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Noninvasive thermographic evaluation of the thermal condition of piglets in the first month of life

Evaluación termográfica no invasiva de la condición térmica de lechones el primer mes de vida

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Abstract

In a commercial swine farm located in Zacoalco de Torres, Jalisco, we carried out an experiment to obtain information regarding environmental temperature effects on the performance of 13 litters of piglets during the first twenty eight days. It was used a Fluke® thermograph to obtain temperature images. Hypothesis was it is possible to establish the effect of heat sources trough thermographic images on the response of the litters. The aim was to evaluate the thermal condition of the piglets in the first twenty eight days of life and their performance until weaning. Piglets were F1 crosses (York x Landrace) x Pietrain. Treatments were minimum, maximum, average and central point temperatures. Variables registered were mortality, weaned piglets, weight of the weaned litters, piglets' individual weight and number of lactating days. Contribution is that temperatures in the first week have more influence on mortality, weaned piglets, weight of the weaned litters, piglets' individual weight and number of lactating days, than the ones in the first month.

Thermography, Piglets, Temperature

Resumen

La localidad del estudio fue una granja comercial situada en Zacoalco de Torres, Jalisco. El experimento se diseñó para obtener información sobre el efecto de la temperatura ambiental en el comportamiento de 13 camadas de lechones. Un termógrafo Fluke® obtuvo imágenes de las temperaturas. La hipótesis fue que es posible establecer el efecto del calor en los animales a través de imágenes termográficas. El objetivo fue evaluar la condición térmica de los lechones en los primeros 28 días y su desempeño hasta el destete. Los lechones fueron cruzas F1 de (York x Landrace) x Pietrain. Los tratamientos fueron temperaturas mínima, máxima, media y de punto central. Las variables fueron mortandad, lechones destetados, peso de lechones destetados, peso individual de lechones destetados y días de lactancia. La principal contribución es que las temperaturas los primeros siete días tuvieron mayor influencia en las variables estudiadas, que las temperaturas registradas durante el primer mes de vida.

Termografía, lechones, temperatura

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Introduction

Mexico pork meat production grew 2.2% in the last decade. In 2018, the production was 1.5 million tons, a 3.8% increase (SADER–SIAP, 2018). Pork meat consumption in 2017 was 2.11 million tons. Pork meat is an important source of protein for consumers. There are three categories of swine production systems in Jalisco: intensive, semi-intensive and extensive production. The three production types coexist in Jalisco, although the predominant one is the semi-intensive system. Largest farmers have a vertical integration as they practice artificial insemination, they have processing plants, places of slaughter and sales points. Genetic improvement done in the last two decades led to better productivity and higher feed to meat conversion. The intensive systems have the highest value added. High technology is used in every stage, as well as better racial genotypes, reproduction, nutrition and animal health (Montero-Lopez *et al.*, 2018). The use a non-invasive method to measure temperatures and its effect on the piglets' performance, may contribute to diminish inconvenient manipulation of the animals, and obtain valuable information.

Literature review

Neonatal mortality is frequent in piglets, as they do not have a hair cover, and their subcutaneal fat is scarce in the first days of life. Adequate management of piglets is crucial to reduce mortality in such a fragile stage. In the intrauterine life the piglet have a high and constant temperature. Outside, they do not find these conditions and loses heat due to its thermoregulation inability, hair shortage, and scarce subcutaneal tissue to diminish the heat flux from the blood vessels (Berthon *et al.*, 1994). When the piglets are born, have a narrow thermo neutrality (32ºC-35ºC) (Nielsen, 1997). If the environment is below the rank, they will use additional energy for heating, its growth will cease and they will consume their energy reserves rapidly, risking their lives. Since an evolutive point of view, 20% mortality is acceptable, but modern farms can reduce mortality to 5% (Arey, 1995). In the first hours after birth, piglets require an ideal microclimate to reach the mammaries. It is required to provide additional heat during the first five days, so they can have the necessary temperature (Curtis, 1974).

