Agronomy Research **19**(4), 1756–1762, 2021
https://doi.org/10.15159/AR.21.139

Decision three to predict respiratory rate of piglets submitted to cold conditions

P.F.P. Ferraz[1,*], V.G. Cadavid[2], G.A.S. Ferraz[1], J.A.O. Saraz[2], G. Rossi[3] and M. Barbari[3]

[1]Federal University of Lavras, Agricultural Engineering Department, Campus Universitário, PO Box 3037, CEP 37200-000 Lavras, Minas Gerais, Brazil
[2]Universidad Nacional de Colombia Sede Medellin, Facultad de Cuencias Agrarias, Departamento de Ingenieria Agricola y de Alimentos, PO Box 050034 Medellín, Colombia
[3]University of Florence, Department of Agriculture, Food, Environment and Forestry, 13 Via San Bonaventura, IT50145 Firenze, Italy
[*]Correspondence: paricia.ponciano@ufla.br

Received: January 16th, 2021; Accepted: March 13th, 2021; Published: October 5th, 2021

Abstract. Pigs subjected to thermal conditions outside their comfort zones may show altered physiological and behavioural responses, which may consequently cause productive losses. For these reasons, the aim of this paper is to develop a decision tree for the prediction of respiratory rate (RR, mov min^{-1}) of piglets exposed to different thermal situations. The experiment was carried out in an experimental pig farm of the Universidad Nacional de Colombia Campus Medellin, located at the San Pablo Agraria Experimental Station located in the eastern sector of the department of Antioquia, during August 2019. A database containing the raw data for dry bulb temperature - tdb (°C), and relative humidity - RH (%) as input variables, and RR (mov min^{-1}) of six piglets were assessed every two hours as output variable for piglets was generated. The experimental database was composed of 78 observed data. The decision trees were developed to conditions of tdb between 19.2 to 29.5 °C and RH between 50.2 to 88.4%. In the experimental period, RR of piglets submitted to tdb higher than 27.1 °C the RR was around 60 mov min^{-1}, tdb smaller than 27.1 °C the RR varied from 36 to 46 mov min^{-1}. These low values of physiological responses may indicate that the piglets are not in a comfortable situation, so their development, welfare and production can be affected. The decision tree developed can be useful to provide a quick understanding of the piglet's welfare condition based on the environmental variables and physiological responses.

Key words: animal welfare, pig, physiological responses, thermal stress.

INTRODUCTION

The newborn piglet, despite being neurologically developed, is still physiologically immature. Some important changes occur early in piglets' life may enabling them to survive. In an intensive production system, the environment can be one of the responsibles for the comfort and welfare of pigs (Cecchin et al., 2019). Pigs subjected to thermal conditions outside their comfort zones may show altered behavioural responses physiological parameters, such as body temperature, respiratory rate and cardiac movements, which may consequently cause losses related to the productive responses of these animals. The first days are the most critical in a piglet's life and the physiological changes occur mainly in this period. According to Damasceno et al. (2019) in the first weeks of life, pig's thermoregulatory system is still inefficient in maintaining their homeotherm effectively. When the dry bulb temperatures (tdb) are below the thermoneutral zone (TNZ), part of the animal's feed energy intake that could be used for growth or production is diverted to thermoregulation to maintain homeostasis (Mujahid, 2010).

Under severe low tdb, homeothermic animals can suffer with decreased alertness hypothermia, and behavioural and physiological problems (Ferraz et al., 2017). Physiological variables can be an indicative of the thermal comfort of the animals. Any variation in physiological responses can indicate if the animal is or not under thermal stress (Nascimento et al., 2012). The physiological variable of easy measurement is the respiratory rate (RR), which can be measured by visual analysis.

Data mining techniques can transform raw data into valuable information, and support for the decision-making process, as well as might promote the discovery of knowledge in the field of pig production (Fonseca et al., 2020). Techniques of decision trees can be used as reliable techniques for the development of predictive models to support decision-making. This technique is an hierarchical graphical structures that can be easily understood and applied. Decision trees are characterized by segmenting heterogeneous data according to their similarities such that the data become more homogeneous about the target variable (Vieira et al., 2018).

