

## REACTIONS OF PIGS TO A HOT ENVIRONMENT

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### ABSTRACT

When compared to other species of farm animals, pigs are relatively sensitive to high environmental temperatures because the pig cannot sweat and is relatively poor at panting. Little information is available about the ambient temperatures above which group-housed pigs start to adapt their mechanisms of balancing heat loss and heat production. The temperature above which an adaptive response occurs (also called the critical temperature or inflection point temperature) may well differ depending on which physiological or behavioral parameter is studied. The objective of these studies was to determine the reactions of pigs to a hot environment (experiment 1) and to study the effects of different cooling systems (sprinklers and water bath) on behavioral, physiological and productive parameters (experiment 2). In experiment one 12 groups of 10 pigs of 60 kg were studied in respiration chambers. Each day, the temperature was increased by 2<sup>0</sup> C from low (16<sup>0</sup> C) to high (32<sup>0</sup> C). In experiment two 12 groups of 5 pigs were studied under the humid tropical climate of Viet Nam. The pig's first visible reaction to increasing ambient temperature was a change in behavior. Wallowing was the first of all behavioral changes. It occurs at relatively low ambient temperature: from 16 to 17<sup>0</sup> C. The first physiological reaction to high ambient temperatures was an increase in respiration rate; on average this occurred at 22.4<sup>0</sup> C. An increase in rectal temperature occurred above an average ambient temperature of 26.1<sup>0</sup> C. This implies that pigs can prevent an increase in their body temperature for an ambient temperature range of about 3.7<sup>0</sup> C. An increase in rectal temperature and an extra reduction in feed intake are indicators that room temperature is clearly above the upper limit of the thermal neutral zone. Pigs in pens with sprinklers or water bath had lower respiration rate and skin temperature than pigs in control pens, especially during the hot period of the day in pens with outside yard. No effect of cooling on the rectal temperature was found. Pigs in pens with outside yard without cooling were less active than pigs in cooling pens. Pigs in control pens were lying more in lateral position than pigs in the cooled pens. Pigs in pens with sprinklers had the highest feed intake and the highest daily gain.

It is concluded that the availability of cooling systems reduces heat stress in pigs. The indicators of heat stress found in this study could be used as set points for these cooling systems, in order to improve animal performance and welfare in hot conditions.

**KEYWORDS.** Pigs, heat stress, temperature, cooling systems, climate, welfare, environment

### INTRODUCTION

Compared to other species of farm animals, pigs are more sensitive to high environmental temperatures because they cannot sweat and do not pant so well. They respond to heat stress by invoking a complex of physiological, behavioral and anatomical mechanisms aimed at facilitating heat loss to, or minimizing heat gain from, the environment. In nature, wild pigs can wallow in mud or water, seek shelter during hot periods of the day and shift their activity from day to night when necessary (Mount, 1979). Since the nineteenth century, pigs have been bred for high lean meat content and fast growth, and have been kept in confined systems (Mount,

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1979). Fast-growing lean pigs generate more heat from their feed consumed. This, in combination with confined housing, makes it difficult for the pigs in intensive systems to regulate their heat balance. Whereas outdoor pigs can choose their own environment (e.g. shadow, mud pool, staying away from other pigs), indoor pigs have to cope with the confined environment.

A lot of research has been done on the factors affecting heat production in pigs (e.g. Verstegen et al., 1974; 1978; Nienaber et al. 1991; 1996; Brown-Brandl et al., 1998; 2000; 2001). The negative effects of upper critical temperatures in animal production have also been discussed (Curtis, 1985; Hahn et al., 1987; Christon et al., 1988). It was found that animals reduce feed intake progressively with increased temperature (Kemp and Verstegen, 1987), with the consequence of reduced growth rate. Heat stress also alters pig behavior. Mount (1979) reported that pigs modify their posture in relation to ambient conditions, to either increase or decrease heat loss. Steinbach (1978) correlated the use pigs made of cooling facilities in hot conditions, showing the relationship between the thermoregulation of pigs and their environments. Hahn (1985) reported that the behavioral patterns of farm animals, including pigs, were altered by hot environments, as animals attempted to maintain homeostasis by postural adjustment. Aarnink et al. (1996; 1997; 2001) reported that fattening pigs preferred to lie on slatted floor at high ambient temperature. They commented that pigs also shifted their excreting area to the solid floor and daubed themselves with manure and urine to cool them by evaporative cooling. However, from the hygienic and environmental pollution point of view this is undesirable.