Hypothermia is the major cause of neonatal mortality in piglets (Tuchschereret *et al.*, 2000; Edwards, 2002). Neonatal pigs with hypothermia are likely to die due to hunger, crushing or diseases (Pedersen *et al.*, 2011). Rectal thermometry is a common assessment of the thermal condition of pigs, but this method could influence the pig performance, and its thermoregulation may be affected. (Kammersgaard *et al*., 2011). A non-invasive accurate method to evaluate the pigs' thermal condition, without individual handling of animals, is of great potential in research and in farm conditions. The base of infrared thermography is the infrared radiation measurement emitted from an object surface. Infrared rays are electromagnetic emissions between the visible radiation and the radio waves, so they are invisible to us, but perceptible in the form of heat through nerve receptors in the skin of the animal (Kammersgaard, *et al.*, 2013).

Thermography measures the corporal surface temperature, which exchanges heat in the surrounding area.

Problem approach

Piglets at birth have a very narrow thermal neutrality, with low critical temperature around 32^{O}-35^{O}C. If they use additional energy to keep warm, it could risk their lives. At birth, it is important to provide the piglets an adequate microclimate so they can reach the mammal glands without cold.

Justification

Survival until weaning is highly related with hypothermia between one or two hours after birth. Inside the uterus there are stable temperatures between 39-40^{O}C, but at birth piglets are in a colder environment. This transition leads to a corporal temperature drop in two to four ^{O}C. Piglets that cannot quickly overcome hypothermia, die because of it and of hunger. Studies on thermic biology allow for progress in the knowledge in the way temperature affects lactating piglets.

Hypothesis

Image thermographic analysis will make it possible to establish the heat sources effect in the response of the piglets the first seven days of life.

General objective

Evaluate the thermic condition of piglets the first 30 days of life, using thermography.

Particular objectives

Analyze the thermographic images of the litters in the maternity area. Measuring the regulatory capacity of the litter. Relate it with the physiological response of the litter.

Materials and methods

Location

The study was carried out in December 2017 to January 2018, in a commercial farm in the Zacoalco de Torres County, state of Jalisco. The farm is a semi-technified one with 230 bellies.

Animals

It was considered 13 litters of (York x Landrace) x Pietrain crosses.

Treatments

Four types of temperatures around the litters during the first 28 days of life: maximum, minimum, average and midpoint.

Studied variables

Four variables were measured in the 13 litters: piglet mortality, number of weaned piglets, litter weight at weaning, and lactating days.

Experimental methodology

A Fluke® thermograph provided thermographic images of the environment around the piglets, from birth to the twenty-eighth day. Images were recorded in three daily periods. The Fluke® software was used for image analysis. Maximum, minimum, mean and mid-point temperatures were obtained from the upper section of the animals.

Experimental design

Randomized complete blocks. Main source of variation was the litters' temperatures. The means comparison method was Tukey procedure (Steel and Torrie, 1960).

Results

Temperatures

Table 1 shows result of statistical analysis of four different temperatures around or above the piglets. All four temperature measurements resulted significant ($p \leq 0.05$). Graph 1 contains four images related to the daily temperatures recorded in the 13 litters during the first 28 days. It can be noticed in the first week all temperatures are pretty close, but from the second week onwards, they split in a very strong way. Graph 2, also with four images, illustrates changes in temperatures throughout the first four weeks and its influence on the productive variables of 13 litters. Table 2 contains results of multiple regression analysis. It can be observed all determination coefficients are low; only piglet mortality and lactating days had $R^2 > 0.20$. This table also contains the summary of the regression equations calculated for the temperatures and the observations made on the litters.

Figure 1 Piglets' thermographic image at 7 days

Source of varia-tion	Ms Minimum tempera-ture	Ms mean tempera-ture
Litters	1384.35*	5003.47*
Days	116.06*	598.69*
Vc%	24.13	20.68
Source of varia-tion	**Ms Maximum tempera-ture**	**Ms Midpoint tempera-ture**
Litters	4585.60*	1642.47*
Days	465.52*	7.43*
Vc%	19.31	15.6

*Significant $p \leq 0.05$

Table 1 Environmental temperatures mean squares in litters during the first 28 days

