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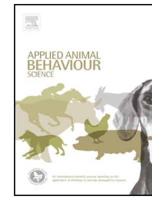

Temperature-dependent consumption of drinking water in piglet rearing

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ABSTRACT

This study focussed on examining the temperature-specific consumption of drinking water by piglets. To this end, a drinking trough system was developed to offer the animals water at three different temperatures (warm (+10 °C then barn temperature), barn temperature (actual barn temperature) and cold (−10 °C then barn temperature)). The findings showed that the piglets did choose water at different temperatures when the barn temperature was high or low. In 90% of cases the piglets preferred the cold water. There was a significant ($p \leq 0.05$) effect on water consumption at the individual troughs when the barn temperature changed. As the barn temperature rose, consumption increased at the cold water and decreased at the warm water trough. It is suggested that the climate control technology (heating and cooling) can be regulated directly based on the water consumption response signals from the piglets.

1. Introduction

In pig farming, it is a challenge to record the ambient climate parameters to develop a thermal comfort index to assess and evaluate the animal's environment (Shao and Hongwei, 2008). Each barn situation is individual, so it is difficult to define absolute temperature ranges for piglet rearing. The animals' ability to adapt on different climate situations depends on internal and external factors (such as age, size of the group, health and humidity) (Le Dividich et al., 1998). Hillmann (2003) listed different ambient temperatures which have been recommended for different pig categories. The recommendation for weaned piglets ranges from 14 °C to 28 °C relating to piglet weight. Basically the temperature demands are dependent on pig age. The range of thermoregulation of young piglets in low ambient temperatures is small because of their large body surface and absence of brown adipose tissue (Roth, 1971). Quiniou et al. (2000) point out that there is a significant correlation between the body weight of the animals and the ambient temperature. They conclude that the heavier the animals the more sensitive they are to high ambient temperatures. The thermoregulation of pigs operates under specific mechanisms. The lowest critical temperature describes the lower point of the thermo neutral zone, from which the body starts to increase the body temperature by heat production. The evaporative or upper critical temperature describes the upper point of the thermo neutral zone, from which the body temperature must be lowered to prevent hyperthermia (Bianca, 1968). The pig has various thermoregulatory mechanisms to dissipate heat to the environment. For pigs in general, respiratory heat loss becomes important when ambient temperatures increase above 20 °C. The animals then cool off by heavy breathing and the heat release is associated with water vapour. A high relative humidity combined with a high ambient temperature results in heat stress in pigs (Brooks and Carpenter, 1993) because pigs are missing perspiratory glands, so that they are not able to sweat (Ingram, 1965). If the ambient temperature increases significantly, respiratory heat loss in itself is insufficient to maintain thermoregulation. Furthermore, water loss during this process can lead to a water imbalance (Georgiev, 1972). Mount et al. (1971) found that this has the consequence that the pig requires more water per kilogramme live weight. Huynh et al. (2005) and Huynh et al. (2006) found that with increasing ambient temperatures the respiration rate also increases. In the afternoon, at ambient temperatures of 32 °C, the number of breaths per minute was 64.8 and in the morning at a temperature of 26 °C breaths per minute was at 36.9.

Another mechanism to reduce the body temperature is the lying behaviour. With increasing temperature the pigs will try to reduce the body contact with their pen mates and lie on their side to deliver the heat through their surface to floor via conductive heat loss (Huynh et al., 2005; Götz and Rist, 1984; Sællvik and Walberg, 1984; Geers et al., 1990). If the outside temperature decreases sharply

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and the animals are exposed to the cold, they can reduce heat loss through social thermoregulation named "social huddling". The "social huddling" is a strategy to reduce the ratio of surface area to volume. The close contact with conspecifics reduces heat loss, as the cold air around is replaced by a warm neighbour (Huynh et al., 2005). Shao and Hongwei (2008) developed a real-time image processing system to measure movement and classify the thermal comfort state of pigs based on their lying behavioural patterns. The most important features were the run-length frequency, pig body occupation ratio, image moment invariants and the pig group compactness. To identify the warm condition of the pigs, blob analyses were used. To differentiate cold vs. comfortable, 'Minimum Euclidian Distance' was used. This system correctly classifies animal thermal behaviours into warm/hot, comfortable, or cold conditions.

