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Faculty of Landscape Architecture, Horticulture and Crop Production Science

Rectal and skin temperature of new born piglets in two different housing systems

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Rectal and skin temperature of new born piglets born in two different systems

Rektal- och hudtemperatur på nyfödda smågrisar födda i två olika system

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Summary

The trial was performed during the year 2015- 2016 at a farm located in the south of Sweden. The aim was to compare the drop in body temperature after birth in pigs in two different farrowing/birth systems; temporary confined sow (at farrowing until 3 days thereafter) (TC) or loose sow. The rectal and skin temperature (caudal dorsal) of 51 new born piglets was taken directly after birth and then every 15 minutes for 2 hours and 45 minutes (12 measurements). Besides rectal/skin temperature and farrowing/birth system, the following information of the individual piglet was recorded: date of birth, birth weight, if the piglet was born on concrete (with floor heating) or cast iron, amount of straw at birth place, and if the piglet was under the heating lamp at any of the 12 measuring occasions. In the TC system, the heating lamp was placed behind the sow at farrowing. This was not an option in the loose system, since the heating lamp had to be protected from the sow. Depending on birth weight, the piglets were divided into large (>1.5 kg), medium (1-1.5 kg) or small (<1 kg) piglets. In total, 21 pigs were categorized as large, 24 as medium and 6 as small.

The results showed a difference between piglets with low birth weight compared to piglets with high birth weight. Piglets with low birth weight reached preferable temperature levels later than heavier piglets and low birth weight piglets also dropped more in rectal temperature.

Measurements with an infra-red-thermometer of surface temperatures within the different combinations of floor type, straw and heating lamp ranged from 15°C for cast iron without lamp and without straw, 17°C for cast iron without lamp but with straw, 21°C for cast iron with lamp but without straw, 25.5°C for concrete with floor heating without lamp and straw to 27.5°C for concrete with floor heating as well as with lamp and with straw.

A minor comparison between a birth place with ‘a little amount of straw’ versus a ‘lot of straw’ within medium pigs in the system with a loose sow, showed a larger temperature drop (about one degree) if the piglets were born on a little amount of straw. A similar minor comparison around being under the heating lamp or not, was made for large pigs in the TC system. This comparison did not indicate any strong results on the piglets rectal and skin temperatures due to a low number of data (only three large pigs under the heating lamp in the TC system).

For large (>1.5 kg) and medium (1-1.5 kg) piglets, the body temperature drop after birth was larger in the TC system compared to in the loose system. This was explained as a consequence of that 100% of the piglets in the TC system were born on cast iron compared to only 11% in the system with a loose sow. However, for the small piglets (< 1 kg) the result was the opposite. One explanation of this contradictory result for small pigs might be that the distribution of vitality among the small piglets was uneven within the systems, since the number of small pigs was very limited (only six pigs in total).

It was concluded that the skin temperatures tended to follow the rectal temperatures with a difference of about 3-6 degrees lower than the rectal temperature, and that a well-placed

heating lamp, floor heating and an optimal floor are important key factors for a smaller temperature drop in newborn piglets. Straw is another positive factor for the piglets, since it makes the heat disappear slower. The lay-out of the pen was found to influence the drop in body temperature after birth. Concrete with floor heating (loose system) resulted in a better outcome compared to cast iron (TC system) in this trial in which the layout in the TC-system resulted in that the piglets were born on cast iron.

Sammanfattning

Försöket ägde rum under år 2015-2016 på en gård i södra Sverige. Syftet var att jämföra nyfödda smågrisars temperatursänkning i två olika grisningssystem; temporärt fixerad sugga (från grisning till tre dagar efter) eller lösgående sugga. Temperaturen på smågrisarna togs rektalt samt på huden (kaudalt dorsalt) på 51 nyfödda smågrisar direkt efter födsel och därefter med en kvarts mellanrum i totalt 2 timmar och 45 minuter (12 mätningar). Förutom grisningssystem, rektal- och hudtemperatur noterades även följande information individuellt för varje nyfödd smågris; födelsedatum, födelsevikt, om smågrisen föddes på gjutjärnsspalt eller betong (med golvvärme), mängden halm där smågrisen föddes, om smågrisen befann sig under värmelampan eller inte under något utav de 12 olika mätningstillfällena.

I det temporärt fixerade systemet, var värmelampan placerad precis bakom suggan vid grisning, detta var inte möjligt i det lösgående systemet. Smågrisarna vägdes efter det sista mätningstillfället och delades då in i 3 olika viktklasser; stora (>1.5 kg), medium (1-1.5 kg) eller små (<1 kg) smågrisar. Totalt kategoriserades 21 smågrisar som ”stora”, 24 som ”medium” och 6 som ”små”.

Resultatet visade en skillnad mellan smågrisar med låg födelsevikt jämfört med smågrisar med en hög födelsevikt. Smågrisar med låg födelsevikt kom upp i normala kropps-temperaturer senare än smågrisar med högre födelsevikt samt att de med låg födelsevikt även hamnade på betydligt lägre kroppstemperatur.

Temperaturen på ytorna inne i stallet mättes med en infraröd termometer. Gjutjärnsspalt utan varken halm eller värmelampa mättes till 15 °C och gjutjärnsspalt med halm mättes till 17 °C och gjutjärnsspalt med värmelampa till 21°C. Betong med golvvärme uppgick till 25,5°C och betong med golvvärme, värmelampa och halm mättes till 27,5°C.

En mindre undersökning har gjorts på den kvadratmetern där den helt nyfödda smågrisen hamnar precis vid födseln gällande mängden halm. Där har platser med “en liten mängd halm” jämförts med födelseplatser med “en stor mängd halm”. Undersökningen gjordes på smågrisar (1-1.5 kg) i det lösgående systemet och resultatet visade att de som föddes på en liten mängd halm tappade ungefär 1°C mer jämfört med de som föddes på en större mängd halm. En liknande undersökning har gjorts där smågrisar (>1 kg) i det temporärt fixerade systemet som vistats under värmelampan jämförts med smågrisar som inte vistats under värmelampan. Denna undersökning gav inga tydliga skillnader i resultat på smågrisarnas hud – och/ eller kroppstemperatur, vilket troligtvis berodde på den låga datainsamlingen (endast 3 smågrisar vistades under värmelampan i detta system).

De stora (>1.5 kg) och mediumstora (1-1.5 kg) smågrisarna tappade mer i temperatur efter födseln i det temporärt fixerade systemet jämfört med det lösgående. Detta förklaras med att 100% av smågrisarna i det temporärt fixerade systemet föddes på gjutjärnsspalt, jämfört med 11% av smågrisarna i det lösgående systemet. Hur som helst, så var det tvärtom för de små smågrisarna (<1 kg). Eftersom antalet smågrisar (<1 kg) var betydligt lägre (endast 6 stycken totalt), kan en förklaring vara att fördelningen av dessa smågrisars vitalitet var ojämn inom systemen.

Hudtemperaturerna verkade följa rektaltemperaturerna med en skillnad på 3-6 °C lägre än rektaltemperaturen. Andra slutsatser som drogs var att en välplacerad värmelampa, golvvärme och ett optimalt golv är viktiga faktorer för att öka de nyfödda smågrisarnas temperatursänkning. Halm är en annan viktig faktor eftersom den gör att värmen försvinner långsammare. Hur boxens inredning är uppbyggd är även en faktor som har stor betydelse för smågrisens kroppstemperatur där det lösgående systemet med golvvärme var mest optimalt.

1. Introduction

A major problem in today's pig production is the high piglet mortality between birth and weaning. The pre-weaning mortalities are usually higher than 10 percentages of live born piglets with the highest losses in the first week after parturition (Kilbride et al., 2012). According to WinPig reports from 2014 the piglet mortality between birth and weaning was in average 17.8 percent in Swedish pig herds (WinPigSugg, 2015). Management strategies are the key factors to reduce the high pre-weaning mortalities (Kirkden et al., 2013).

Pig producers are paid according to quantity of produced pigs and thereby the breeding programs have been focusing on selecting pigs with high litter size. However, the high litter size is highly correlated with higher piglet mortality which causes economic losses for the producers. Piglets are exposed to different types of risk factors such as low or no colostrum intake, crushing, disease etc. If the new born piglet goes through large heat losses it may be fatal since this may increase the risk of crushing, disease etc. Heat loss is particularly life-threatening for piglets directly after birth, since their thermoregulatory ability is poorly established compared to other newborn mammals which are born with brown adipose tissue and fur (Blasco et al., 1995).

