Agronomy Research **17**(3), 704–710, 2019
https://doi.org/10.15159/AR.19.113

Behavioural and physiological responses of rabbits

P.F.P. Ferraz[1*], G.A.S. Ferraz[1], M. Barbari[2], M.A.J.G. Silva[1], F.A. Damasceno[1], D. Cecchin[3] and J.O. Castro[1]

[1]Federal University of Lavras, Agricultural Engineering Departament, Campus Universitário, PO Box 3037, Lavras, Minas Gerais, Brazil
[2]University of Firenze, Department of Agriculture, Food, Environment and Forestry, Via San Bonaventura, 13, IT50145 Firenze, Italy
[3]Federal University Fluminense, Department of Agricultural Engineering and Environment, Campus Praia Vermelha, São Domingos, BR24.210-240 Niterói, Rio de Janeiro, Brazil
[*]Correspondence: patricia.ponciano@deg.ufla.br

Abstract. The profitability of a rabbit farming system must consider the thermal environment that the animal will be exposed during the productive period. The goal of this study was to evaluate the physiological responses and behaviours of 26 New Zealand rabbits during seven days of their lives at three times a day. The experiment was carried out in rabbit house in the Federal University of Lavras at Lavras, Brazil. To characterize the thermal environment sensors were used to measure the dry bulb temperature and relative humidity at 48 points inside the rabbit house, at 6:00 a.m., 12:00 a.m. and 6:00 p.m. In addition, the temperature and humidity index (THI) was calculated. The respiratory rate and the superficial temperature of the rabbits' ears were measured. Behaviour evaluations were monitored in punctual record, with duration of two min/cage. Later an ethogram was made with the main behaviours identified. Similar data of behaviour and data of physiological responses were identified by using Ward's method of cluster analysis. It was observed the period of 6 a.m. showed more comfortable conditions of THI values than the others analysed. Besides, physiological responses presented better values at 6:00 a.m. in comparison to 12:00 and 6:00 p.m. Furthermore, in general, a similar behaviour was observed in the rabbits at 12:00 and 6:00 p.m., while at 6:00 a.m. was different. But rabbits demonstrated to be more comfortable at 6 a.m. maybe because at this time environment conditions were better than the rest of the day. Besides, it can be observed that rabbits were more active in sunrise and sunset than in the rest of the day.

[illegible]re.

INTRODUCTION

Brazil has incredible agricultural potential due to its extensive land area, which benefits the establishment of several types of production systems, especially animal production systems, including rabbit production.

Several products derived from rabbits can be commercialized, such as meat, fur, urine, and handicrafts, among other products. However, this branch of agribusiness is underdeveloped in Brazil considering its high agricultural and rabbit production potential (Santos, 2010).

Rabbit production is considered a strategic production activity because it generates a large number of products, co-products, and by-products of high added value in a short time; furthermore, it is considered a sustainable activity due to its carbon and water savings and consequent low environmental impacts due to reduced production time (Machado & Ferreira, 2012).

In human nutrition, foods derived from animal products are important sources of protein and other nutrients. Thus, rabbit meat is considered an excellent source of protein and nutrients because it is considered to be a leaner and healthier meat than beef, sheep meat, and pork (Hernández et al., 2000). In addition, it is a tasty meat that is easy to digest, low in fat and cholesterol, and often recommended by nutritionists for the elderly and children (Hernández et al., 2000).

However, the rabbit breeding industry in Brazil is typically disorganized and subjected to many challenges related to production technology, which increases production costs (Machado, 2012). Therefore, it is of the utmost importance to understand the parameters that affect rabbit production to obtain and combine maximum rabbit productivity with lower production costs (Machado, 2012).

Among these parameters, rabbit welfare analysis deserves attention, and many studies aim to evaluate alternatives to improve existing housing systems (Verga et al., 2007).

Analysing the interaction between genetic, nutritional, and especially environmental factors are of the utmost importance for establishing an efficient rabbit production system. Thus, according to Lebas et al. (1996), for rabbit production to be efficient, the ideal air temperature to raise rabbits after weaning (after 30 days of age) should range between 15 and 20 °C, and the relative humidity (RH, %) should be approximately 60 to 70%.