Little information was available about the ambient temperatures above which group-housed pigs start to adapt their mechanisms of balancing heat loss and heat production. The temperature above which an adaptive response occurs (also called the critical temperature or inflection point temperature) may well differ depending on which physiological or behavioral parameter is studied. The objective of the following study was to determine the reactions of pigs to a hot environment and to study the effects of different cooling systems on behavioral, physiological and production parameters.

### **INFLECTION POINT TEMPERATURES**

In an experiment with 12 groups of 10 pigs of approximately 60 kg the temperature in a climate chamber was gradually increased from 16 to 32° C. Physiological parameters (respiration rate, heat production, and rectal temperature), behavioral parameters (wallowing, lying on slatted floor, and excretion on solid floor) and feed intake were measured. Respiration rate and rectal temperature were determined twice a day by direct observation and measurement of 3 pigs in each group. Heat production was determined by the method of indirect calorimetry (Brouwer, 1965). Behavioral parameters were determined by video recording. For detailed description of material and methods see Huynh et al. (2005). From these parameters the upper critical temperatures were determined. Such temperatures allow us to assess in which sequence the behavioral and physiological adaptations to heat stress appear. The sequence is presented in figure 1: wallowing, lying on cool slatted floor, increase respiration rate, decrease feed intake and heat production, and increase rectal temperature. It clearly shows that at the end of the chain of reactions to rising ambient temperatures, heat stress in pigs caused a reduced heat production and feed intake. Finally, in the last reaction, when heat loss cannot totally balance out heat production, the rectal temperature will increase.

The first visible sign of how the pig reacts to increasing ambient temperature is a change in behavior. Wallowing was observed as the first of all behavioral changes. It occurs at relatively low ambient temperature: from 16 to 17 °C. The first physiological indicator that the pigs are reacting to high ambient temperatures is an increase in respiration rate; on average this occurs at 22.4 °C. The second step is for rectal temperature to rise; this happened when ambient temperature was on average above 26.1 °C. This implies that pigs can avoid increasing their rectal temperature for a temperature range of about 3.7 °C. An increase in rectal temperature and

an extra reduction in feed intake are indicators that room temperature is clearly above the upper limit of the thermal neutral zone (figure 1).

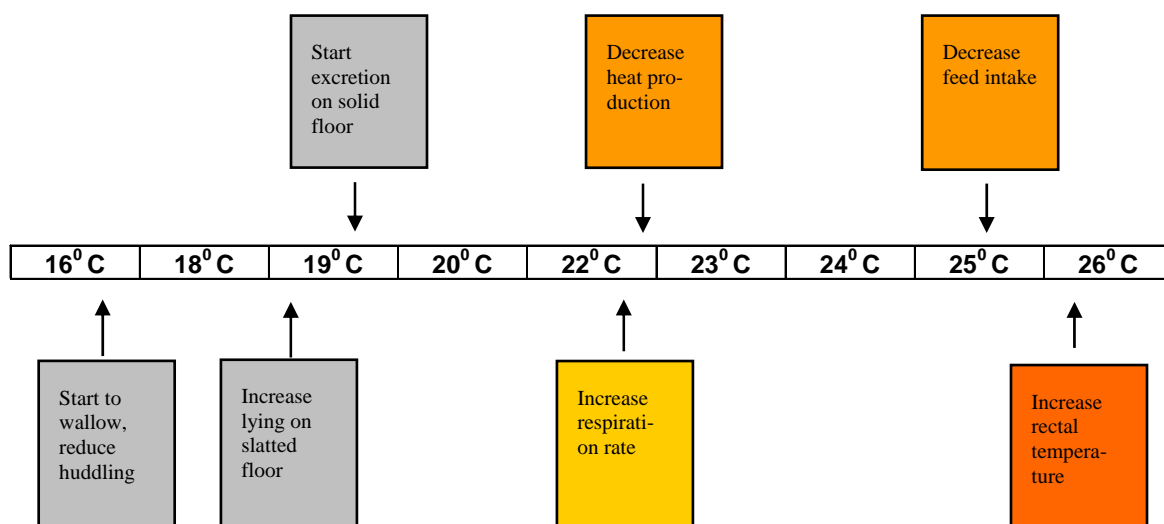


Figure 1. Adaptation of 60 kg finishing pigs to increasing temperatures

## COOLING SYSTEMS

In a study in the hot and humid climate of Vietnam the influence of two types of cooling systems (water bath versus sprinklers) with a control group on the physiological, behavioral and performance responses of pigs housed on small scale farms either with or without an outside area was determined.