This master thesis will be focusing on the rectal and skin temperatures of newborn piglets and a comparison between farrowing crates and loose system will be done. Factors such as placement of the heating lamp, amount of straw and floor type (concrete versus cast iron) will also be investigated.

2. Aim of the study

The aim of the study was to investigate if there are any differences in heat losses in new born piglets when housing the sows in temporary crates compared to loose at farrowing.

3. Literature study

3.1 Reasons behind piglet mortality

The two main causes of neonatal deaths are crushing and starvation, which may contribute to 50-80 percentages of all mortalities. Within two to three days after farrowing, approximately 60-80 percentages of all the deaths occurs (Marchant et al., 2000). There are several factors that influence the piglet mortality in a herd, and some of them will be faced bellow.

3.1.1 Diarrhea

The reasons behind piglet diarrhea are multifactorial, and the presence of enteric pathogens is not always enough to show clinical signs of disease. Usually piglet diarrhea is caused by environment- pathogens interactions. Environment and management practices as well as herd structure and animal, has been shown to largely influence the risk of disease. Factors that may affect pre-weaning morbidity and mortality due to diarrhea include (Devey et al., 1995):

- large litter sizes
- piglets with low birth weight
- low or absence of colostrum intake
- inadequate nursing care
- cold piglets due to environmental temperature
- poor hygiene in the farrowing pen.

The most common cause of diarrhea in the first 3 days of age is enterotoxigenic *Escherichia coli*. Later in life (4-14 days), piglet diarrhea may be caused by other agents and these include; *Clostridium perfringens* type C, rotavirus, *Strongyloides*, *Serpulina hyodysenteriae*, transmissible gastroenteritis virus (TGE) and other corona viruses. However, usually there is only one agent that is the primary reason, but that specific agent may result in mixed infections (Devey et al., 1995).

3.1.2 Non-infectious diseases

3.1.2.1 Colostrum intake

Hence the piglets are born without plasma immunoglobulins (Bland et al., 2003) the colostrum plays an important role to provide the piglets with passive immunity protection (Rooke & Bland, 2002). A sufficient amount of colostrum can reduce the pre-weaning mortality rate. If the piglets do not consume a sufficient amount of colostrum they are more likely to be exposed to starvation and thereby crushing (Quesnel et al., 2012; Devillers et al., 2011) or they will die due to disease like diarrhea. Colostrum contains energy (fat and lactose) vital for growth and regulation of body temperature (Le Dividich et al., 2005). There are also immunoglobulins (IgG) available in larger amounts the first 3 hours after farrowing in the swine colostrum, see table 1 (Foisnet et al., 2010).

Table 1. After parturition, the milk composition changes with focus on the three highlighted components (fat, lactose and protein). The piglets consume the highest amount of colostrum 9-12 hours after birth. A small amount of colostrum is produced in the first hours which later will dilutes into milk (Jackson et al., 1995)

Time after parturition	Fat, %	Lactose, %	Protein, %
0 h	5.2	3.4	16.3
3 h	5.9	3.4	15.2
6 h	5.8	3.3	13.1
12 h	6.6	3.8	9.9
24 h	7.9	4.4	9.4
2 days	6.5	4.8	6.4
28 days	6.1	5.8	5.4

3.1.2.2 Crushing

The risk of being crushed as a piglet are more likely if the piglet has a low body weight and slow weight gain (Svendsen et al., 1986). Starving piglets might move slower and therefore harder to avoid the sow's movements. The piglets use to prefer to stay close to the udder which also increases the risks of getting crushed (Baumann et al., 1966).

3.1.2.3 Litter size and birth weight

The litter size has been changed over the last decade. Sows are bred for an improved prolificacy which has eventuated in an increased litter size at farrowing and weaning. Unfortunately, the improvement in litter size is also associated with higher natal mortalities (Gueblez and Dagorn, 2000), which partly depend on the decreased mean birth weight. The increased mortalities may be linked to the increased number of piglets born with low body weight. Piglets with low body weight also have a lower capacity to store energy which also makes them more sensitive to cold. These piglets have a prolonged time between births and first suckle which also influence access to the best teat negatively. Also, colostrum intake will be negatively affected (Le Dividich, 1999).

Litter size has an impact on teat competition and weak piglets in large litters are more likely to die because of starvation. Sometimes the number of functional teats is less than the number of born piglet. A solution is to cross-foster in order to prevent piglets from dying due to starvation. Piglets from large litters are usually moved to smaller litters (Straw et al., 1998).

3.1.2.4 Splay leg disease

This type of diseases is characterized by a malfunction with a reduced ability to keep the legs together. The disease can be divided into two groups; either (1) the vital splayed leg piglet, or (2) the weak splayed leg piglet. The vital pig shows signs already 12 hours after birth and usually only the back legs are affected. The number of boar piglets that become ill are higher than gilt piglets and the disease seems to be genetically innate. The vital pigs use to survive but could be helped by getting the legs tape for two to three days to keep the legs together. The disease seems to be non-affected by factors such as farrowing length, sow age, litter size or housing type (Olsson & Svendsen, 1999).

The weak splayed leg piglet has a low chance of surviving. Usually both the front and back legs are affected and the symptom shows up shortly after birth. It is more common in litters with short farrowing length, but the gender or father seems not to affect the result of a weak splayed leg piglet (Olsson & Svendsen, 1999).

3.1.2.5 Umbilical bleeding

Umbilical bleeding may be hard to detect. The piglets bleed to death by constantly and slowly losing small amounts of blood. The number of piglets that get ill is 0.1 percent of all piglets that dies with other reasons. The cause of disease is still unknown, but it is possible to have relations to the use of wood chips litter. Even well-kept farms with high hygiene standards may experience the problems with umbilical bleeding piglets (Olsson & Svendsen, 1999).

3.1.2.6 Abnormalities

Some sort of abnormalities in new born piglets always comes up in piglet production farms. Examples of abnormalities are; brain and heart abnormalities, abnormalities on extremities and closed rectum. As soon as detected, piglets with these types of abnormalities should be put to death and registered on the sow card so that no recruitment from this litter will be used since it might be genetically innate (Olsson & Svendsen, 1999).

3.1.3 Generalized infections

3.1.3.1 Joint infections

Joint infections are usually caused by *Staphylococcus* and special strains of *Streptococcus*. Joint infections are not only a disease or mortality problem, but also a problem in the matter of animal welfare protection, since the animals are starved to death. This type of infection may occur in any ages but are most common during the 2nd and 3rd week after birth. A piglet who suffers from joint infections usually gets fever, loses locomotion and stays close to the heating lamp. Most commonly the large joints get affected, which can be noticed as they get swollen, warm and tender. A bacteriologic entrance in to the gastrointestinal tract is a common way of infection and most of the piglets that die have infections in other organs as well (Svendsen & Rantzer, 2007).

3.1.3.2 Respiratory diseases

Respiratory infections in piglet farms do exist, but are more common in slaughter pig houses. Bacteria (*B. bronchisetica, P. multocida, A. pleuropneumonia*), *Mycoplasma* (*hyopneumonia*) and virus (influenza virus) are the main infectious agents. The risk of respiratory diseases infections increases with poor climate conditions, high concentrations of toxic gases and dust. Also, sudden changes in the indoor climate may increase the risks, for example drafts (Svendsen & Rantzer, 2007).

Porcine reproductive and respiratory syndrome (PRRS) affects pigs in different ages worldwide. Fortunately, Sweden has not become affected. PRRS causes reproductive failure in sows (abortions, weak born piglets, mummified fetuses) and problems with the respiratory system in piglets. The agent of PRRS is a positive sense, single-stranded, enveloped RNA virus which belongs to the family *Arteriviridae*. Management strategies to control most viral diseases are mainly vaccination. However, no vaccination has yet proved to be fully efficient to a large scale of PRRS or its spreading (Salguero et al., 2015).

3.1.3.3 Exudative epidermitis

Exudative epidermitis (greasy pig disease) is caused by pathogenic strains of *Staphylococci*. The disease is contagious and affects the skin. Exudative epidermitis is most common seen in suckling and recently weaned piglets as a peracute or acute infection whereas in adult pigs a chronic infection may occur (Sato et al., 1990). In piglets, the disease develops as a generalized form of exudative epidermitis which in a few days may result in death due to dehydration. The causative agent is usually *Staphylococcus hyicus* which have the ability to produce secretory exfoliative toxins (Andresen et al., 1993).

