables through underground air inlet ducts

Farrowing accommodation with 266 pens was built with an underfloor air intake system. Permanent measuring points were installed enabling comprehensive evaluation of temperature, air moisture and gas analyses (NH_3, CO_2) in respective trial and control compartments with different lengths of air ducting in each. The results showed that on summer days with 28 to 33 °C a supply air cooling of 6 K was achieved with 8 K achieved on extreme days with 35 °C. The cooling of the supply air enabled regulation of air moisture content and relative reduction of NH_3 concentration in the trial compartment. Documented is a series of proven recordings on the temperature layering within the housing (at 0.6 m to 2.4 m). In addition, livestock production performance parameters and cooling costs are documented in this ministry of agriculture supported project.

Keywords
Ventilation, underground air inlet ducts, cooling of pig stables

Abstract
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In the agricultural cooperative “am Duen” Deuna e.G. the sow stable complex Rüdigershagen was gradually reconstructed. Since 2008, the new building of a farrowing stable was up for decision which should be built to replace 2 demolished stables. In the planning phase an underground channel air flow was decided, so that existing concrete channels could be used.

The new building of farrowing stables with 4 compartments with each 63 farrowing crates and 2 x 7 reserve places required a stable with a length of 52 m and a width of 39,3 m for lactating sows. It which was built on the tear-off plots of the old stable.

Due to the set up of the new stable at the end of 2008 extensive data could be gathered in 2009/10 within the KTBL project “Cooling of pig stables”.

Data collection and installation of measurement points

The temporal conformity of starting up the farrowing compartments in the new stable with the opening of the KTBL project made it possible to install a fixed system of measurement points for temperature, humidity and gas analysis in 2 identical farrowing compartments.

By the different air supply – concrete channels 1/2 long underground ducts as the pilot compartment and 1/2 a short underground floor area directly linked to the outside air as a comparison compartment – direct comparative measurements to stable temperatures, humidity, dust, ammonia and CO_2 content were possible.

The collection of structural characteristics, operating costs, and animal performance parameters were aligned to the requirements of the KTBL-project, but it was not possible to split them up in each case to the farrowing group.

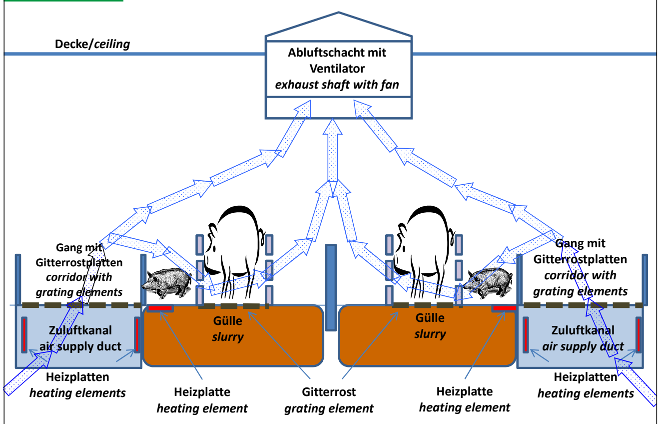
Figure 1 shows the most important measuring points in the plan. and the air flow into the compartments schematically.

Figure 2 shows the cross profile of the air flow from the underground channel into the compartment. The construction of a central walkable channel for incoming air for all the farrowing compartments resulted in the installation of drain-tubes for liquid manure in this central corridor. This simplifies management and ensures good access conditions in case of accidents.

Fig. 1

Lay-out of measuring points and air inlet ducts

Fig. 2



Air flow from underfloor area into the compartment

The measurement of the concentration of NH_3, CO_2 and water vapour was done by an INNOVA- multi-gas analyser assigned to the TLUG (Thuringian State Institute for environment and geology). The measurement periods were put in the summer months to capture hot external temperature phases parallel to the continuous measurements. The acquisition of total and fine dust levels in the stable compartments were done as appointed date measurement.

