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PIG BEHAVIOUR IN RELATION TO WEATHER CONDITIONS – A REVIEW

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Abstract

Weather conditions (temperature, humidity, solar radiation, air pressure, wind strength, wind direction and precipitation) have a significant impact on the behaviour of farm animals. Pigs have developed a wide range of thermoregulatory behaviours that are particular for this species. With increases in temperature the most characteristic behaviour for pigs is decreased activity and increased wallowing in wet surfaces. In addition to this, rooting and wallowing are highly influenced by temperature and humidity. The lack of possibility to express these behaviours leads to development of stereotypies. Interestingly, low temperatures do not increase the use of shelter if not in combination with wind or precipitation. Furthermore, wild pigs build stronger nests in severe conditions. Also, resting behaviour and reproduction may be disturbed by high temperatures. There is a negative impact of foehn wind on boars' libido and semen parameters.

Key words: pigs, atmospheric conditions, weather, behaviour

In a common view, the impact of weather on human and animal behaviour is obvious. Scientifically, the weather is an overall term that describes many parameters such as temperature, humidity, cloudiness, precipitation, solar radiation, atmospheric pressure as well as air movement. It should be considered carefully whether the impact of these factors should be analysed separately or comprehensively, but the value of each should be always determined. The scientific papers about the effects of weather on swine behaviour, focus mostly on the temperature (Blackshaw and Blackshaw, 1994; Bracke, 2011; Geers et al., 1986; Huynh et al., 2005; Ingram and Legge, 1970), humidity (Olsen and Simonsen, 2001; Andresen and Redbo, 1999; Buckner et al., 1998) as well as the wind speed (Buckner et al., 1998; Ingram and Legge, 1970). However, information about the remaining factors such as solar radiation, and precipitation are still insufficient. What is more, most of the studies were conducted in indoor housing systems where the environmental conditions are con-

trolled and the weather does not have an impact on the animals. Nevertheless, there are places, mostly in southern Europe, with extensive production and outdoor housing systems. In addition to understanding pigs' behaviour and preparing a good environment for them, it is important to understand how pigs react to different weather components even in intensive farming systems.

The aim of this review is to explore, summarize and systematize the knowledge about the relationship between pig behaviour and different weather conditions.

Thermoregulatory behaviour of pigs

One of the most commonly researched topics is the effect of temperature on pig behaviour according to the housing system, age or phase of the reproductive cycle. Already in 1919, Spencer (1919) drew attention to the negative impact of low temperatures, which can be dangerous for life and health of piglets kept in the "old piggery". Nevertheless, the high temperatures are the biggest challenge for an organism of Suidae.

Pigs are homeothermic animals which, for various reasons, are prone to overheating. Their reduced ability to transfer heat is mainly caused by the small amount of sweat glands (Farrell, 1977; Bracke, 2011), a subcutaneous fat layer (Zervanos and Hadley, 1973) and barrel-shaped body. Furthermore, compared with a wild boar, the snouts of domesticated swine are shorter. This is the reason why their heat transfer capacity through evaporation apparatus is reduced (Bracke, 2011). Due to specific physiology and body shape, pigs have had to develop a wide range of behavioural thermoregulation systems. As a response to the high temperature the following behavioural patterns are observed:

- increased respiration (panting) (Zervanos and Hadley, 1973; Huynh et al., 2007),
- decreased activity (Huynh et al., 2005; Johnson et al., 2008),
- reduced food intake (Barnett et al., 2001; Silva et al., 2009 a),
- altered behaviour connected with resting and lying (limited contact with other animals, putting up the body surface in cool, humid places as much as possible) (Olsen and Simonsen, 2001; Huynh et al., 2005; Shi et al., 2006),
- shade seeking (Blackshaw and Blackshaw, 1994; Buckner et al., 1998),
- increased water intake (Zervanos and Hadley, 1973; Silva et al., 2009 b),
- wallowing (Bracke, 2011; Huynh et al., 2007; Olsen and Simonsen, 2001; Shi et al., 2006).

Long-term exposure to low or high temperatures results in thermoreceptors adaptation to the external conditions. As a consequence those pigs manifest thermoregulatory behaviours significantly later (they have greater tolerance) than animals exposed to sudden temperature changes (Swiergiel, 1997).

Wallowing

The wallowing behaviour of pigs plays an important role in maintaining the proper level of welfare. Bracke (2011) suggests that wallowing in pigs is internally motivated and highly satisfies them. If these assumptions are correct, it means that this is a very important aspect of the psychological comfort of pigs.