3.1.4 Other reasons

3.1.4.1 Sow parity number

A large mobilization of body reserves occurs during lactation. This mobilization is more palpable in first parity sows since their development is still ongoing. Piglets from multiparous sows have higher birth weight compared to piglets from primiparous sows (Carney-Hinkle et al., 2013). Multiparous sows also produce more milk and wean heavier piglets (Beyer et al., 2007). Furthermore, sows in parities higher than six have a significantly higher risk for stillborn fetus, compared to sows in their first parities (KilBride et al., 2012).

3.1.4.2 Farrowing crates

The aim of developing farrowing crates was to improve piglet survival and increase production efficiency. Management and supervision of individual piglets and sows is easier achieved using farrowing crates. However, these benefits compromises and affect the sow welfare since she cannot move around freely. The sow's pre-farrowing behavior of nest building is limited when housing sows in crates (Wischner et al., 2009). The sow may experience stress and perform unnatural behavior due to the crates restrictions (Damm et al., 2003).

One of the most important indicators of the lactation period is the piglet survival from birth to weaning (Baxter et al., 2011). Previous research has shown different results regarding piglet survival when using crates compared to pens. Blackshaw et al. (1994); Marchant et al. (2000) and Hales et al. (2014) reported a higher pre-weaning mortality in farrowing pens, compared to crates. However, Weber et al. (2007); Pedersen et al. (2011) and KilBride et al. (2012) did not find any significant differences between farrowing crates and pens on the pre-weaning mortality.

3.1.4.3 Season

In a study conducted in Switzerland, Weber et al. (2009) found a significant higher number of crushed piglets during summer (May- Sep) and a lower number of crushed piglets during winter, Dec-Feb. According to Cecchinato et al. (2008) the months have a great impact on piglet mortality. The season may influence with differences in epidemiological, climate and management. Miller et al. (2012) did not found any differences in piglet birth weight during the year, but the season may still have an impact on piglet mortality.

3.1.4.4 Temperature

After farrowing the piglets must find a teat and later reach the creep area. During this time the piglets are exposed to large heat losses, which could be fatal for weak born piglets. Mortalities due to coldness can be reduced by adding heat sources like lamps, floor heating and straw according to Morrison et al. (1983).

At birth the neonatal piglets need an environmental temperature of 32-34 °C, which is closely related to the abdomen sensitiveness. After birth this temperature should be kept for approximately one week. The majority of piglets at 1 day of age choose to rest beside the sow on the cold slatted floor instead of the heated piglet creep area. Consequently, the piglets may strike a low abdomen temperature and hypothermia. Neonatal piglet hypothermia may affect colostrum intake and later diarrhea or sow crushing (Spicer at al., 1985).

3.2 Thermal environment

3.2.1 Heat production

A thermal equilibrium in the body is accomplished through a balance between heat loss and metabolic heat production. Heat production depends on activity level and feed intake and will also be influenced by the ambient temperature in the stable (Henken et al., 1993). The temperature regulation through increased metabolism in the new born piglet is limited during the first time in life, since the metabolism is weakly developed during the embryogenesis (Mount, 1969).

The two main mechanisms of heat production are *shivering* and *non-shivering thermogenesis*. During shivering all the components of skeletal muscle energy metabolism can be involved theoretically. In order for the muscle fibers to produce heat, they need to display (1) an optimal link between excitation and contraction, (2) an optimal influence of contraction, (3) a sufficient source of substrates and oxygen and lastly (4) an effective ATP synthesis (Herpin et al., 2002). When an animal is exposed to cold over time the heat production may be increased through non-shivering thermogenesis, which involves an increased activity of the CNS and an increased excretion of thyroid hormones. Thyroid hormones can develop a slowly increased and prolonged metabolism in most tissues and thereby their heat production (Sjaastad et al., 2010).

Piglets with low birth weight more easily drops in body temperature than heavier piglets. When the piglet is born, it is covered with foetal fluid which partly will dry through evaporation and partly through close contact with the siblings and the sow. If evaporation occurs the skin is further cooled. Additionally, the piloerection will not work efficiently if the skin is wet (Mount, 1963). Cold exposure induces piloerection, vasoconstriction and a slight drop in skin blood flow in hypothermic new born piglets (Williams et al., 1979), but these mechanisms have a rather low impact on insulation (Herpin et al., 2002).

3.2.2 Heat losses

3.2.2.1 Sensible heat loss

Heat loss can be divided into either; *Sensible heat loss* or *latent heat loss*. Sensible heat loss in pigs is influenced by cardiovascular and behavioral adjustments. If these adjustments result in a higher/lower change than required in the heat loss, the opposite adjustment in the other parameter must be expected to sustain homeostasis (Andersen et al., 2008). Sensible heat loss can be defined as the sum of heat lost by convection, conduction and radiation. The heat lost by conduction is mainly vanished to the floor when the pig is lying down, convection heat loss to the air and radiation to different surfaces of the construction (Bruce and Clark, 1979).

The pig can influence the heat lost by conduction through choosing a lying or standing position where pigs use to lay down at high surrounding temperatures. If the ambient temperature is high pigs most likely will seek for a cold place to lie down. The coolest place to lie down in modern housing systems is the slatted floor. Thermal resistance of the tissue and skin also influence the heat lost by conduction, which is a physiological autonomous process. The temperature difference between the skin and air is mainly influencing heat loss by convection. Also, the total skin area exposed to the air and air velocity impacts. Furthermore, the ambient temperature, thermal resistance and air velocity affects the skin temperature. The pigs can reduce the skin area exposed to the air by contact with other pigs. Primarily the radiative heat loss depends on the differences in temperature between the skin of the pig and surrounding construction. If the ambient temperature is high pigs try to increase the distance to the other pigs in order to increase radiative and convective heat loss, which also might be the case in conductive heat loss (Bruce and Clark, 1979).

3.2.2.2 Latent heat loss

If the temperature increases, the sensible heat loss decrease and the latent heat loss increase. It is also shown in different studies that if the feed intake increase and total heat production decrease the latent or evaporate heat loss will increase. At high ambient temperature pigs lack active sweat glands. The major mechanism for pigs to lose heat is through evaporative heat loss (Morrison and Mount, 1971). Evaporative heat loss can be increased through increased respiration rate, for example by panting. Heat can also evaporate at a rapid rate if the skin is wet (Ingman, 1965), e.g. mud bathing (Hacker et al., 1994). In confinement pigs are largely dependent on respiratory heat loss at high ambient temperatures as well as wallowing in their own urine (Ingman, 1965).

3.2.3 Thermoregulation

If the thermal need of the piglet is not satisfied, it might lead to welfare problems or even death (Hillmann et al., 2001). The body has two centers located in the hypothalamus which acts as a thermostat. There are thermosensors (temperature sensitive sensory neurons) in the body core and skin with information which the thermoregulatory center compares. The thermosensors in the skin are specific sensitive to changes in skin temperature. If the frequency of nerve impulses in the sensors changes, it will initiate a reflex mechanism that either affect heat production or heat loss in order to accomplish a normal body temperature. The thermoregulatory center in the hypothalamus is build up by groups of neurons with different locations inside the hypothalamus. In the anterior part of hypothalamus, a heat-loss center exists. If this center is activated cutaneous blood vessels will dilute and it will also induce panting. The heat production center is located in the hypothalamus posterior part and if this center is activated it will result in peripheral vasoconstriction, erection of hairs and shivering (Sjaastad et al., 2010).

Neonatal pigs will partly be dependent of muscular thermogenesis like shivering which gradually will be improved during the first 5 days in life. After birth behavioural thermoregulation will develop which includes huddling with siblings and seeking after warm places (Berthon et al., 1994). A reduction of heat loss through peripheral vasoconstriction may be the case in neonatal pigs (English and Morrison, 1984), but piloerection is probably ineffective since the piglets are born with poor hair coverage. The lack of brown adipose tissue and low amounts of mobile glycogen/lipids reserves for metabolic heat production results in a poor insulation and thermoregulative ability (Herpin et al., 2002).

Figure 1 shows a broad model of thermoregulation applied on pigs formulated by Mount (1979). The model is based upon a certain feed level intake. The pigs can keep their body temperature constant within the zone A-D. Surrounding temperature below A gives the effect of a temperature drop, in contrast to above D where the body temperature increases. By regulation of the heat production the body temperature is kept constant within the zone A-B. Within this zone (A-B) the heat can be produced by either shivering thermogenesis or non-shivering thermogenesis. By regulation of the heat loss the body temperature is kept constant in the zone B-D. Line B is titled the lower critical temperature and line D is called the upper critical temperature. The zone interval B-C is titled the comfort zone (Mount, 1979).