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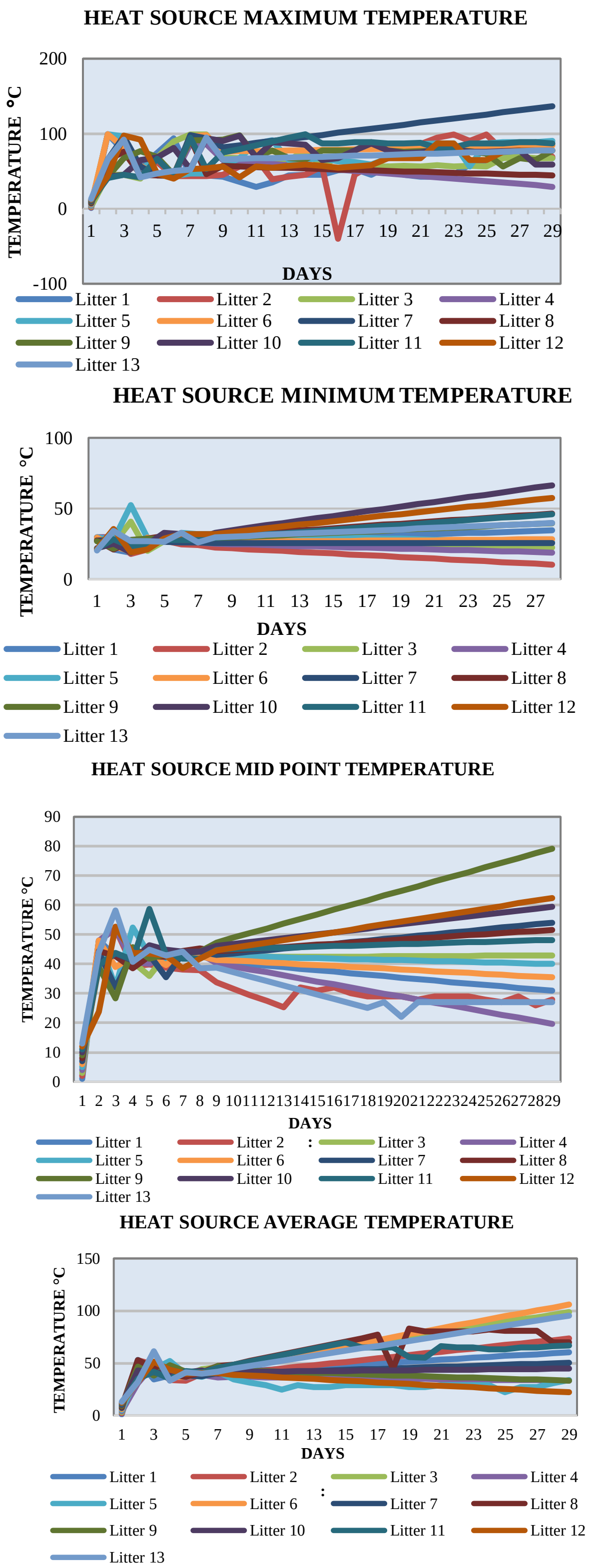
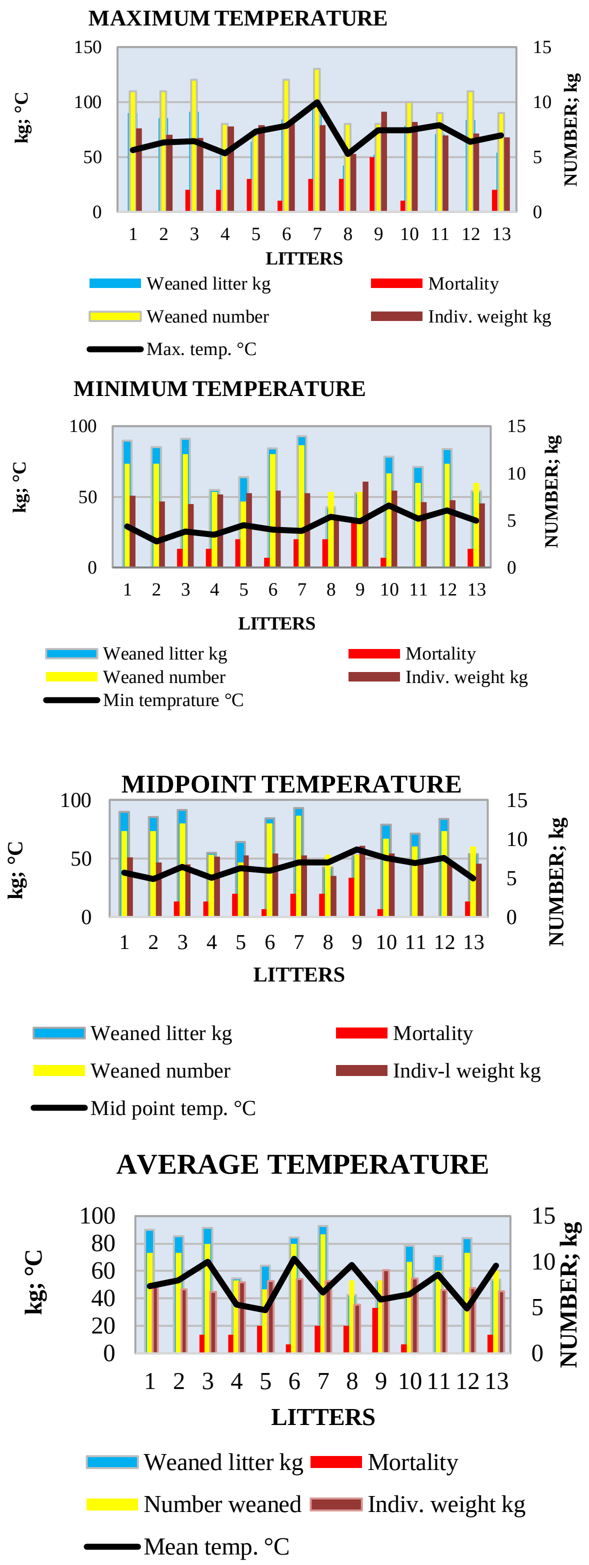