There are positive correlations between the intensity of wallowing, and temperature and humidity. Together with increasing humidity the animals begin to roll at lower temperatures (Huynh et al., 2005). This is associated with difficulties in heat exchange with the environment, when almost all thermoregulation processes rely on skin contact with cool surfaces. Furthermore, wallowing in the mud is very effective and can decrease body temperature by 2°C (Hörning et al., 1999). As the temperature increases by one degree, pigs wallow longer by 1.2% (Huynh et al., 2005).

Older and larger pigs are much more susceptible to overheating (optimum: 16ºC) in comparison to piglets, which need high temperatures (optimum: 32ºC before they finish 2 weeks, 24ºC between 2–4 weeks). Domestic pigs and wild boars wallow with pleasure in the mud or other wet locations (Bracke, 2011), and they mostly begin wallowing at temperatures above 12°C. However, late pregnancy sows will show this kind of behaviour even in winter (Buckner et al., 1998). What is more, there is a correlation between the temperature and the frequency of changes in position while lying down in the mud, also the time spent in the "bathing area" (Olsen and Simonsen, 2001). When temperatures are not high, pigs often stand in water, and as the temperature increases they start to lay down, at the beginning on the stomach, and then roll from one side to the other. During the hottest days, when the wallow area is deep enough, it is easy to observe the animals almost completely submerged in the mud. After leaving the area pigs are covered with a thick layer of mud, which prevents hyperthermia through long-term evaporation (2 hours compared to 15 minutes of evaporation of "free" water) (Huynh et al., 2007). Moreover, the mud covering the skin of pigs becomes a protecting layer against ectoparasites as well as insulating the skin from the sunburn. When the amount of sun increases at high ambient temperature pigs plunge snout and release air making bubbles on the water surface. This behaviour is negatively correlated with air humidity (Olsen and Simonsen, 2001).

In intensive housing systems where pigs do not have access to the pool, the need to wallow at high temperatures causes that pigs start lying down and wallowing in their own faeces (Aarnink et al., 2006; Hillmann et al., 2004; Spoolder et al., 2012). Scientists emphasize how important it is to reconsider customization of pig housing systems in order to meet their internal instincts associated with wallowing (Andresen and Redbo, 1999).

Rooting

Andresen and Redbo (1999) observed that the rooting behaviour of finishers in outdoor system remained constant irrespectively of the temperature. In contrast, Burne et al. (2001) noted that low temperatures increase the frequency of rooting. Rooting behaviour can be oriented towards foraging, nest building or thermoregulation. What is more, it is suggested that while the temperature increases the time spent on eating decreases. Thus, with higher temperature the rooting orientation is changed from foraging into thermoregulatory behaviour. When the ambient temperature reaches 20°C pigs root in drinking or wallowing area trying to dig a hollow for wallowing to increase the cooling effect (Andresen and Redbo, 1999). Olsen

(2001) showed that pigs spend more time on rooting for wallowing while the temperature and the amount of sun increases. Furthermore, pigs root deeper in wet areas, which suggests that there is a relationship between soil humidity and expressing rooting behaviour. Moreover, it was observed that precipitation induced behaviour like chewing, suckling and rooting (Andresen and Redbo, 1999). In intensive pig housing, when pigs do not have any enrichments, the need for rooting can develop stereotypic behaviour and tail biting (Edge et al., 2005; Nowicki et al., 2008; Nowicki and Klocek, 2012).

Resting behaviour

Among all the farm animals, pigs spend the most amount of time on resting (Shi et al., 2006). Wild boars spend 85% of their active day on foraging and feeding behaviour (Briedermann, 1971). When domestic pigs are allowed to live freely in a woodland setting, they still spend 75% of their active time on foraging and feeding behaviour – even when fed to satiety once daily (Stolba and Wood-Gush, 1989). All pigs are still highly-motivated to explore their surroundings and forage for food, but investigation and manipulation activities can be expressed when enrichment is provided. When the environment is poor in stimuli pigs prefer to rest. This is very important for their health (low stress level, low level of aggression), and from economic point of view, to maintain high growth rate. A comfortable sleeping area ensures the possibility of lying in calmness in a stretched side-body position. When the temperature is too high, the resting time is interrupted and animals start to search for a good place to lie down. Pigs move to cool areas to lie down without contact with other individuals. If it is not possible and buildings are not adjusted, pigs become irritated, and this leads to stereotypic behaviours or increases aggression. What is more, if there are no cool places, they start to lie down in their own faeces (Shi et al., 2006; Spoolder et al., 2012). Shi et al. (2006) conducted an experiment in an open pig house with two groups: one with a floor cooling system and control group without a floor cooling system. Significant differences in the behaviour between these two groups were observed. When the air temperature increased the pigs without the floor cooling system moved from the resting area to the manure alley. Within the temperature range of 23–25°C, 85% of pigs stayed in resting area, if air temperature increased up to 30°C only 57% of pigs were lying comfortably. Moreover, only 10–20% of pigs were seen lying in sleeping area when temperature reached 30–33°C. However, in housing with floor cooling system pigs spent 60% of time on resting in sleeping area regardless of air temperature (Shi et al., 2006).