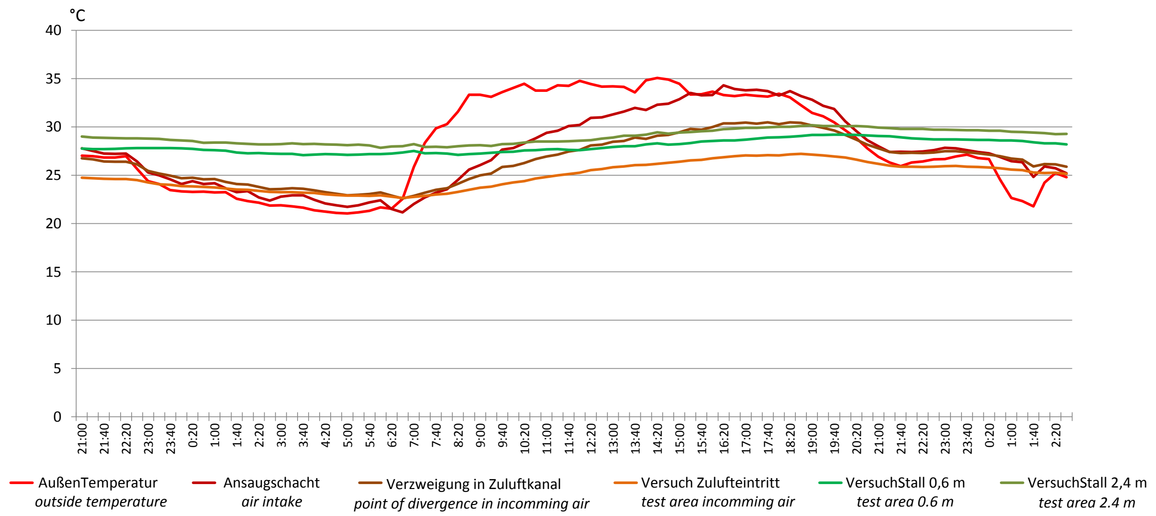
Measurement results

Temperature and humidity

The temperature profile (**Figure 3**) at selected measuring points along the airflow ducts on the hottest day shows the efficiency of the under floor air supply for the air conditioning in the compartment.

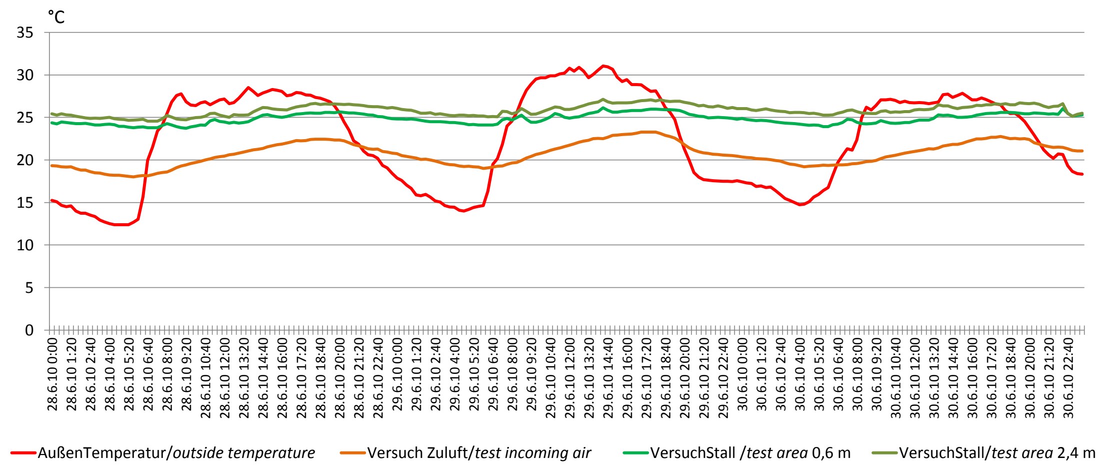
Already in the suction channel the temperature rises significantly slower than outside. Maximum values were reached not