A total of 120 growing to finishing western cross-bred pigs were used in two batches of 60 each. The study was conducted in 12 pens for 5 pigs each. The main testing period was 47 days for trial 1 and 48 days for trial 2. The temperature ranged from 24.3 to 29.7°C with relative humidity from 65 to 86.7% in the trial 1; a temperature range of 25.9 to 32.8°C with relative humidity from 43.8 to 82.6% in the trial 2. In four of the 12 pens, a simple sprinkler system was installed at the back of the pen. A timer was used to control the sprinkling schedule; the sprinklers were activated for 2 min every 30 min from 10:00 in the morning until 16:00 in the afternoon; the hottest period of the day. Underground water was approximately 22°C at the source, when water was pumped to the sprinklers; its temperature became approximately 25°C. In four other pens, a water bath (0.3 x 0.8 x 1.5m) was placed at the back of the pen. The bath was filled with clean water twice a day. The bath was filled up to 20 cm. The remaining 4 pens served as control.

On average, each pig used the sprinklers 4.7 times of the 12 sprinkling periods daily between 10:00 and 16:00. The pigs used the water bath on average 7.4 times per day. The intensive bathing time was between 14.00 and 17.00. The minimum duration that the pig stayed in a water bath was 1min and the longest duration was 9min. The water bath could contain maximum two pigs at the same time. The pigs had an average respiration rate (RR) of 50.9 min<sup>-1</sup>. Mean RR was higher in the afternoon than in the morning (64.8 vs. 36.9 min<sup>-1</sup>, respectively; p<0.001). Pigs in pens with sprinklers or water bath had lower respiration rate (49.3 vs. 54.1; p<0.01) and skin temperature (35.5 vs. 35.8; p<0.05) than pigs in control pens. No effect of cooling on the rectal temperature was found. Pigs in control pens were lying more (were less active) than pigs in cooling pens (88.4 vs. 84.5% of the time; p<0.05). Pigs in control pens were lying more fully on their side than pigs in the cooled pens (77.3 vs. 63.9% of the time; p<0.05). Pigs in pens with sprinklers had the highest feed intake (2.17 vs. 2.07 and 2.03 kg/d per pig for control and water bath, respectively) and the highest daily gain (586 vs. 2.07 and 2.03 g/d per pig for control and water bath, respectively).

## IMPLICATIONS

Yousef (1985) defined stress physiology as a study of the animal's physiological, biochemical, and behavioral responses to the various factors of the physical, chemical, and biological environment. According to this definition and in the light of this study, the pig's responses can be respiration rate, rectal temperature, skin temperature, postural behavior, and performance; the environmental factors can be temperature and relative humidity. When pigs experience thermal conditions above the thermoneutral zone as defined by Mount (1974), the pigs' ambient temperature is at above the inflection point temperature in this study. When this happened, we concluded that the animals were in heat stress. Heat stress can be measured (Yousef, 1985), as the animals respond by trying to maintain their conditions at constant state as in the thermoneutral environment. Heat stress has implications for the animals' welfare, as discussed below.

### *Welfare*

The definition of welfare in an individual animal is its state with regard to attempts to cope with its environment (Broom, 1986). Recent public debate on sustainable animal production has focused on the concept of animals' needs (Broom, 1992; Bartussek, 1999). The needs of the farm animals include all management and environmental factors e.g. quality of microclimate (temperature, humidity, air velocity, ventilation), quality of housing (flooring, wall, fence, indoor, outdoor), method of management (feeding, confinement, free or confined range). Welfare indicators associated with physiology, performance and behavior are often used. In general, it is not simple to quantify the welfare state of an animal; Dantzer and Mormede, (1980) therefore suggested that to assess welfare, its opposite should be evaluated. This entails looking for signals that indicate impaired welfare. When pigs are heat stressed, an impaired performance can be good evidence of poor welfare. If the heat-stressed pigs can use their postural behavior repertoire, this can be used as a signal of all the internal and external environmental factors at work, and the pig's welfare status can be inferred. In other words, when pigs show a change in postural behavior, an upset in their homeostasis may have occurred.

When temperature rose, the pigs we studied displayed signs of discomfort: they became inactive, extended their body contact with the floor while lying, and avoided physical contact with other pigs. So, when they are hot, pigs show less space sharing and lie more on their sides compared to low temperatures. This means that with increasing temperature, the need for physical surface space increases.