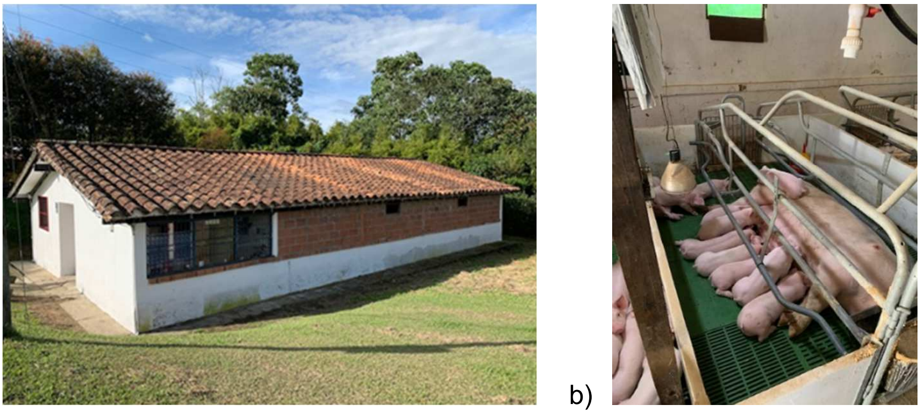
For those reasons, the objective of this paper is to develop decision trees for predicting the respiratory rate (RR, mov min^{-1}) of piglets exposed to cold thermal situations.

MATERIALS AND METHODS

The experiment was carried out at the maternity facility of an experimental pig farm on the Nacional University of Colombia, Campus Medellin, located at the San Pablo Agraria Experimental Station located in the eastern sector of the department of Antioquia, Rionegro municipality, during August 2019. The raising system evaluated involved intensive confinement, and the animals did not have access to the outside of the pig house.

The experimental facility has a width of 8.0 meters and a length of 12.0 meters, built in brick without thermal insulation, with a right foot 2.0 meters high with a concrete floor and biogas heating systems (Fig. 1, a). The evaluated piglets from commercial genetic lines (Fig. 1, b)

In order to characterize the thermal environment inside the house, dry-bulb temperature (tdb, °C) and relative humidity (RH, %) at 1.0 m height inside the house were measured. For the collection of respiratory rate (RR) was adopted methodology used by Cecchin et al. (2019), where is made the measurement and counting of the movements of the animal for 15 seconds. So, the value is multiplied by four to get the amount of movement per minute. The RR was evaluated with the aid of a digital timer (± 0.01 s). The environmental variables (tdb and RH) and physiological response (RR) of six piglets from commercial genetic lines from 0 until the first 24 h of life were assessed every two hours, totalizing 13 times during a day. A database was generated considering as input variables the raw data: tdb (°C), RH (%), and as output variable RR (mov min^{-1}) for piglets. The experimental database was composed of 78 observed data.



a) b)

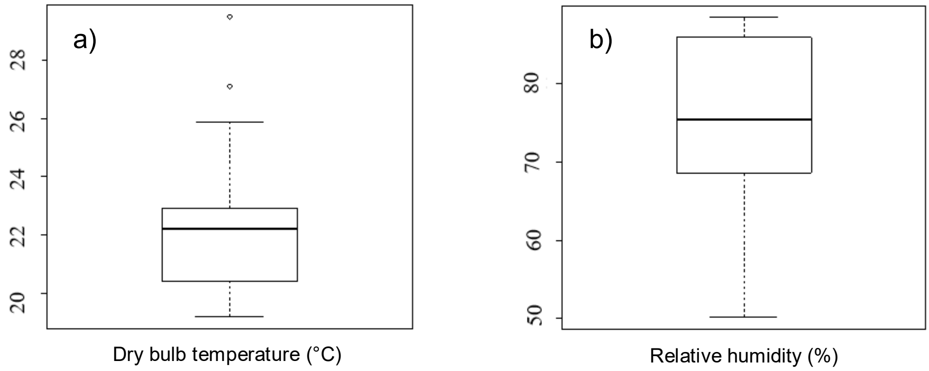
Figure 1. The experimental maternity facility for pigs (a) and the evaluated piglets (b).

The dataset was randomly distributed among two subsets using random sampling as data partition method. The first subset (70% of the data) was for training the decision trees, and for the second subset (30%) was used for validation, following the methodology proposed by Hernández-Julio et al. (2019). For the prediction of RR of piglets exposed to different situations of dry bulb temperature (tdb, °C) and relative humidity (RH, %) 60 decision trees models were developed. The model with the best performances was selected. The decision trees were developed to conditions of tdb between 19.2 to 29.5 °C and RH between 50.2 to 88.4%.