Water consumption also plays a role in the thermoregulation of pigs. The analysis of Fraser et al. (1990) showed that the water consumption of piglets almost quadrupled when the ambient temperature increased from 20 °C to 28 °C. The ingestion of drinking water can cause heating or cooling or no effect in this respect. Water consumption can be used to moderate 3% of the total heat loss to heat the water absorbed (Mount, 1968). In the studies of Steinhardt et al. (1970), six pigs received drinking water having a temperature of 3, 20 and 39 °C concurrently, at ambient temperatures of 35, 20 and 1 °C. The results showed that the animals preferred 39 °C drinking water at ambient temperatures of 20 °C. Steinhardt et al. (1970) concluded that the observation indicates the possibility to differentiate water temperatures. Kamphues and Schulz (2002) confirmed that the ambient temperature plays an important role as a factor influencing the drinking behaviour of pigs.

1.1. Objectives

This analysis lead to the idea that the temperature-specific consumption of drinking water among piglets could perhaps be used to document response signals to the current barn temperature and indicates their thermal welfare. Two key questions arose in this context:

1. Are piglets able to distinguish between different water temperatures offered by three different troughs at the same time?
2. Is there any effect of barn temperature on water consumption of piglet's drinking water at specific temperature?

Based on the three different water temperatures, the authors hypothesise is that the animal's behavioural response may indicate physiological cooling or heating demand. Furthermore, in a long term perspective the 'digital water intake observation' may serve as a response signal from the animals to confirm thermal welfare and to control the current barn temperature.

2. Materials and methods

2.1. Structure and operating principle of the trough system

The trough system was made up of three individual troughs with water at different temperatures. The barn temperature' trough is adjusted to the barn temperature. The water in the 'cold' and 'warm' troughs was set at 10 °C colder respectively warmer than the water in the trough that was regulated at barn temperature.

A DR O-C digital controller by Moeller GmbH (Im Fange 1, D-49356 Diepholz) was used to regulate the barn temperature automatically. It also set the water temperature based on the same temperature level. Temperature sensors in the water troughs were used to record the water temperatures. The system responded to any differences in an appropriate manner, heating or cooling the water as required. The digital controllers recorded the barn and water temperatures as well as water consumption data and transferred this information to the central climate control system at 15 min intervals.

2.2. Location and animals

Over a 17-month period a total of 13 trials were conducted on piglets at the University of Bonn's research centre in Frankenforst (Königswinter, Germany). The animals were divided into two groups each containing between 19 and 22 piglets. The piglets were put into the trail barn from the age of five weeks (8 kg body weight) and taken out of the trial barn again when they were aged between nine and ten weeks (30 kg). Pure breeds (German Landrace, Piétrain, Duroc) and cross breeds (German Large White × German Landrace, Piétrain × Duroc, Duroc × Piétrain) were used. An automatic dry food dispenser located opposite the trough system was used to feed the piglets ad libitum. The feed was representative of industry standards for a piglet rearing feed I (18.5% crude protein, 7.6% crude fat, 3.6% crude fibre, 5.5% crude ash) and included a protein-rich feed supplement (40.0% crude protein, 3.0% crude fat, 3.8% crude fibre, 17.5% crude ash).

2.3. Recording the data

Not only the barn and water temperatures were recorded, but also the piglets' water consumption data were recorded. The relative humidity values were collected every 15 min in two trials using a capacitive humidity sensor and a data logger (Almemo 2590-2, Ahlborn, Germany). The barn temperature was artificially changed in individual experiments in order to have a significant impact on the drinking behaviour. In the first week of the experiment, the barn temperature was lowered for one week to allow the animals a period of acclimatisation to the water system. In the cold months the temperature has been lowered for a week to about 18 °C from the second week of the experiment. The barn temperature was subsequently increased to a level of 30 °C to expose the animals to a "heat stress" situation for one week. For the last two weeks the room temperature was returned to the thermal neutral temperature requirements of animals. During summer months it was not possible to reduce the barn temperature down to 18 °C. For this reason, the barn temperature was set from the second to third week at 30 °C in these experiments.

2.4. Data analysis

For the evaluation of the measured barn temperature and relative humidity daily average values have been recorded. Absolute water consumption was converted into relative values. The water consumption of each drinking trough was set to the total water consumption. The percentage of water consumption at each individual drinking trough is reported. The Superior Performing Software System (SPSS, 2013, IBM Deutschland GmbH, Allee 1, 71139 Ehningen) was used to determine whether the barn temperature had an influence on the water intake of the piglets. A one-factor analysis of variance (ANOVA/Tukey test) was conducted. The same process was used to determine if water intake of the piglets depended on relative humidity. The temperature and humidity index (TH index) was also calculated by the following formula of Johnson (1965):

$$\mathrm{THI} = \mathrm{DBT} + 0.36\,\mathrm{DPT} + 41.2$$

where THI is the temperature and relative humidity index; DBT is the dry bulb temperature (°C); DPT is the dew point temperature (°C).