The heat-stressed pigs in the current study could only choose between lying on the slatted floor or on the solid concrete floor. With high ambient temperatures, more pigs lay on the slatted floor or in the excretion part of the resting area. They increased this shift until there was no longer enough space to do so. We concluded that they preferred the slatted floor because they experienced it as cooler than the solid floor. Lying on the slatted floor or excreting area is not the natural motivation of the pigs (Aarnink et al., 2001; Hesse and Jackisch, 1995; Randall et al., 1983). Thus, pigs had to lie on slatted floor or in their own urine and faeces to reduce heat stress; to do the latter they had to abandon the natural desire to avoid contact with excrement. In hot conditions this behavior can be interpreted as a decline in welfare.

An important adjustment of the pigs with regard to thermoregulation is wallowing. Wallowing of the pigs greatly increases their heat dissipation (Mount, 1971). A distinctive behavior of the pigs was observed in our study: wallowing in their own urine and faeces. Wild pigs also wallow when temperature is high (Schein et al., 1969). With regard to wallowing, Roller and Goldman (1969) noted that the pig evolved in warm, wet swampy areas. So, evolution favored their behavioral adaptation of wallowing instead of the physiological adaptation of sweating as the evaporative heat loss mechanism. Mount (1971) remarked that a clean, dry pen for pigs may therefore force pigs to pant in order to dissipate excess heat.

## *Environment*

When pigs wallow in their own manure and urine to increase evaporative heat loss, the emission of environmentally damaging gases such as  $\text{NH}_3$  will increase. Hacker et al., (1994) reported that pen dirtiness is an important factor for ammonia emission. A study on ammonia emission by Aarnink et al., (1996) showed that urine-fouled floor area related positively with ammonia emission. In other study, Aarnink et al., (1997) observed that pen fouling was higher in summer than in winter, and that pen fouling increased towards the end of growing period.

From the research reported in this thesis, it is clear that on exposure to heat stress the animals immediately changed their lying and excretion behavior. Those changes could cause a large increase in ammonia and odor emissions. The implication of this finding is that it is important to offer the animals cooling systems like water bath or sprinklers. During hot periods, this could prevent the animals from fouling their pen with manure and urine and thus from increasing emission of environmental pollutants.

### *Prevention of heat stress*

The present study has demonstrated the benefits of spray cooling and water bath systems. Spray cooling is one of the cheapest and simplest ways of reducing the negative effects of hot weather. This system can be used to improve the production efficiency and welfare of pigs not only in Viet Nam, but also in intensive production systems outside the tropics. Spray cooling has to be managed according to the actual air temperatures and diurnal temperature variations. Most modern spraying systems are designed to allow this. When using spray-cooling equipment it is important to use spray heads capable of producing large droplet sizes. In addition, the water should be sprayed just directly above animal level. In this way it is possible to avoid producing high humidity conditions, which can actually increase rather than decrease heat stress. A combination of sprinkling with a high airflow can also cause too much heat loss, especially in young pigs, even at high air temperatures (Hahn et al., 1987). It is therefore essential to have a well-controlled sprinkling system. It is also important that the animal can choose whether or not to use the cooling system, as the animal itself is the best sensor of heat stress.

## **CONCLUSIONS**

Upper critical temperatures (inflection point temperatures) have been derived for many different animal parameters. In order of appearance, these include wallowing, lying on slatted floor, excretion on solid floor, respiration rate, total heat production, voluntary feed intake and rectal temperature. These inflection point temperatures were different for the different parameters and explained the subsequent strategies the animal followed as ambient temperature rose.

The best indicators for assessing heat stress of finishing pigs were: increased respiration rate followed by reduced feed intake, and, finally, increased rectal temperature. Decreased feed intake and increased rectal temperature were found to be good indicators of reduced performance of heat-stressed pigs. Observations of lying and excreting behavioral changes of the pigs proved to be useful to assess the animals' very first reactions in thermal regulation.

On the basis of our findings on thermoregulation we recommend that when determining the physical space required by fattening pigs the behavioral changes at increasing temperatures should be taken into account. The number of pigs lying on slatted floor could be the first indicator for assessing the welfare of pigs exposed to high ambient temperatures.

Ad libitum, fast-growing, group-housed pigs raised under tropical climate conditions clearly show physiological and behavioral responses to this climate similar to those of pigs kept under controlled environmental conditions. The pigs adapt to adverse tropical conditions by maintaining a high respiration rate in order to maintain homeostasis and performance.

The availability of cooling systems e.g. water bath or sprinklers, reduces heat stress in pigs. In hot humid tropical conditions, these two systems contribute only little extra humidity to the air.

The indicators of heat stress found in this study could be used as set points for cooling systems, in order to improve animal performance and welfare in hot conditions.

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