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Comparison of space and zone heating systems in piglet rearing

After two years of investigations, different variants of ventilation and heating in piglet production were able to be comprehensively evaluated. Alongside the economy aspects of the variants, the lying behaviour of the piglets, the air quality within the housing and the pollutant gas emissions were considered. Regarding electricity consumption, the possible savings through EC energy saving fans was over 50% on average. With heating energy, the savings using the variants with gas cannons was also 50% compared with warm water underfloor heating with gas as energy source. The underfloor heating, however, offered advantages in lying behaviour of the young piglets and in the air quality.

For advisers and farmers wishing to build, the planning of piglet rearing housing involves considerable insecurity regarding appropriate heating system and flooring for the best animal welfare aspect. In order to deal with such planning doubts and to collect reliable practical housing data, a long-term trial was established on the Barnstädt farm, (Querfurt district, Saxony Anhalt) with the support of the AEL and six different ventilation and heating companies.

The aim of the now completed long-term investigation was the comparison of different heating systems and exhaust air fans in piglet rearing in the context of heat and electricity energy consumption. The recording of livestock performance and the lying behaviour of the piglets was included to allow a comprehensive view of the situation.

Materials and method

The method used in the first sector of the investigation was already presented last year through this medium [2]. In the second investigation sector (winter 1999/2000) additional measurements took place regarding the lying behaviour of the piglets as well as air quality in the individual housing compartments and the environmental pollution arising from this.

The lying behaviour of the piglets was recorded parallel in two departments with and without underfloor heating using stationary installed video cameras. The data was evaluated with the help of software for ethological investigations ("Observer"). The length of time and the frequency of the behavioural characteristics "lying" and "not lying" were used in the behavioural comparison.

The quality of the air and the emission performance in the variants compared were recorded with help from the proven gas analysis system (Brüel and Kjaer Multigasmonitor; measurement position switch, measurement fan in the round exhaust air shafts). Measurements were also taken of the dust concentration, of odour concentration and of the homogeneity of the climate factors in the housing.

Results

Following the balancing of the heat flows according to DIN 18910 [3] there were large deficits in the investigated piglet compartments despite good insulation. The variety of technical possibilities made a systematic compilation and classification of the different heating systems used in piglet production difficult. A review of current systems is given in *tables 1 and 2*. Here, the energy sources used in the housing are differentiated, how the heat reaches the compartments and which physical principle is used in mainly helping the energy reach the livestock.

In the evaluation of heating systems the capital and running costs played an important role. Alongside the classic space heating systems, farmers are increasingly choosing underfloor heating under the laying areas for piglet rearing. In the literature the following

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Keywords

Heating, house climate control, ventilation

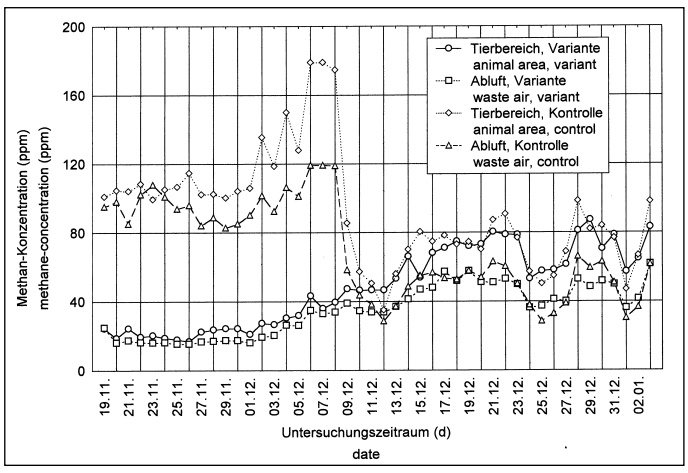

Fig. 1: Methane release from liquid manure by using room heating (control) and floor heating (variant) in piglet houses during the winter period 1999/2000