Besides high temperatures, the air velocity also has an impact on pig behaviour. When air temperature is low (15–18°C) an increase in air movement causes lying with contact to other animals, decrease of lying in the manure alley, better pen hygiene, lower growth rate and tendency for tail biting. Furthermore, high air temperatures with low air velocity lead to a decrease in contact between animals and growth rate, an increase in lying in manure alley and the occurrence of stereotypic behaviours (Sällvik and Walberg, 1984). Sällvik and Walberg (1984) also suggest that air velocity should be from 0.15 to 0.28 m/s when air temperature is 16°C, and when temperature is 28°C air velocity should be from 0.74 to 1.31 m/s.

The use of shelter and shade

Pigs kept in outdoor systems are much more active than indoor pigs. If they are kept in forest area they spend 75% of their time to search for food and in exploratory behaviour, even if they are fed *ad libitum* (Stolba and Wood-Gush, 1989). What is more, those pigs are more exposed to the influence of the external environment and changes in behaviour are expressed more clearly.

Interestingly, low temperatures during daytime do not influence the use of shelter by pigs. It seems that animals prefer to be outside, even though the temperature in the shelter is higher. On the other hand, during night pigs choose to be inside, which probably results from the sense of security. The difference between the outside and inside temperature is usually very small, but the shelter ensures the possibility to avoid heat loss due to increased air movement and by radiation (Buckner et al., 1998).

It was observed that up to 5°C even young animals do not use shelter or increase lying in groups during daytime (Ingram and Legge, 1970; Rodríguez-Estévez et al., 2010). However, extremely low temperatures can lead to fights for the best place to lie down. Furthermore, if there is limited area, individuals that failed to find a suitable place may feel discomfort. On the other hand, individuals that had place to rest may be vulnerable to disturbance from others (Rodríguez-Estévez et al., 2010).

There is a correlation between the effects of air temperature, humidity and air velocity on pig behaviour. Low temperatures with high humidity and wind significantly increase the use of shelter by pigs. Moreover, Buckner et al. (1998) suggest that during darkness sows spent most of the time inside the shelters. They observed that sows slept outside only just before farrowing. In addition, growing pigs also spent the night inside, the only exception is going outside for a short time to drink or defecate (Ingram and Legge, 1970).

The air velocity influences the choice of position by pigs. It has been shown that animals avoid the most windy places in the pasture, regardless of the air temperature (Sällvik and Walberg, 1984). The most important factor is the wind strength and the correlation between the air velocity and the air temperature. However, the wind direction had no significant effect on the behaviour of animals (Buckner et al., 1998).

Outdoor pigs react differently to high temperatures than pigs kept indoors. Usually when it becomes too hot pigs search for shade or shelter. It was observed that within the range 15–20°C only few individuals look for shaded areas, but when temperatures reach 26–30°C around 87% of sows, boars or growers try to find place in the shade (Blackshaw and Blackshaw, 1994). However, weaners were less sensitive because only 65% moved to shade area. When the temperature increased up to 35°C over 85% of pigs from all groups moved to shade. It was observed that young individuals become irritated when temperatures are too high. This is probably caused by the lack of experience in searching for a shade or their lower position in hierarchy (Blackshaw and Blackshaw, 1994).

Nest building

Observations of wild pigs have revealed that the environmental conditions affect nest building behaviours by sows. The nest primary function is to protect piglets from the severe weather conditions (rain, wind, low temperature), and from potential

predators (Wischner et al., 2009). The nest building behaviour in domestic sows is usually observed a few days before farrowing. The PGF2α application induces this behaviour in non-pregnant pigs. What is more, Burne et al. (2001) observed that when sows were treated with PGF2α, the air temperature influence was still observed. Both the time and intensity spent on nest building is correlated with weather conditions. High temperatures have negative effect on nest building behaviour (sows spend more time lying). In contrast, low temperatures stimulate them, affecting mostly rooting behaviour (Burne et al., 2001). The nests were stronger and made from greater amount of materials, which ensured better protection, in young forests where tree crowns have lower density (Mayer et al., 2002). Furthermore, the place where the nest is built also depends on weather conditions. Sows choose areas with better protection when the weather is unpleasant, for example if it is raining or snowing (Algers and Uvnäs-Moberg, 2007). Before farrowing both wild and domestic pigs exhibit increased nest building activities when it is cold, rainy and windy. During the cold seasons wild hogs' nests were higher and domestic pigs collected greater amount of material (Burne et al., 2001; Mayer et al., 2002).