Fig. 3



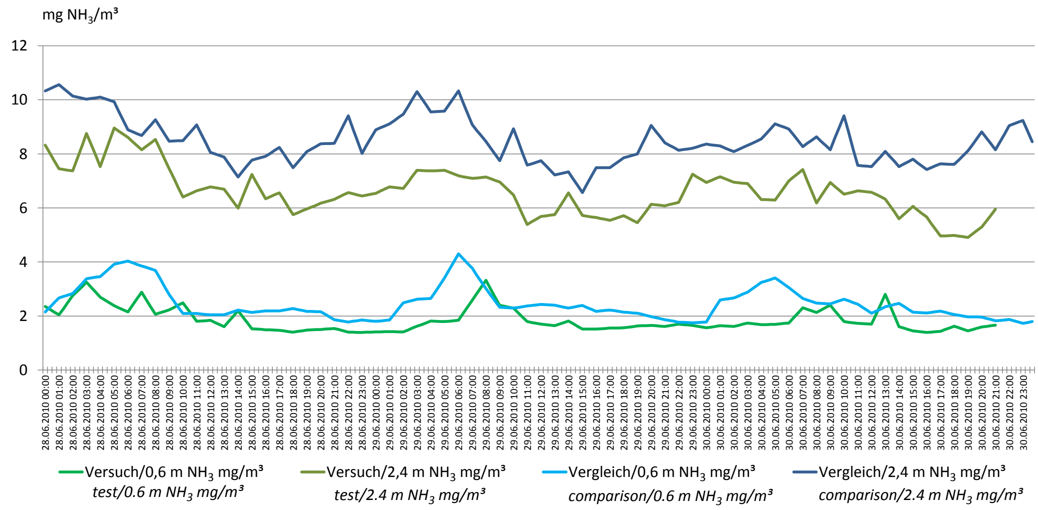
Temperature variation during a hot day

Fig. 4



Temperature variation at 3 consecutive warm days

Fig. 5



Ammonia concentration in the stable at a height of 0.6 and 2.4 m

before the afternoon. Already before branching in the basement corridors the maximum temperature is about 5 K lower than the daily maximum. At the entry point into the compartment the temperature is up to 8 K lower than the outside temperature. The compartment temperature is set at 25 °C. Temperatures between 27 and 29 °C in the area of the sows arise as a result of the waste heat of the sows and the piglets' nest heating. The heat absorbed from the walls of the incoming air channel during the day is emitted at night. A significant temperature stratification in the compartment of approx. 2 K from bottom to top is formed as a result of the incoming air from the bottom.

Figure 4 shows the temperature curve on 3 consecutive warm days. The phase shift of the maxima of the outside temperature and the temperature of the incoming air becomes evident. In comparison to the temperature of the exhaust air the lower temperatures at the bottom (measuring height 0,6 m above the ground), which is relevant for the sows, are well to see. On the other hand possibly cooled air from above is already warmed up under a perforated ceiling when lowering before reaching the sow and the effort to cool the supply air is toned down in the effect.

Critical conditions concerning humidity couldn't be found in any case. The relative humidity in the stable was always in the area between 40 and 70 % r H. Even if the outside air is very humid this emits moisture when cooled down in the supply air duct falling under the dew point and dries during the subsequent heating in the stable so far, that it can absorb the here evaporating water.

Ammonia

The concentration of ammonia in the stable in the height relevant for the pigs (0,6 m) and the exhaust channel (2,4 m) in the course of 3 days is shown in **Figure 5**.

Again, the advantage of the supply from the bottom shows up. In the area of the sow snout, the ammonia concentration is increased only slightly compared to the outside air. However, already at a height of 2.4 m, a recognizable NH_3 enrichment to approximately 5 mg/m is to be recognized. But also these concentrations between 5 and 9 mg/m³, as well as the 10–15 % higher values in the comparison stable are tolerable.

Animal performances

Table 1 compares the achieved breeding pperformance in the experiment and comparison part exemplarily for a selected period of time. A distinct advantage of better tempered test compartment shows up in spite of the low temperature benefit of 1–2 K in critical weather periods. Even in the rate of non-pregnant sows the test compartment is better as shown in **Figure 6**. As a result of the overlay of other influencing factors, this statement turns out less clearly.