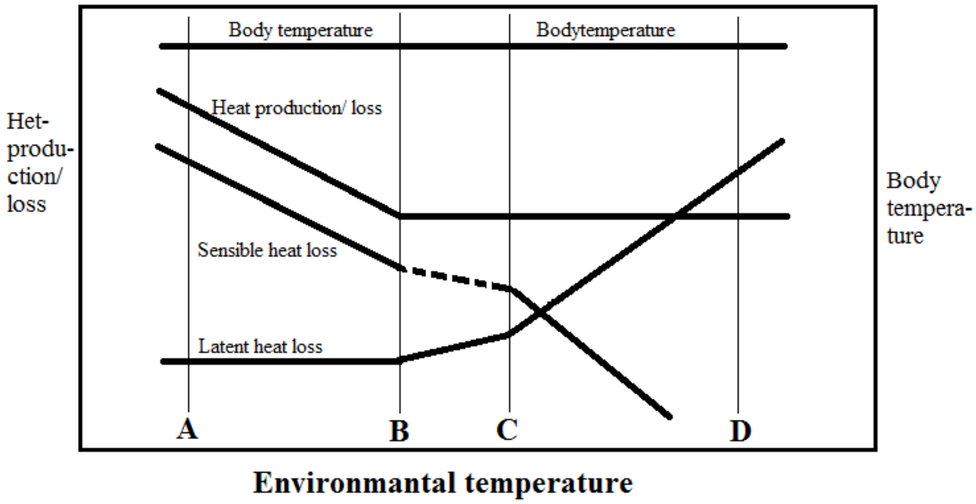

Figure 1. General model of heat regulation in pigs, (after Mount, 1979).
The temperature zones are defined as;
A-B: extra heat needed for a constant body temperature,
B-C: the comfort zone,
B-D: thermoneutral zone,
A-D: the constant body temperature (Mount, 1979).

3.2.4 Thermal comfort and thermal neutral zone

The challenge to measure and maintain thermal comfort in pigs (and other farming animals) has been based on modification and measurements of the ambient temperature in the stable. Today it is rather well-known that the health and welfare of pigs is not only affected by the ambient temperature. Other factors that influence the well-being of the pig is radiation, air draft, humidity, floor condition, group size, nutrition and health state (Bruce and Clark, 1979). Environmental impacts on thermal comfort also includes air velocity, evaporative cooling and insulation level of the building (Mount, 1975). Many caretakers agree to that the best way to assess an optimal environment and thereby well-being of the pigs is to monitor their behavior. When pigs feel cold they huddle, when hot they spread in the pen, when comfortable they nearly touch each other (Mount, 1968).

Normally the temperature in the farrowing units in Sweden is kept at around 20˚C, which is the sows' comfort zone. Therefore, it is necessary to add heat sources to avoid hypothermic piglets (Svendsen & Svendsen, 1997). Baxter (1974) indicated three methods in order to accomplish a good micro climate for piglets; (1) cabins, (2) heat lamps above the lying area and (3) floor heating under the lying area.

The metabolic heat production is the most effective and the energy consumption is minimal when an animal stays in the *thermal neutral zone*. The majority of the processes in the body are most effective when the animal stays in a comfortable climate, where the heat production does not have to change. The thermal neutral zone is restricted to an upper and lower critical temperature limit. Within the limits the heat regulations can be done without any extra energy consumption, but if outside the limits energy is required to keep the body temperature (European Food Safety Authority, 2004).The thermal neutral zone is affected by different factors such as feed intake (colostrum and milk), type of floor, straw, stocking density and also thermal factors in the surrounding environment like radiation and air velocity (Randall, 1993).The piglets' thermal neutral zone is 34-36 ˚C and when the temperature drops below this interval the piglet try to increase it through muscular shivering thermogenesis (Berthon et al., 1994). The piglet also tries to reduce their heat loss by individual and social thermoregulation (Vasdal et al., 2009).

4. Material and Method

4.1 Animal material and housing system

The trial was performed at a conventional farm with piglet production in the south of Sweden. The farm consists of about 130 sows (Yorkshire/Swedish Landrace) with the sire line Hampshire. The stable was built in 1970 but became totally refurbished in 2012. Wet feed is used in all sections. The number of weaned piglets per sow and year reached 24.4 during the year 2016 and the farm goal is to improve the production to 26 piglets. The dry sows are kept on a deep straw bed in a section that is not isolated. When it is time for farrowing, the sow is moved into the farrowing pen which is provided with floor heating. The sows and piglets are held together until weaning, when the piglets are moved to a rearing section with the siblings. Two farrowing sections and three growing sections are present and the breeding material is built up by their own recruitment on the farm.

Figure 2. A sow in temporary confinement (TC) to the left and a sow in a loose system to the right (Foto: Edenfur, 2015).

The herd consists of 7 sow groups (18 sows per group), farrowing every 22^{nd} week (3-3-3-4-3-3-3-week interval), with a suckling period of 32 days. The two farrowing sections were constructed so that 9 sows were loose and 9 sows were temporary confined (TC) during the time of trial (= at farrowing). The crates for temporary confinement were only used while the sow was farrowing and 2-3 days later. The lamps (kruuse heating lamp, 150 W) were placed 25-30 cm above the floor. In the loose system, the lamps were placed in the piglet corner and in the TC system the lamps were placed behind the confined sow where the piglets were born. When the sows in the TC system was finished farrowing, the heating lamp was replaced back into the piglet corner.

4.2 Experimental design

The study was performed in October 2015 – February 2016 during five farrowing batches. Fifty-one newborn pigs from 13 different sows were followed from birth to 2 hours and 45 minutes after birth in the farrowing batches. During this time both rectal and skin temperature was registered (every 15th minute = 12 measurements) for every piglet involved in the study. When a piglet was born, the body and skin temperature immediately was measured and the recordings started every time the animal keeper noticed that a sow was about to give birth, everything was prepared. Marking crayons with different colors for marking the piglets were used. The first piglet got the color blue, 2nd piglet red and 3rd piglet green. If more than three piglets were followed from the same sow, color combinations were used and different marking combinations such as dots and stripes with the crayons.

Body temperature thermometer (Kruuse rectal thermometer ~30˚C ~ 50˚C), skin thermometer (Dibotech infrared thermometer ~50˚C ~ 500˚C) and a protocol were used. The measuring instruments were used without touching the piglets, except for the tail in order to affect the results as less as possible. The body temperature was measured in the rectum and the skin temperature at the caudal part of the back of every piglet (dorsal) with an infrared thermometer. The infrared thermometer was measured at a distance of approximately 5-10 cm between the instrument and skin. The skin temperature was taken on all piglets involved in the study, but in order to limit the work only the skin temperatures was compared with the rectal temperatures of the piglets born in the TC system.

4.2.1 Farrowing system and piglet weight

All the piglets, from TC and loose sows, used in the trial were registered in a protocol. In order to investigate if there were any differences between the systems (TC or loose) it was registered in the protocol what system the piglet was born in. Week of birth and the sow number was also written down in the protocol.

When temperature measurements were finished, the piglet was weighed in order to influence the result during the trial as little as possible. The piglets were divided into three different weight groups; Small (<1 kg), Medium (1-1.5 kg) and Large (>1.5 kg), which also was registered in the protocol.

4.2.2 Floor type

The floor type, where the piglet was born, which either could be on cast iron or concrete, was also marked down in the protocol. In the TC system, the sows were confined in a way that makes them farrow on cast iron (figure 2). In the loose system, the sows could choose between concrete and cast iron.

4.2.3 Straw

The amount of straw behind the sow (= the birth place of the piglet) was examined for every newborn piglet used in the trial. Approximately one square meter behind the sow (where the new born piglet fell out) was examined with respect to the amount of straw. Based on eye measurements three different amount levels of straw were used (little, average and a lot). The amount of straw was considered as 'little' if less than half of the floor area was covered with straw behind the sow, if more than half of the floor area was covered with straw behind the sow, the amount of straw was considered as 'a lot'. Between these two extremes the term 'average' amount of straw was used.

In order to see how the piglet temperature is affected by the amount of straw in the birth place a small comparison was made. The comparison included in total six piglets with relatively similar conditions. All six piglets were born in a loose system and the weight class was medium for all of them (1-1.5 kg). Three piglets with a little amount of straw and three piglets with average or a lot of straw were compared. All six piglets in this comparison were born on the concrete floor without heat lamp.

4.2.4 Heating lamp

Under or not under the heating lamp was also written down in the protocol individually for every piglet and every occasion of temperature measurement in the trial. If the piglet showed up under the heating lamp it was marked in the protocol with a star. For example, see table 2. This piglet was not under the heating lamp during the first measurements (rectal temperature 1 and skin temperature 1) but during the second and third measurements it was.