According to Arveaux (1991), the welfare of rabbits depends to a large extent on the available space, and cages that are too small or characterized by overcrowding rates have immediate consequences, such as changes in hygiene, sanitary conditions, and behaviour, that negatively affect the performance of animals.

Reduced rabbit welfare may lead to atypical behaviours that may be signs of frustration and anxiety (Barros, 2011). Thus, according to Morisse et al. (1999), abnormal aspects of social, maternal, and food intake behaviour can be indicative of thermal stress.

Rabbits are homoeothermic animals and are more sensitive to high air temperature conditions because they cannot perform thermoregulatory sweating (McNitt et al., 1996), thereby limiting their ability to eliminate excess body heat.

Therefore, when behavioural changes no longer have an effect on the maintenance of homeothermy, increased respiratory rate (RR) becomes one of the mechanisms necessary to stimulate evaporative heat loss (Zeferino et al., 2011).

According to Zeferino et al. (2011), in addition to RR, ear temperature (ET) is another physiological mechanism used by rabbits to dissipate surplus heat.

In this context, it is possible to use methods that analyse the rabbit breeding system to serve as a tool for the producer to make quick and accurate decisions. Hierarchical agglomerative clustering (HAC) analysis can be a simple and effective method because it is based on the simple idea of placing objects that are similar according to some pre-determined criteria in the same group; thus, HAC is suitable for the analysis of data that represent many different situations (Linden, 2009).

This technique also allows the results to be visualized and classified using dendrograms that hierarchically illustrate the degree of similarity between clusters. Within each cluster, the objects are similar to each other, whereas objects located in other clusters are different from each other (Dominick et al., 2012).

Dendrograms are especially useful in visualizing similarities between samples or objects represented by points in space where conventional plotting is not possible (Lau et al., 2009).

To evaluate the thermal environment to which the rabbits were exposed, the temperature- humidity index (THI) proposed by Thom (1958) was used. This index can be used to evaluate the thermal comfort of commercial rabbits within their environment.

Thus, the present study aimed to evaluate the physiological responses and behaviours of 26 New Zealand White (NZB) rabbits three times a day for seven days by making technical dendrograms.

MATERIALS AND METHODS

The experiment was conducted in a house of the rabbit production unit of the Department of Animal Science of the Federal University of Lavras (UFLA), in Lavras, Brazil, during May 2016. Twenty-six NZB rabbits (14 males and 12 females) aged 58 days were housed at random in 13 collective galvanized wire cages. During the experimental period, the animals had *ad libitum* access to balanced feed and drinking water.

Behaviour was monitored and logged by an observer at a distance of 1 m from the cages for two minutes per cage at 6 am, 12 pm, and 6 pm every day for seven days.

The list of the types of behaviours monitored during the experiment as well as the definition of each observed item is listed below (Table 1).

Table 1. Ethogram of primary rabbit behaviours and their description

Behaviour	Definition
Exploratory	Smell the surrounding environment, bite.
Intake	Feed in the feeder or drink water.
Playful	Jumps; Dig the floor of the cage frequently and insistently; Performing body care (cleaning the ears).
Stereotypies	Biting or licking cage bars; Roer frequently and insistently.
Indicative of heat stress	Lying; sitting, prostrate, excessive body care

After the behavioural analysis, the physiological indicators were analysed. The respiratory rate was assessed by visually counting the flank movements using a digital timer (± 0.01 s). The respiratory movements were monitored for 15 s and then multiplied by four to obtain breaths per minute. ET was measured at three different points with the use of a thermometer (laser).

To characterise the thermal environment inside the rabbit shed, the dry bulb temperature (t_{db}, °C), dew point temperature (t_d), and relative humidity (RH, %) were measured at a height of 1 m (from the ground) to the centre of the cage and evaluated three times during the seven days of observation.

To measure t_{db}, t_d, and RH, a sensor (base station) with an accuracy of 0.1 °C and 1% was used. These values were then converted to THI, according to the equation by Thom (1958).

The HAC analysis and the dendrograms of the THI and behaviour averages were performed using the statistical computer system R (R Development Core Team, 2018), and the cophenetic correlation coefficient fit was also estimated using the same software.

RESULTS AND DISCUSSIONS

THI values and the dendrogram with clustering analysis in the morning (6 am), afternoon (12 pm), and evening (6 pm) periods during the seven-day study (Fig. 1).