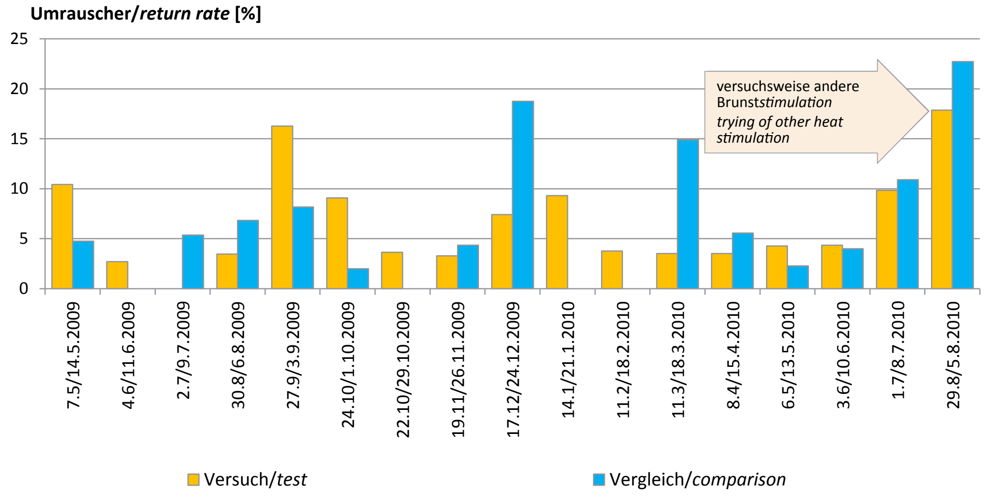
The increase of the rate of non-pregnant sows during heat waves mostly is much lower in the test section. Due to the large

Table 1

Performance data Juli/August for the test and control compartments of the stable

Zeitraum *Period*	**4.6.–1.7.10 Versuch** *test*	**11.6.–8.7.10 Vergleich** *control*	**2.7.–29.7.10 Versuch** *test*	**9.7.–2.8.10 Vergleich** *control*
Anzahl Sauen *Number of sows*	63	62	63	59
Leb. geb. Ferkel je Wurf *Live born piglets per litter*	13,85	13,9	13,55	12,8
Abgesetzte Ferkel je Wurf *Weaned piglets per litter*	12,71	12,1	12,31	11,1
Ferkelverluste % *Loss of piglets*	8,3	13,0	9,2	13,1

Fig. 6



Comparison of the course of the return rate

number of superimposed factors and because the pregnancy can be determined only one month later, an extension of the evaluation period would be desirable.

Conclusions

In the summer of 2010 a difference of 4 K at the air inlet to the stable was found when there were differences of 18 K between day and night outdoors. In our test compartment 2009 at maximum outdoor temperatures of 34 °C the stable temperature was limited to 28 °C for the sow. In 2010 at temperatures of 35 °C outside the stable temperature was limited to 29°C for the sow. In the comparison section (incoming air supply via a short tour through the basement) 30 °C were measured at the same time. This underlines the effectiveness of the air supply of the floor channels.

In periods of 3 to 5 days in a row with daily temperature maxima between 28 and 30 °C a maximum temperature could be kept in the air below 24 °C for the entire time. On the following day with a temperature of 35°C outside the incoming air was not above 27 °C. No statement is possible for longer-lasting heat periods. The reported temperature stratification in the compartment of the snout height to the entrance of the fan is of fundamental importance. This provides very favourable NH_3 values for the animals.

A major characteristic of animal productivity is the number of the weaned piglets per litter. During the summer months in 2009 and 2010 the found values are better in the version with the long under floor air supply, whereby the direct comparison to conventional upper-floor air supply houses is impossible (weaned piglets + 0.3 to 0.5 per litter, losses 9 % to 13 %).

Thus, the proof of the effectiveness regarding the room temperature control by sub floor systems is provided.

Planning further projects with under floor air supply it should be considered already in the construction phase that the cooled air flows into the sow area (in accordance with nasal ventilation), not into the area of the piglets. Thus also structural engineering benefits could be achieved. Existing underground reservoirs should be used in any case.

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