Energy source	Heating oil (burner) Natural gas (burner) Liquid gas (burner) By-produced heat (heating/power station[1])	Direct Burning of gas *without* removal of residues	Burning of gas or heating oil with removal of residues
Transport and distribution medium	**Warm water** -delta pipes -iron pipes -radiators	**Air** - gas cannons - gas convector	**Air** -fan convector -warm air fan
Main principle	**Convection**	**Direct air warming** (enthalpy increase)	

Table 1: Room heating variants in pig houses

1) Centralised heat/power station with fuels biogas, heating oil, rape oil, straw

Energy source	Heating oil (burner) Natural gas (burner) Liquid gas (burner) By-produced heat (heat/power plant1)	Electricity	Electricity -infrared lamp Liquid gas - gas lamp
Transport and distribution medium	**Warm water** --> flooring	**Electricity** --> flooring	**Strahlung**
Main principle	**Conductivity** (heat conductivity)		**Radiation** (heat radiation)

Table 2: Zone heating variants in pig houses

1) Centralised heat/power station with fuels biogas, heating oil, rape oil, straw

arguments are used for these systems:

- With increasing periods of use for the heating technology, and with increasingly greater numbers of animals, zone heating systems based on warm water are gaining in economical advantages. The possibilities, too, of using heated water from central heating/power stations is also an important argument for such heating systems in the light of increasing energy costs and the sale possibilities for farmers into the electricity supply network of renewable power.
- Pen design enables the offering of (comfort) heat in the lying area. The house interior temperature can then be reduced. The air quality (pollutant gas content) is thus improved. Conditions for a homogenous growth of the pig batch include a lying area of sufficient size and even distribution of warmth. To regulate available heating to meet the requirements of the animals, lying area temperature curves can be followed.

To maintain the desired housing temperatures with as low as possible energy consumption in the trial compartments [5], it was decided to compare the following typical heating variants in the investigation:

- gas cannons as space heating
- warm water underfloor heating in the lying area in combination with delta pipelines as space heating

The results of the first trial cycle with regard to energy consumption could thus be confirmed. No statistically significant differences in piglet performance were able to be secured between the investigated variants. The most important economical parameter in the system comparison were thus the capital and running costs for ventilation and heating per piglet reared. Using the period costing method, the winter, spring and summer cycles were weighted according to time for the cost calculations. The calculations showed that the energy represented over 50% of total special costs for ventilation and heating in all variants. The underfloor heating involves substantially higher investment which can be seen to be very disadvantageous in total rearing costs per piglet. The space heating (gas cannon) had, in comparison with plastic flooring heating under the above-mentioned trial conditions, an unexpectedly high advantage as far as heating costs were concerned of over DM 1,0/reared piglet. The EC energy saving fans used required only 50% of the energy input compared to that for standard axial ventilation fans.

The behavioural observations also provided a surprising result. Over the total rearing period there was no significant difference in the length of time and the frequency of lying periods between the underfloor heating and space heating where the investigated plastic flooring was used. Only in the first days after being housed did the pigs lie a little more often on the heated floor laying area. The presumption that through this type of heating the rehousing stress for the animals is less, cannot be backed-up either by growth performance, feed conversion nor mortality losses. When the hot water heating elements were switched off, there occurred dunging in these areas with the effect that the piglets were dirtier too.

The air quality with the warm water underfloor heating was substantially better when compared with the system using direct gas-fired space heating. As expected, the CO_2 concentrations very definitely exceeded the 3000 ppm upper limit as stated in the Pig Production Act [5]. The release of methane from the slurry and emission through the exhaust shafts were unexpectedly higher where gas cannons were used (*fig. 1*) The reasons for this result require further investigation.

Consequences for advisors and farmers

As in the past, no planning of a suitable heating plan can take place without a balancing of the heat flows involved. The planning values used in literature in determining the heat capacity to be installed per piglet (200 W) are often greatly exceeded. With well-insulated ridge compartments, 40 W per piglet place was sufficient in own investigations. In the purchase of a heating plant, and in the solving of heating problems, it is generally advised to pay attention to the following criteria:

- How can one satisfy the thermophysiological requirements of piglets?
- Which technology fits best into the energy concept of the farm (gas, oil, electricity)?
- Which system requires the least total costs in this context (fixed and variable costs)?

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