A small comparison was also made to investigate the effect of piglets contact to the heating lamp. This comparison also included 10 piglets with similar conditions (large piglets born in a TC system). Two piglets with contact to the heating lamp were compared to eight other piglets with no contact to the heating lamp during the three first registrations after birth.

Table 2. An illustration of the protocol. Sow number, system (TC or loose), piglet weight, type of floor (concrete or cast iron) and amount of straw. If the piglet had any contact to the heating lamp during the trial it was marked with a star in the protocol at the time of temperature measuring. Rectal temperature (Rec) and skin temperature (Skin) number 1 that was taken immediately after birth. Next temperature measurement (number 2) was taken 15 minutes later and so on. In total 24 temperature measurements was taken for every piglet (12 rectal temperatures and 12 skin temperatures) which is not shown in this table

Sow number	System	Piglet weight	Floor type	Straw	Rec 1	Skin 1	Rec 2	Skin 2	Rec 3	Skin 3
117	loose	1.2 kg	concrete	little	39.1	32.1	36.9*	33.0*	37.1*	33.7*

4.3 Analysis of data

The data collected was compiled with Microsoft Excel and by using the programme Minitab, t-tests has been done. The data used was exported into the Minitab worksheet which came from the previous compiled data in Excel.

5. Results

In table 3 an overview is presented of farrowing system, piglet weight group and farrowing batch for the piglets.

Table 3. All piglets used in the trial during the year 2015-2016 divided into the three different weight groups. The measurements were taken during five batches according to the description below

Batch (week)	Total number of piglets studied	Number of Large piglets (>1.5 kg)		Number of Medium piglets (1-1.5 kg)		Number of Small piglets (<1 kg)	
		TC	**Loose**	**TC**	**Loose**	**TC**	**Loose**
1 (42)	1	0	0	0	1	0	0
2 (45)	13	6	0	3	2	1	1
3 (49)	19	3	1	7	4	2	2
4 (5)	16	0	9	0	7	0	0
5 (8)	2	2	0	0	0	0	0
∑	**51**	**11**	**10**	**10**	**14**	**3**	**3**

Some of the piglets used in the study were born by the same sow. The distribution of the piglets and sows is viewed in table 4 below.

Table 4. Number of sows used in the study and how many piglets included in the study the sows gave birth to. The number of piglets studied is further divided into the three weight groups. For example, the sow with number 189 gave birth to three piglets and two of them were in the weight group medium and one small

Sow number	Week	Total number of piglets studied	Number of Large piglets (>1.5 kg)	Number of Medium piglets (1-1.5 kg)	Number of Small piglets (<1 kg)
39	42	1	0	1	0
3186-8	45	4	0	3	1
3147-8	45	3	3	0	0
53-4	45	3	3	0	0
52-4	45	4	1	2	1
115	49	1	0	0	1
189	49	3	0	2	1
136	49	3	2	1	0
159	49	8	0	6	2
1	49	3	1	2	0
117	5	11	4	7	0
122	5	5	5	0	0
213	8	2	2	0	0
∑	**-**	**51**	**21**	**24**	**6**

5.1 Farrowing system and piglet weight

5.1.1 Small piglets

The effect on piglet body temperature of six small piglets in a TC versus a loose system is shown in the figure below (figure 3). Small piglets born in the loose system did not even reach 36.5 degrees during the whole time of trial after the temperature drop. The rectal temperature of small piglets born in the loose system started to increase after about two hours which is more than one hour later compared to medium and large piglets.

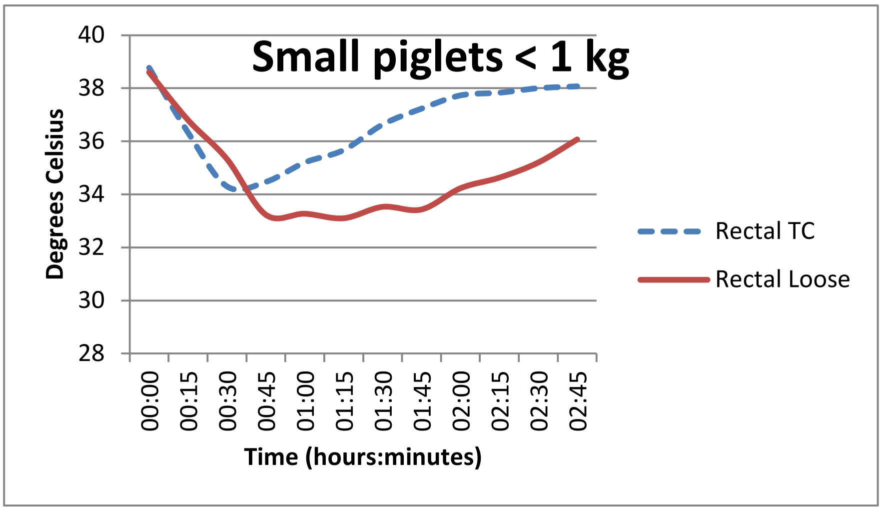

Figure 3. Rectal temperature of small piglets (< 1 kg) born in the two different systems (TC or loose). The temperature measurement in the TC system is based on three piglets and the temperature measurement in the loose system is also based on three piglets.

Table 5. The mean value for each measurement of small piglets born in the TC system and loose system

Small piglets	***Rectal temperature TC Degrees Celsius***	***Rectal temperature Loose Degrees Celsius***	***P-value***
No. piglets	*3*	*3*	
Time after birth			
00:00	*38.8*	*38.6*	*0.73*
00:15	*36.3*	*36.8*	*0.72*
00:30	*34.3*	*35.3*	*0.33*
00:45	*34.5*	*33.2*	*0.22*
01:00	*35.3*	*33.3*	*0.08*
01:15	*35.7*	*33.1*	*0.04**
01:30	*36.6*	*33.5*	*0.01**
01:45	*37.2*	*33.4*	*0.002***
02:00	*37.7*	*34.2*	*0.001***
02:15	*37.8*	*34.6*	*0.002***
02:30	*38.0*	*35.2*	*0.04**
02:45	*38.1*	*36.1*	*0.02**

A comparison between rectal and skin temperature was made for pigs in the TC system (three pigs). The rectal temperature followed the skin temperature and vice versa. The temperature drop for skin occurred about 15 minutes before the rectal temperature drop. The lowest skin temperature measured for small piglets was 29 degrees, see figure 4. At most the rectal and skin temperature differed seven degrees.

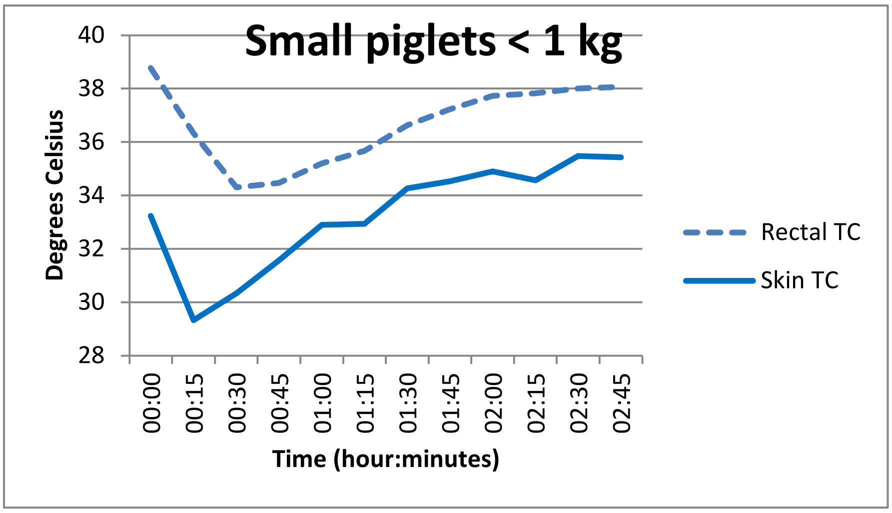

Figure 4. Rectal and skin temperature of small piglets (< 1 kg) born in the TC system. The figure covers measurements of in total three piglets.

5.1.2 Medium piglets

Medium piglets (1-1.5 kg) displayed a higher temperature and a smaller temperature drop than small piglets (<1 kg). The temperature drop occurred about 30 minutes after birth and reached a minimum of 35.5 degrees in the TC system and 36.6 in the loose system, see figure 5.