Abnormal behaviour

The severe environment (mostly high temperature and air velocity) can have an adverse impact on animals causing stress. The long term influence of unsuitable weather conditions may lead to chronic stress in pigs. Animals that suffer discomfort resulting from excessive heat or excessive air movements become irritated, which leads to the behavioural changes such as stereotypies and agonistic behaviours (Smulders et al., 2006).

When the air temperature is too high, the frequency of tail-biting increases (EFSA, 2007), as does space requirement per individual (Olsen and Simonsen, 2001) Also, the draughts can intensify agonistic behaviours (Scheepens et al., 1991). Moreover, the lack of undisturbed rest increases the irritability of animals, which shows even more agonistic behaviours (Smulders et al., 2006; Spoolder et al., 2012). Over-stimulation and aggressive behaviour induced by the weather conditions can cause decreases in weight gain, fertility disorders and the animals may suffer from the injuries. High temperature can also cause an increase of abnormal behaviours such as walking to the nipple without drinking or standing for a long time without any movement (de Oliveira Júnior et al., 2011).

The weather and the reproduction

There are numerous studies, which have shown that the season and its related weather conditions have a significant impact on pig breeding parameters (Chenoweth, 1981; Adamiak et al., 2010). It is suggested that this is an atavistic tendency to manifest greater sexual activity in the autumn and winter (Kondracki et al., 1997). The largest impact on reproduction is the daytime length, air temperature (Adamiak et al., 2010) and humidity (Chenoweth, 1981).

It is well known that high temperatures decrease boar libido (Chenoweth, 1981) and stress may lead to problems with erection, or cause ejaculation in sexually immature boars (Wingfield and Sapolsky, 2003). To minimize the impact of temperature

on boar sexual function during the summer months, it is suggested to collect semen early in the morning. What is more, the boars' libido decreases with increased photoperiod. To eliminate the impact of the day length, the artificial light is used to increase testosterone level up to the point that is observed in autumn (Banaszewska et al., 2007). Moreover, it was observed that the time of insemination has an impact on number of born piglets. If the insemination is provided during winter there are significantly more piglets born alive compared to summer (Knecht and Duziński, 2014). These results can relate to the influence of high temperatures that may lead to a lack of heat or increased embryos dying in the first three weeks of sow pregnancy. Heat stress results in decreased fertility and can cause seasonal infertility that is known as summer infertility syndrome (SIS) (Williams, 2012; Mroczek, 2001).

In addition, season has a significant impact on sperm parameters (Adamiak et al., 2010). From pure breed boars the best ejaculates are collected in autumn and winter (Kondracki et al., 1997). However, there is less impact of season on Duroc boars than other breeds (Banaszewska et al., 2007). The research on hybrids showed similar results (Kondracki et al., 1997). A significant increase in sperm concentration and semen volume in autumn were found in feral pigs, which confirms the breeding seasonality of these animals (Kozdrowski and Dubiel, 2004).

Not only temperature and season affect pig fertility, Orlicki and Migdał (2006) found foehn wind (halny) to cause a decline in libido, ejaculation volume and semen parameters in boars from the Boar Station in Klecza Dolna. This may not be surprising as the influence of foehn wind has already been reported on humans (lower concentration, physical discomfort, increased amount of suicides) (Muecher and Ungeheuer, 1961; Trepińska et al., 2006). All the weather components have an impact on swine reproduction effectiveness.

Conclusions

Pigs' behavioural response to changing weather conditions may vary due to the weight and age of the animals, the reproductive cycle phase, health, and housing systems. High temperatures cause lying in wet surfaces (often in the manure alley), low activity level, and reduced food intake. Lower temperatures induce nest building behaviour and increase activity. High humidity increases rooting behaviour, as well as chewing and biting. If housing system does not allow expressing natural behaviours, pigs start to manifest abnormal and stereotypic behaviours. Higher aggressiveness can be induced by high temperatures and air velocity. There are many studies that report about the impact of the climatic conditions on pigs in intensive housing systems. However, the scientific reports about extensive farming are insufficient. In addition, wild pigs and pigs kept outdoors provide the most meaningful picture of typical pig behaviour, as they allow the animals to express their natural instincts.

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