RESULTS AND DISCUSSION

Fig. 2 shows the box plot analysis of tdb (Fig. 2, a), RH (Fig. 2, b) and RR (Fig. 2, c) results for the evaluated period. The mean values were 22.18 °C, 75.25% and 49 mov min^{-1} for tdb, RH and RR, respectively. According to Ferreira (2015) thermoneutral zone for piglets from 0 until 2 days of live is 32 to 34 °C and the lower critical effective temperature is 22 °C. Ferreira et al. (2007) studied physiologic parameters of the first 24 hours of sucking pigs life and found values of 41 to 63 mov min^{-1}.

Based on this information it is possible to observe that the piglets were submitted to a thermal discomfort situation. In a stress condition, in which there is a higher demand for thermal maintenance energy, the energy contribution to the productive functions is reduced, generating health imbalances, reduced production rates and changes in animal behaviour (Huynh et al., 2005; Fonseca et al., 2020). According to Ferreira (2015) the recommendable RH for piglets is 60–70%.



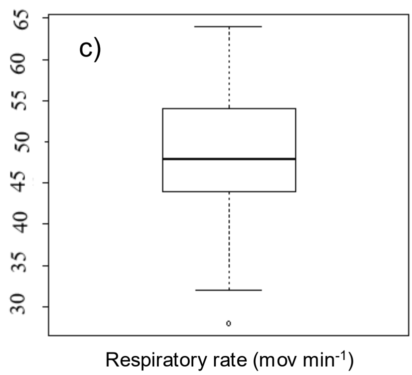


Figure 2. Box plot of dry bulb temperature (°C) (a), relative humidity (%) (b) and respiratory rate (mov min^{-1}) (c) of piglets during the evaluated period.

Principal component analysis was used to associate the RR, tdb, and RH data. Fig. 3 shows that the RR were positively correlated with the tdb and negatively correlated with the RH. Thus, the data suggest that an increase in tdb will increase the piglets' RR. Conversely, an increase in RH will decrease the piglets' RR.

To evaluate the level of comfort and welfare of animals in confinement systems, practical and easy to apply technologies are being used. The average structure of the RR decision tree is described in Fig. 4. The first split is related to tdb that is the most important factor influencing the RR and the second split is related to RH. According to the experimental data, this decision tree is related to tdb values of 19.2 to 29.5 °C and RH between 50.2 to 88.4%, which can be considered a cold condition for piglets.

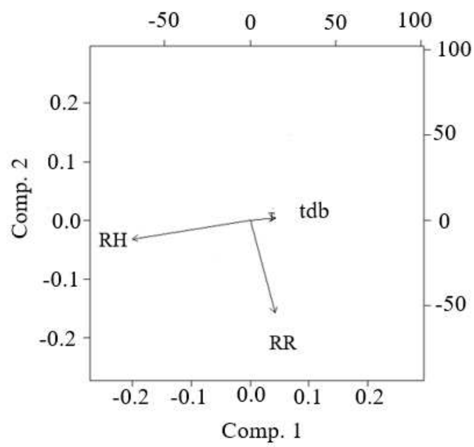


Figure 3. Principal component analysis of the respiratory rate (RR), dry bulb temperature (tdb) and relative humidity (RH).