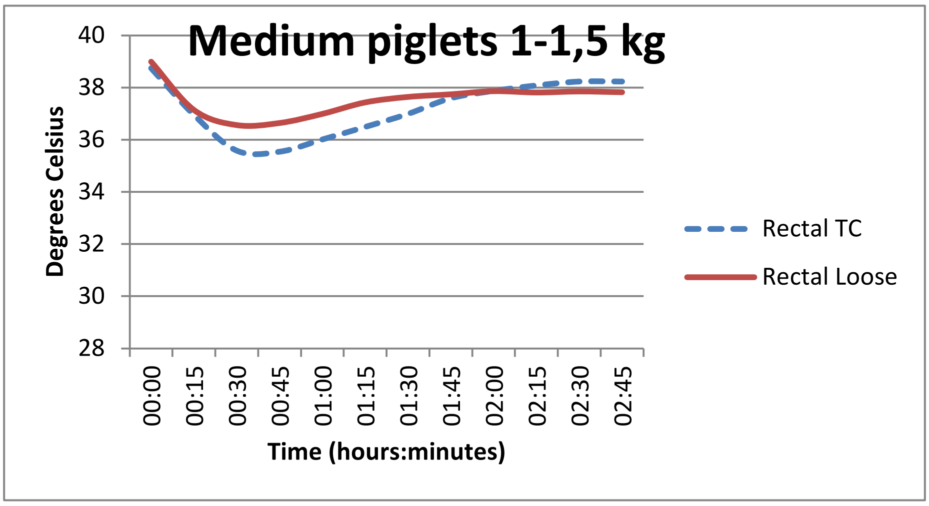

Figure 5. Rectal temperature of medium piglets (1-1.5 kg) born in the different systems (TC or loose). The temperature measurements in the TC system are based on 10 piglets and the measurements in the loose system are based on 14 piglets.

Table 6. The mean value for each measurement of medium piglets born in the TC system and loose system

Medium piglets	*Rectal temperature TC Degrees Celsius*	*Rectal temperature Loose Degrees Celsius*	*P-value*
No. piglets	*10*	*14*	
Time after birth			
00:00	*38.7*	*38.9*	*0.21*
00:15	*36.9*	*37.1*	*0.47*
00:30	*35.6*	*36.6*	*0.02**
00:45	*35.5*	*36.6*	*0.12*
01:00	*36.0*	*37.0*	*0.16*
01:15	*36.5*	*37.4*	*0.19*
01:30	*37.0*	*37.6*	*0.31*
01:45	*37.6*	*37.7*	*0.77*
02:00	*37.9*	*37.9*	*0.98*
02:15	*38.1*	*37.8*	*0.48*
02:30	*38.2*	*37.8*	*0.28*
02:45	*38.2*	*37.8*	*0.16*

The skin temperature differed about 5.5 degrees as most compared to the rectal temperature and the lowest measured temperature reached 30 degrees for medium piglets born in the TC system (see figure 6). The temperature drop occurred 15 minutes (skin temperature) and 30 minutes (rectal temperature) after birth.

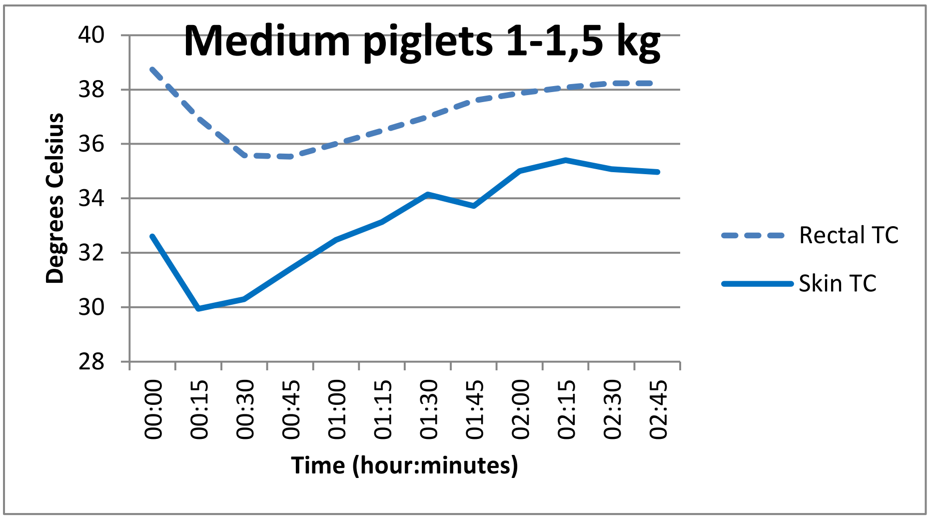

Figure 6. Rectal and skin temperature of medium piglets (1 – 1.5 kg) born in the TC system. The figure covers measurements of in total 10 piglets.

5.1.3 Large piglets

Large piglets (> 1.5 kg) exhibit a higher temperature and a smaller temperature drop than small piglets (<1 kg). Figure 7 below, shows a difference where the piglets born in the TC system dropped more in rectal temperature. This relation between the farrowing systems was the same as found for medium piglets (figure 5).

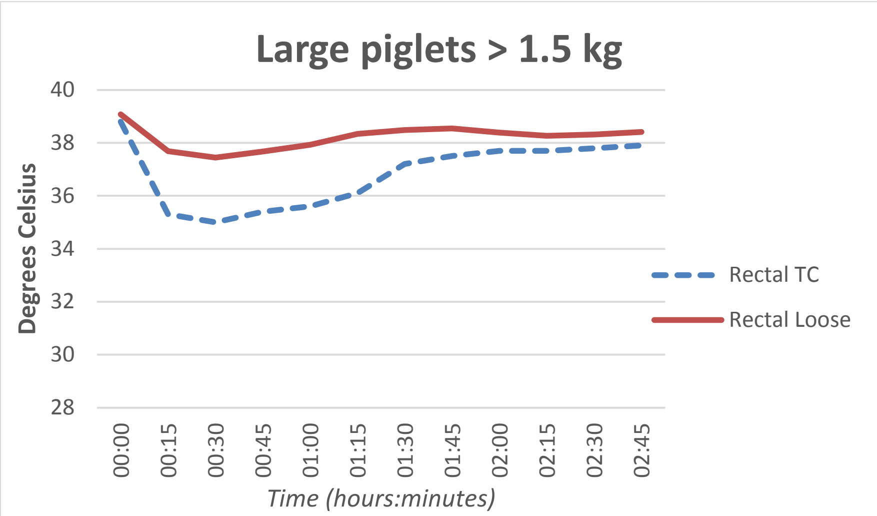

Figure 7. Rectal temperature of large piglets (> 1.5 kg) born in the two different systems (TC or loose). The temperature in the TC system is based on 11 piglets and the temperature in the loose system is based on 10 piglets.

Table 7. The mean value for each measurement of large piglets born in the TC system and loose system

Large piglets	***Rectal temperature TC Degrees Celsius***	***Rectal temperature Loose Degrees Celsius***	***P-value***
No. piglets	*11*	*10*	
Time after birth			
00:00	*38.8*	*39.1*	*0.149*
00:15	*35.3*	*37.7*	*0.001****
00:30	*35.0*	*37.4*	*0.000****
00:45	*35.4*	*37.7*	*0.000****
01:00	*35.6*	*38.0*	*0.000****
01:15	*36.1*	*38.3*	*0.000****
01:30	*37.2*	*38.5*	*0.000****
01:45	*37.5*	*38.6*	*0.000****
02:00	*37.7*	*38.4*	*0.124*
02:15	*37.7*	*38.3*	*0.123*
02:30	*37.8*	*38.3*	*0.103*
02:45	*37.9*	*38.4*	*0.008***

For the large piglets, the skin temperature dropped to 31 degrees' which occurred about 15 minutes after birth, see figure 8. The rectal temperature dropped at the same time. When comparing the rectal and skin temperature for small and medium piglets, the difference tends to be approximal 3-6 degrees lower for the skin temperature. When comparing the rectal temperature and skin temperature the difference was about four degrees for large piglets.