According to Lebas et al. (1996), the ideal tdb values for rabbit breeding vary between 15 to 20 °C, and the ideal RH value is 60 to 70%, according to Ferreira et al. (2012). Based on this information, if we calculate the ideal THI values using the equation proposed by Thom (1958), we can calculate that the ideal minimum and maximum THI for the rabbit breeding environment will be 59 and 61, respectively.

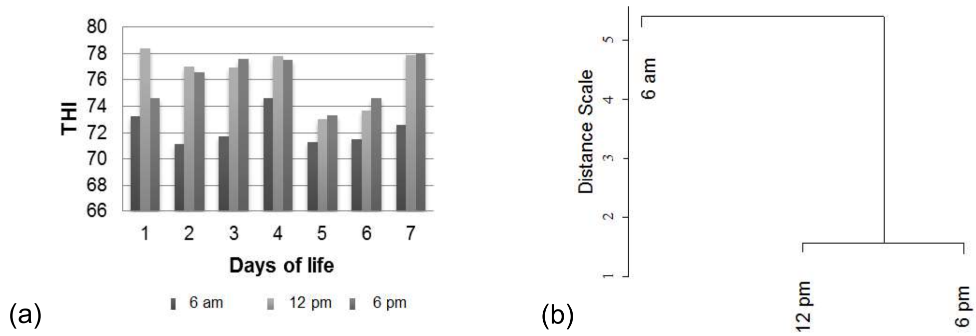


Figure 1. Graphs: (a) with THI values and (b) dendrogram analysis in the morning (6 am), afternoon (12 pm), and evening (6 pm) periods during the seven-day study.

Fig. 1 (a) shows that during the experimental period, the THI ranged from 66 to 78; these values are much higher than the ideal values. The assessment of THI values during the three periods (6 am, 12 pm, and 6 pm) using HAC (Fig. 1, b) revealed that the THI values were similar between 12 pm and 6 pm (mean THI value of 76) but were different from the values at 6 am (mean THI value of 72). In other words, the 6 am time exhibited the best conditions with the lowest THI values ranging from 71 to 75, but the THI was not within what is considered the optimal range. The cophenetic correlation coefficient of Fig. 1 (b) was 0.99, indicating a high accuracy of analysis.

The dendrograms comparing the physiological responses at the three time periods (6 am, 12 pm, and 6 pm): ET (Fig. 2, a) and RR (Fig. 2, b) for the seven days of the study period (Fig. 2).

Thus, as in Fig. 1 (b), the rabbits were under better thermal comfort conditions at 6 am, which resulted in a lower ET (23.8 °C) and RR (76 mov min^{-1}), whereas at 12 pm and 6 pm, ET and RR exhibited similar averages (27.7 °C and 88 mov min^{-1}, respectively). Rabbits are more sensitive to heat than to cold, and abrupt temperature variations are more harmful than a gradual change in temperature outside the comfort zone (Ferreira et al., 2012).

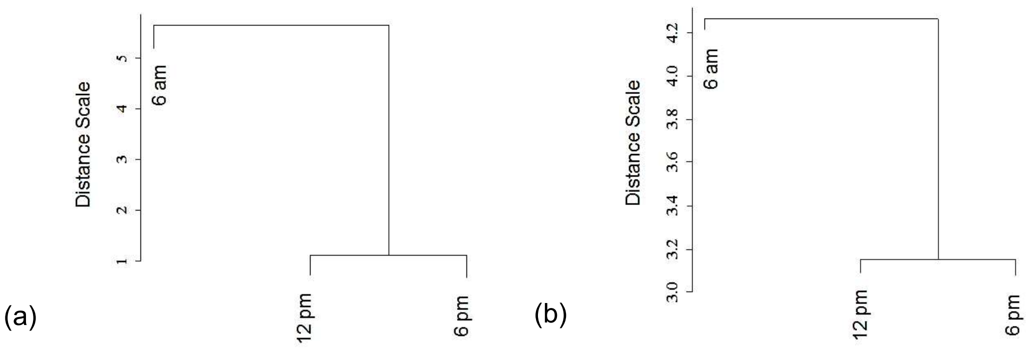
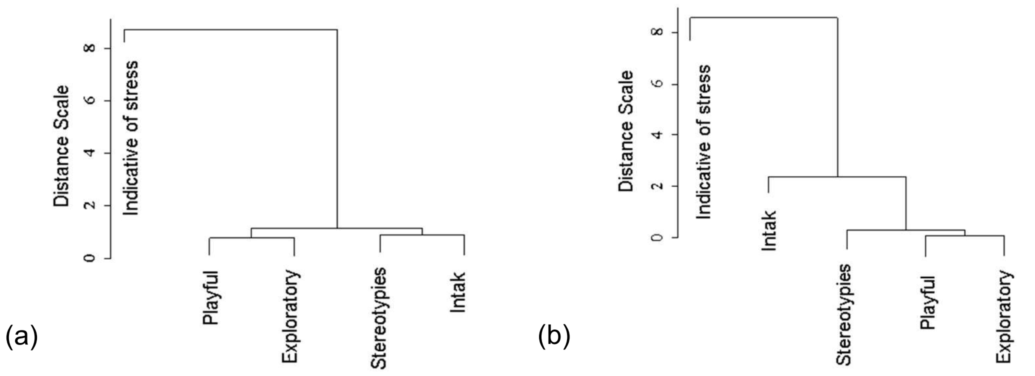