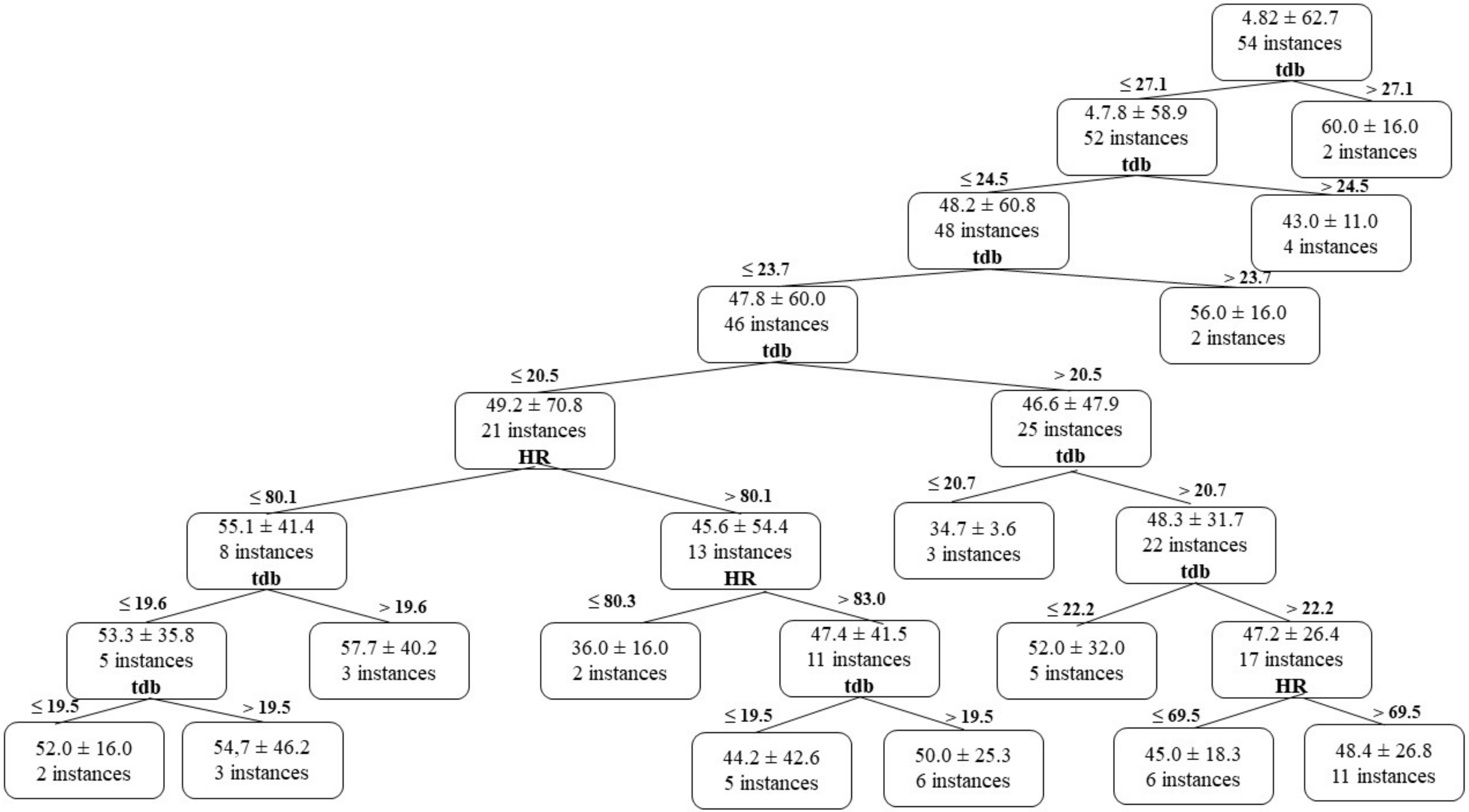


Figure 4. Visual decision tree for the respiratory rate output variable (mov min^{-1}).

The first split for tdb occurs at approximately 27 °C. The decision tree model chosen presented R^2 of 0.997, which indicates an excellent adjustment to predict the RR.

The variation of pig's RR can be considered one of the first physiological adjustments to maintain thermoregulation (Oliveira et al., 2019). Besides, this physical property has the advantage of being measured through visual analysis.

Pigs, due to their physiological characteristics, have difficulties in adapting to environmental thermal fluctuations. The temperature range for your comfort varies with age. In the experimental period, RR of piglets submitted to tdb higher than 27.1 °C the RR was around 60 mov min^{-1}, tdb smaller than 27.1 °C the RR varied from 36 to 46 mov min^{-1}. These low values of physiological responses may indicate that the piglets are not in a comfortable situation, so their development, welfare and production can be affected. When the tdb values are below the thermoneutral zone, part of the feed energy intake is diverted to thermoregulation to maintain homeostasis (Mujahid, 2010). On the other hand, high environmental temperatures negatively affect pigs, causing changes in their rectal temperature, skin surface and respiratory rate (Manno et al., 2005).

The decision tree developed can be used in field situations to provide a quick understanding of the piglet's welfare condition based on the environmental variables and physiological responses, as RR, for example. This information can be obtained in real-time, and it may help the suines breeder in decision making to get a satisfactory environmental condition for the piglets. The decision tree models were successfully employed to predict the RR, obtaining the ranges of the input variables values and the decision-making rule base from the data. Thermal variables (as tdb and RH) and physiologic variables (as RR) could be considered as knowledge-based management subsystem in a decision support system. These variables can provide information about data and their relationships can help in decision making.

CONCLUSIONS

Using the proposed decision tree models it was possible to predict respiratory rate successfully, based on environmental variables (such as tdb and RH).

Environmental variables and physiological responses as, RR can be evaluated as a knowledge-based management subsystem in a decision support system, which provides information about data and potential relationships to assist in decision-making.