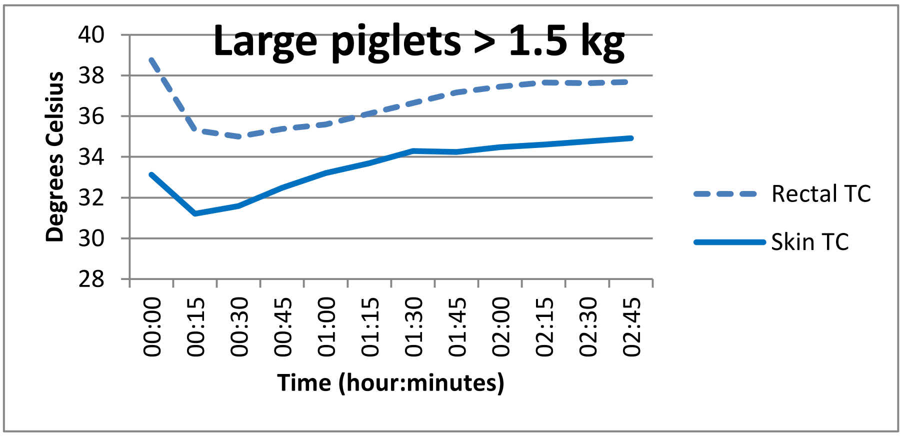

Figure 8. Rectal and skin temperature of large piglets (> 1.5 kg) born in the TC system. The figure covers measurements of in total 11 piglets.

5.2 Floor type

A diagram that shows the differences if the piglet was born on concrete or cast iron in the different farrowing systems was not an option since all piglets in the TC system were born on cast iron. In the loose system 11 percent of the piglets were born on cast iron (89 percent on concrete) in contrast to the TC system where 100 percent was born on cast iron. In December 2015, different floor temperatures were taken inside the farrowing pens, see table 8.

Table 8. Different temperatures were measured on floors (2015-12-03) in the stable by using the infra-red-thermometer

Location	Temperature
Cast iron without lamp and straw	15 ˚C
Cast iron without lamp but with straw	17 ˚C
Cast iron under the lamp without straw	21 ˚C
Concrete with floor heating without lamp and straw	25.5 ˚C
Concrete with floor heating and straw under the lamp	27.5 ˚C

5.3 Straw

Even though the care taker gave lots of straw under the lamp just before farrowing in the TC system, the number of piglets born on a lot of straw was low. The sow usually moves a lot with her legs before and during the farrowing, which resulted in less straw close to her (see figure 9). About one square meter behind the sow was examined with respect to the amount of straw, based on eye measurement. The amount of straw was considered as ‘little’ if less than half of the floor area was covered with straw behind the sow, if more than half of the floor area was covered with straw behind the sow, the amount of straw was considered as ‘a lot’. Between these two extremes the term ‘average’ amount of straw was used.

Figure 9. The amount of straw behind the TC sows was usually poor due to the sows' movements (Foto: Edenfur).

In the TC system 87 percent were born on a little amount of straw, and 13 percent were born with an average amount of straw. No piglet in the TC system was born on a lot of straw. In the loose system 74 percent were born on a little amount of straw, 11 percent were born on an average amount of straw and 15 percent were born on a lot of straw.

Figure 10 on the next page shows the rectal temperature of piglets with different amounts of straw. The data sets compared was 'a little amount of straw' versus a 'lot of straw'. The temperature drop was higher (about one degree) if the piglets were born on a little amount of straw.

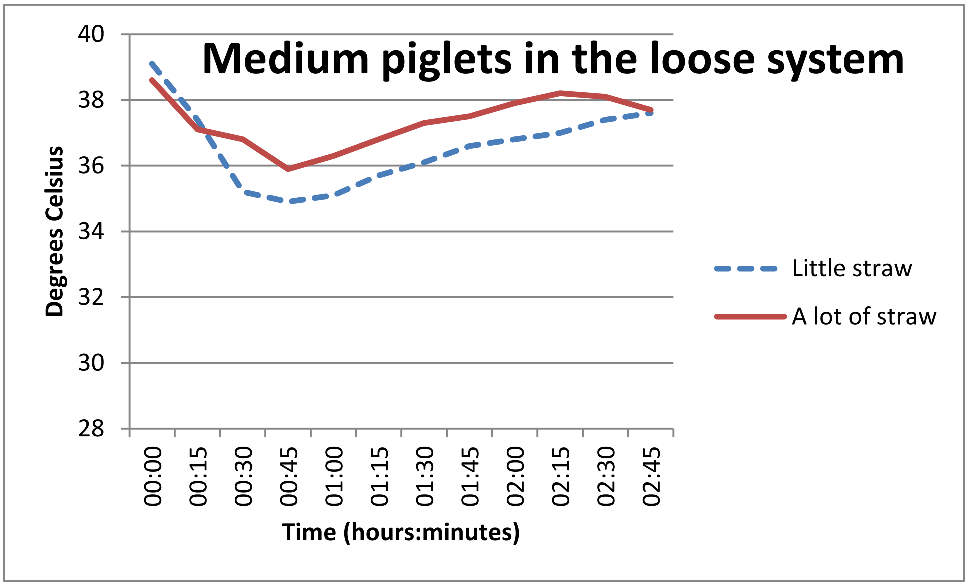

Figure 10. Rectal temperature of medium piglets (1-1.5 kg) born in the loose system with little straw or a lot of straw. Three piglets for each data set were involved. The floor type was concrete for all piglets.

5.4 Heating lamp

Fourteen percent of all the piglets stayed under the heating lamp at least at one time of the 12 temperature measurements (from TC and loose systems). Piglets born in the loose system that stayed under the heating lamp at least one time was 14.8 percent, while 12.5 percent of the piglets born in the TC system stayed under the lamp at least one time, see table 9. Usually the smallest piglets stayed under the lamp more often. Piglets in the loose system that had contact to the heating lamp had varying weights and they did not stay under the lamp as long as the piglets born in the TC system. This is why the loose system is not involved in this investigation.

Table 9. Number and percentage of piglets with contact to the heating lamp in the two farrowing systems

System	Total number piglets studied	Contact to lamp	No. of pigs	Percentage
TC	24	Yes	3	12.5
		No	21	87.5
Loose	27	Yes	4	14.8
		No	23	85.2

A comparison of how the heating lamp may influence the rectal temperature was made within large piglets in the TC system (figure 11). Since a small number of piglets stayed under the lamp the number of large piglets within this group was very low (only three piglets). All the piglets in this trial were born on cast iron. However, piglets which did not stay under the heating lamp dropped to 34.8 degrees and piglets with contact to the heating lamp dropped as most to 35.3 degrees. Both groups did increase their body temperature at the end to about 38-38.5 degrees.

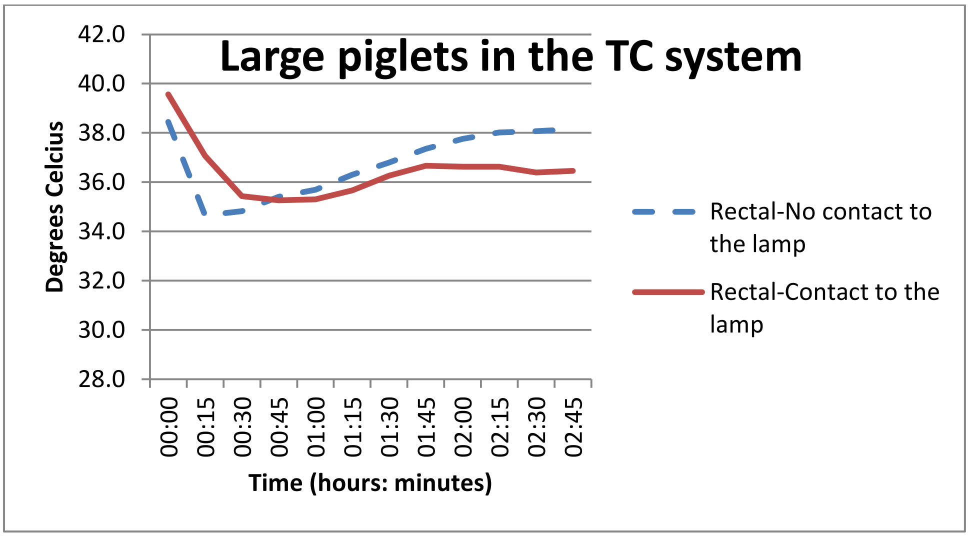

Figure 11. Rectal temperature of large piglets (> 1.5 kg) born in the TC system. Either no contact at all to the heating lamp (no lamp) or contact to the heating lamp during the time of experiment (lamp). Three piglets in the data set “lamp” and eight piglets in the data set “no lamp”.

6. Discussion

The total number of piglets studied was 51, with an especially low number of small piglets (6 piglets), see table 4, were a higher amount of data would be desirable. The measurements in different farrowing systems and weight groups were not made in parallel since it was impossible to know when the piglets would be born and what weight group they will have. This means for example that in batch number four no large piglet was born in the TC system whereas six large piglets were born in the TC system in batch number two. This makes the comparisons more complicated since surrounding environmental impacts might differ between batches and influence the results.