Graphic 1 Four images containing daily different measurements of temperatures recorded in 13 litters in the first 28 days



Graphic 2 Four images containing the influence of four different temperatures on 13 litters' production traits

MULTIPLE REGRESSION EQUATIONS $\hat{y}$ = a+b1(x)+b2(x)+b3(x)+b4(x)
Mortality number: R^2 = 0.2332
$\hat{y}$ = 0.7980-0.0349-0.0349-0.0615+0.0513
Weaned litter weight: R^2 = 0.0672
$\hat{y}$ = 55.5328-0.0673+0.0101+0.0648-0.0460
Weaned piglets' number: R^2 = 0.0167
$\hat{y}$ = 10.8418-0.0083+0.0270-0.0369+0.0002
Lactating days: R^2 = 0.2193
$\hat{y}$ = 34.1419-0.0486+0.0101+0.0648-0.0460
Individual weight of weaned piglets: R^2 = 0.0167
$\hat{y}$ = 2.3572+0.0100+0.0478-0.0162+0.0533

Table 2 Multiple regression equations between four different temperatures and five traits

Performance of the litters from birth to weaning

In appendix table 4, there are five variables measured in 13 litters, and the ambient temperatures in which they lived 28 days after birth. Litters performance from birth to weaning are in table 3. Determination coefficients values (table 2) correspond to piglet mortality and lactating days and its relation with temperatures (0.233, and 0.219 respectively). In a previous report (Sánchez-Chipres *et al*., 2019) it was found a definite relation between minimum, maximum and midpoint temperatures during the first seven days after birth and data about piglet mortality, number of weaned piglets, weight of weaned litters, individual weight of weaned piglets and lactating days. Average temperature was the less relevant one in such report. The low R^2 for all traits obtained in the current work, may be due to temperatures separation as the piglets grew (Graphic 1). Besides, the average of the four temperatures showed a wide range of variation in the 28 period (Graphic 2).

LIT	IWW	LAD	LWW	MOR
1	7.9	30	93	3
12	6.7	36	91	2
11	7.6	30	90	0
2	7.0	30	85	0
13	8.1	30	84	1
9	7.2	31	84	0
5	8.2	29	79	1
3	7.0	30	71	0
10	7.9	31	64	3
8	7.8	34	55	2
6	6.8	30	54	2
7	9.1	34	52	5
4	5.3	34	42	3
Average	7.4	31.5	72.6	1.7
Criteria	$\geq$7.9	$\geq$30	$\geq$85	$\leq$1

Table 3 Productive traits of 13 litters

LIT=Litter; IWW=Individual weight at weaning; LAD=Lactating days; LWW=Litter weight at weaning; MOR=Mortality.

Better litters in the first month

Table 3 shows a comparison between litters in the first 28 days after birth. In an empirical manner, criteria used was the following: litter weaned weight $\geq$ 85 kg; mortality $\leq$ 1; weaned piglets $\geq$ 11; individual weight at weaning $\geq$ 7.9 kg; lactating days $\leq$ 30 days. With these criteria, the best litters were 1, 11, 2, and 13, as they had at least four out of the five mentioned traits.