In the experimental period, RR of piglets submitted to tdb higher than 27.1 °C the RR was around 60 mov min^{-1}, tdb smaller than 27.1 °C the RR varied from 36 to 46 mov min^{-1}.

The propoed model exhibited a good fit between the observed and predicted data. Therefore, the decision trees can support decision-making to avoid thermal stress conditions.

ACKNOWLEDGEMENTS. The authors would like to thank the Nacional University of Colombia, Sede Medellin, where the experiment was performed. The authors also express thanks to Federal University of Lavras Universidad for its support of this research.

REFERENCES

Cecchin, D., Ferraz, P.F.P., Campos, A.T., Sousa, F.A., Amaral, P.I.S., Castro, J.O., Conti, L. & da Cruz, V.M.F. 2019. Thermal comfort of pigs housed in different installations. *Agronomy Research* **17**(2), 378–384.

Damasceno, F.A., Osorio, J.A., Alves Oliveira, C.E., Ferraz, P.F.P. & Brandão, L.F. 2019. Assessment of a low-cost solar water heating systems in farrowing facilities. *Agronomy Research* **17**(1), 49–59.

Ferraz, P.F.P., Yanagi Junior, T., Lima, R.R.D., Ferraz, G.A.S. & Xin, H. 2017. Performance of chicks subjected to thermal challenge. *Pesquisa Agropecuária Brasileira* **52**(2), 113–120. doi:10.1590/s0100-204x2017000200005

Ferreira, R.A. 2011. Greater Production with Better Environment: For Poultry, Swine and Cattle. Viçosa, MG: Aprenda Fácil Editora, 526 66. (in Portuguese).

Ferreira, R.A., Chiquieri, J., Mendonça, P.P., Melo, T.V., Cordeiro, M.D. & Soares, R.T.R.N. 2007. Valuation of behavior and physiologic parameters of the first 24 hours of sucking pigs life. *Ciência e Agrotec*nologia **31**(6), 1845–1849 (in Portuguese).

Fonseca, F.N., Abe, J.M., de Alencar Nääs, I., da Silva Cordeiro, A.F., do Amaral, F.V. & Ungaro, H.C. 2020. Automatic prediction of stress in piglets (Sus Scrofa) using infrared skin temperature. *Computers and Electronics in Agriculture* **168**, 105148.

Hernández-Julio, Y.F., Prieto-Guevara, M.J., Nieto-Bernal, W., Meriño-Fuentes, I. & Guerrero-Avendaño, A. 2019. Framework for the development of data-driven Mamdani-type fuzzy clinical decision support systems. *Diagnostics* **9**(2), 52. doi:10.3390/diagnostics9020052

Huynh, T.T.T., Aarnink, A.J.A., Gerrits, W.J.J., Heetkamp, M.J.H., Canh, T.T., Spoolder, H.A.M., Kemp, B. & Verstegen, M.W.A. 2005. Thermal behaviour of growing pigs in response to high temperature and humidity. *Applied animal behaviour science* **91**(1–2), 1–16.

Manno, M.C., Oliveira, R.F.M.D., Donzele, J.L., Ferreira, A.S., Oliveira, W.P.D., Lima, K.R.D.S. & Vaz, R.G.M.V. 2005. Effect of environmental temperature on pig performance from 15 to 30 kg. *Revista Brasileira de Zootecnia* **34**(6), 1963–1970. doi: 10.1590/S1516-35982005000600021 (in Portuguese).

Mujahid, A. 2010. Acute cold-induced thermogenesis in neonatal chicks (Gallus gallus). Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, **156**(1), 34–41. doi: 10.1016/j.cbpa.2009.12.004

Nascimento, S.T., Silva, I.J.O.D., Mourão, G.B. & Castro, A.C.D. 2012. Bands of respiratory rate and cloacal temperature for different broiler chicken strains. *Revista Brasileira de Zootecnia* **41**(5), 1318–1324. doi: 10.1590/S1516-35982012000500033

Oliveira, R.F., Moreira, R.H.R., Ribeiro, B.P.V.B., Resende, M., Chaves, R.F., Gionbelli, M.P. & Ferreira, R.A. 2019. Acute heat stress compromises the physiology of growing pigs. *Archivos de zootecnia* **68**(262), 300–302.

Vieira, E.M.A., Neves, N.T.A.T., Oliveira, A.C.C., Moraes, R.M., Nascimento, J.A. 2018. Performance evaluation of the J48 algorithm for building models based on decision trees. *Rev. Bras. Comput. Apl*. **10**, 80–90 (in Portuguese).