Another factor that is needed to take into consideration is the sows, see table 4. In total 13 sows were included in the study. In batch number three the sow with number 115 did not give birth to any medium piglet and in batch number four the sow with number 117 gave birth to seven medium piglets included in the study. It might be the case that one sow give birth to a special type of piglets, for example only weak piglets versus only vital piglets with good health status. Piglets in the small weight group were born from five different sows, whereas piglets in the large weight group were born by eight different sows. Differences between sows might include factors such as parity number, genetics, disease etc., which may influence the condition of the piglet.

In the results, it was found that the rectal temperature decreased during the first 15 minutes after birth in order to increase again after a while, which also was found by Mount (1963). As mentioned before this temperature drop depends on different concurrent factors. For example, the piglet is born with poorly developed heat insolation and the ability to generate heat through metabolism is limited. The piglets need time to adapt the body to the new environment outside the uterus before they react fast enough to new impressions such as coldness (Mount, 1969).

The skin temperature was compared with the rectal temperature for piglets born in the TC system. The choice of only using the TC system when comparing the skin and rectal temperature, was a matter of limiting the work. The skin temperature was taken on every piglet behind the back. The skin temperature was shown to follow the rectal temperature, which means when the rectal temperature drops so does the skin temperature, often the skin temperature tend to decrease first. Both the rectal and skin temperature drops about 15-30 minutes after birth. The skin temperature was lower than the rectal temperature and the difference varied between 3-6 degrees. This relatively large variation might depend on failure in using the skin thermometer consistently, i.e. too long distance between the thermometer and the skin or reading the thermometer before it is finished. Another explanation could be that details in the local environment influence the difference between the rectal and skin temperature, for example if the piglet is exposed to a certain heat source like floor heating and/or heating lamp. It was also shown that the skin temperature drop decreased one degree for each weight group e.g. lowest measured temperature for large piglets was 31 degrees, 30 degrees for medium piglets and 29 degrees for small piglets. This might indicate that the weight intervals were well selected and will be suitable for future trials. It would be interesting with further research to investigate if the skin thermometer could be a new tool to examine the body temperature of pigs.

6.2 Farrowing system and piglet weight

Today the use of TC system is not allowed in Sweden but has been used for research purposes. According to the personal opinion of Ida Berglund, animal care taker in the herd, advantages do exist with the TC system. For example, the sow is easier to handle in the TC system. However, Ida also claimed that the quantity of infants stuck in the sows was a larger problem in the TC than in the loose system. Ida claims that sows sometimes need to move around in order to minimize the risk of stuck infants.

6.2.1 Small piglets

Small piglets did drop more in rectal temperature than medium and large piglets. Svendsen (1982) showed that weakly born (often small) piglets have a disturbed organ development and function. The reduced ability to regulate body temperature during the natal period is probably a result of this disturbed organ development. Another ability that is negatively affected is locomotion. A reduced locomotion prevents the newborn piglet to immediately start to look for a teat. Instead they stay behind the sow in the amniotic fluid, which most likely make the piglet further cooled. As a consequence, small piglets have a higher mortality rate than normal pigs.

In order to work for a higher piglet survival during the first days, one way would be special treatment of weak piglets with low birth weight (or piglets with other obvious problems such as splayed legs). For example, by drying them with towels and helping the piglets forward to a teat. This is not viable for all weak piglets in all farms, but it is an easy way that might help some piglets to survive. Another way is split-litter suckling, which could be useful in large litters where half the litter is confined under the heat lamp so that the other half can suckle without teat competition. The piglets are forced to stay under the heating lamp and the body temperature will most likely increase and maybe make it easier for the piglet to suckle later.

In contrast to the other weight groups the small piglets born in the TC system increased their body temperature faster than piglets born in the loose system. Small piglets born in the loose system did not even reach preferable temperature levels during the whole time of trial (about three hours). Explaining this contradictory result compared to “normal” pigs is not easy and gives rise to some uncertain hypotheses. One comment is that the number of small piglets in the study was very low. Only three small piglets in each system were born during the trial. Since not all small pigs have reduced vitality and a disturbed organ development, one explanation might be that the small pigs born in the TC system by chance were more vital than the small pigs born in the loose system. A larger number of piglets in all weight groups would be desirable and advices for future trials could be a larger farm with more farrowing sows and perhaps collaboration with more than one data collector.

6.2.2 Large and medium piglets

In the investigation, large and medium piglets kept a higher body temperature in the loose system. Large and medium piglets born in the TC system lost about one degree Celsius more than large and medium piglets in the loose system did. When a piglet is born in the TC system, they are born on the cast iron, most likely without straw. Probably cold air comes up through the cast iron and cast iron leads away heat faster than concrete. It was concluded that large piglets, born in the loose farrowing system had the most optimal body temperature development after birth (= lowest drop in body temperature).

6.3 Floor type

The floor in the farrowing pens is partly cast iron and partly concrete. All piglets in the TC system were born on cast iron and almost all piglets in the loose system were born on concrete, except for three piglets. This could be the reason why piglets born in the TC system tend to drop more in temperature. Table 8, which illustrates the temperatures on the two floor types, shows that if a piglet is born on concrete the floor temperature is about 25 degrees in contrast to the cast iron which only reaches 15 degrees.

Perhaps the differences between crates and loose system would not be that large if the piglets in the TC system were born on concrete and not cast iron. A perforated rubber math behind the sow might affect the piglet temperature in a positive direction. If a comparison between these two systems will be repeated in future research, a strong recommendation is to correct the floor type behind the sow so that it will be comparable to the floor temperature in the other system.

6.4 Straw

Few piglets were born on a lot of straw. Even if the care taker gave a lot of straw behind the TC sow right before farrowing, the sow would most likely remove it with her legs while farrowing. In the TC system, 87 percent of the piglets were born on a little amount of straw and 74 percent in the loose system were born on a little amount of straw. A comparison between piglets born with a little or a lot of straw has been made. Figure 9 shows a slight difference where piglets born on a little amount of straw decreased about one degree more than pigs born on a lot of straw. A solution could be a rubber carpet behind the TC sow.

6.5 Heating lamp

A lower number of piglets than expected stayed under the lamp in the TC and loose system. Almost no piglet was born directly under the lamp, 12.5 percent of the piglets in the TC system and 14.8 percent of the piglets in the loose system stayed under the lamp at least one time during the study. Piglets, that did not search for teats and/or stayed under the heating lamp rather than searching for teats and milk, were often weak and small.

A comparison of how the heating lamp affects the body temperature of the piglets has been summarized in figure 11. The weight group used in this trial was large piglets, since most of the piglets with contact to the heating lamp during the first time in life were large. All piglets used in this investigation were born in the TC system. Three piglets were included in the data set “contact to the heating lamp” and eight piglets were included in the data set “no contact to the heating lamp”. The outcome showed that the piglets with “contact to the heating lamp” increased their body temperature faster than the other group. Further on, both groups reached 38- 38.5 degrees Celcius at the end of measurement and overall the differences were rather small. This might depend on the chosen weight group, since large piglets usually are more vital and well developed compared to small born piglets. A future investigation on how the heating lamp might affect small and weak born piglets would be interesting.

If the sow’s space within the confinement stall in the TC system would be shorter maybe a higher quantity of piglets would be born under the lamp. The problem in this scenario would be the impaired welfare of the sow because of less space. But on the other hand, the sows where only confined for 2-3 days. It would also be interesting to see if a lamp, which emits more energy/heat > 150 W could have any impact. Also, a further investigation of the placement of the heating lamp would be interesting. For example, how is the piglet body temperature affected by a different length between the floor and heating lamp, or would it be preferable to place the lamp even more close to the sow in the TC system?

7. Conclusion

Medium (1-1.5 kg) and large (>1.5 kg) piglets did not cope better with their body temperature in the TC system compared to the loose system. Instead it was found that the drop in body temperature was less in medium and large pigs when they were born in the loose farrowing system. For small piglets (< 1 kg) the relation between the farrowing systems was the opposite. However, this could be explained by a limited number of small pigs in total and an uneven distribution of vitality among the small piglets within the systems. The skin temperatures tended to follow the rectal temperatures with a difference of about 3-6 degrees lower than the rectal temperature. The lay-out of the pen was found to affect the piglet temperature. Concrete with floor heating (loose system) resulted in a better outcome compared to cast iron (TC system) in this trial. A well-placed heating lamp, floor heating and an optimal floor are probably key factors for a lower temperature drop in new born piglets. Extra straw also impacts the piglet body temperature since it makes the heat disappear slower.

8. References

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