Discussion

Temperature values recorded in this work with some influence on the piglets' performance were the average minimum temperature (26°C) and the average mid-point temperature (41.4°C). The piglets' thermal sensation depends on the temperature, humidity and air flux. There is a relation between these factors and the animal size, animal number, the isolation facilities, and the type of material in the bed (Mc Ginnis *et al*., 1981).

Reaching an ideal and constant temperature for the pigs in the facilities can be difficult, that is why it was defined a thermal neutrality zone, which is the adequate environmental temperature for keeping the normal body temperature in the pig (Herpin *et al*., 2002). The thermal neutrality zone is the basal metabolic rate, which is the minimum energy necessary to keep the animal alive, this way the animal maintain a constant heat loss.

There are two values in the neutral thermic tables, for piglets in the first week of life; the lowest value corresponds to the low critical temperature (30°C), the minimum temperature that allows the greatest growth. Below it, the animal uses energy in fighting the cold. The upper value corresponds to the higher critical temperature (35°C), this temperature allows the greatest growth, and above it, the animal decreases the feed intake (Lay *et al*., 2002). As the animal growths, the thermoneutral zone becomes wider, and the animal is capable of withstanding more extreme temperatures.

The values found in this work allow us to recognize that litters were under temperatures below the low critical temperature. It is clear there is a positive relation between environmental temperature and heat production with the calostrum intake.

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This demonstrates that the piglets that cannot intake calostrum are unable to achieve thermo stability, which can affect their growth rate, reduce the vigor to compete for a tit and even to promote greater hair growth as an isolation to keep the adequate corporal temperature (Le Dividich y Noblet, 1981; Mota-Rojas *et al*., 2011). When reviewing the productive performance of the litters, minimum and maximum temperatures were highly related with the weight litter weaned weight, individual weight at weaning, and number of weaned piglets.

The use of thermography to determine heat source temperatures, contributes to minimizing the handling of the piglet, allowing the animal to devote its energy to finding its optimum temperature and its food; this makes possible a higher growth rate in grams day^{-1}. The non-invasive technique described, provides knowledge of the thermal condition for sows, and allows knowing if an excessive temperature will decrease milk production. The knowledge on the environmental condition of the females, will allow us to improve the efficiency of the biological behavior of sows and piglets.

Conclusion

The thermography used allowed us to verify the importance of the piglet microclimate. This methodology made possible to obtain useful information about temperatures in the maternity area. The heat source can provide a wide range of temperature areas in the beds. Some piglets had temperatures below the adequate range, which could influence their performance at weaning.

Appendix

LITTER NUMBER	MORT	WEAN WEIGHT kg	WEAN NUM	IND WEI kg	LAC DAYS	MEAN TEMP °C	MIN TEMP °C	MIDP TEMP °C	MAX TEMP °C
1	3	93	13	7.89	30	48.81	29.14	37.67	56.01
2	0	85.2	11	7.02	30	53.40	18.44	32.38	63.31
3	0	71	9	6.95	30	66.60	25.48	42.49	64.29
4	3	42.4	8	5.3	34	35.66	23.04	33.57	53.31
5	1	78.6	10	8.16	29	31.48	29.83	41.91	72.85
6	2	53.8	9	6.78	30	68.90	26.93	39.51	78.62
7	5	52.4	8	9.11	34	44.48	25.65	46.59	99.77
8	2	54.8	8	7.75	34	64.42	35.66	46.70	52.71
9	0	83.8	11	7.15	31	39.32	32.48	57.67	74.20
10	3	63.8	7	7.91	31	42.77	43.84	50.45	74.01
11	0	89.8	11	7.6	30	57.29	34.63	45.99	79.03
12	2	91.2	12	6.72	36	32.76	40.34	50.35	64.03
13	1	84.2	12	8.13	30	63.95	32.99	33.00	69.74
Average	1.69	72.6	9.9	7.42	1.5	49.99	30.65	42.94	69.38

Table 5 Traits of 13 litters recorded from birth to weaning and temperatures during the first 28 days

MORT = mortality; WEAN WEIGHT = weight litter weaned; WEAN NUM= number of weaned piglets; IND WEI = individual weight at weaning; LAC = lactating days; MEAN TEMP = mean temperature; MIN TEMP = minimum temperature; MIDP TEMP = mid-point temperature; MAX TEMP = maximum temperature

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