Figure 2. Dendrograms of physiological responses of rabbits during the experimental period: (a) ear surface temperature (ET, °C) and (b) respiratory rate (RR, mov min^{-1}).

Animals under thermal stress tend to exhibit behavioural changes to try to minimize this effect. Thus, Fig. 3 presents the behaviours logged at each observation period during the seven experimental days. The cophenetic coefficients of Fig. 3 were 0.99 for Fig. 3(a) and 0.98 for Fig. 3, b, c.



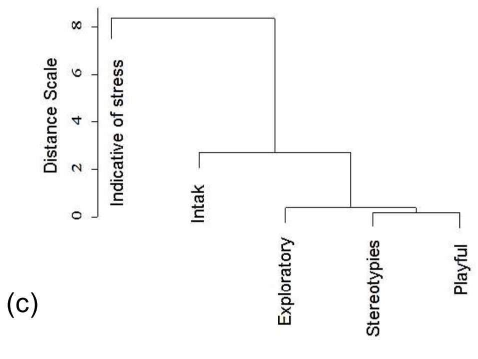


Figure 3. Dendrogram of rabbit behaviour during seven days at different times of the day: 6 am (a), 12 pm (b), and 6 pm (c).

The time the rabbits spent exhibiting playful and exploratory behaviours or stereotypies was very similar during the three observed periods (6 am, 12 pm, and 6 pm) and accounted for less than 10% of the total time observed (Fig. 3). However, the time they spent on behaviours indicative of heat stress was much higher than the time spent on other behaviours (approximately 75% of the time), especially in the afternoon (Fig. 4).

At 6 am, there was lower food and water intake compared to other observation times (approximately 10%, 19%, and 21% of the time at 6 am, 12 pm, and 6 pm, respectively). In addition, at 6 am, the animals were calmer. This observation is in accordance to Diez et al. (2013) that affirm that less activity during the day in experimented rabbits could be resulted not only by temperature reason, but also by rabbits behavioral pattern. According to the same authors rabbits are active in sunrise and sunset period and totally no active during the day. At 12 and 6 pm, the THI values were higher, as shown in Fig. 1, and this may have influenced the greater intake, primarily of water, at these times.

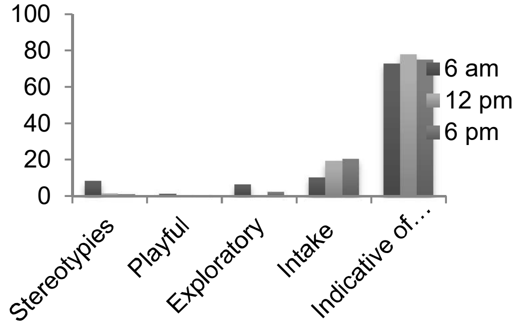


Figure 4. Frequency of occurrence of behaviours (%) during the three evaluated periods.

Adverse climatic conditions are important stressors that negatively affect the environmental quality in which a rabbit is raised, its behaviour, and its productive and physiological responses (Verga et al., 2007).

CONCLUSIONS

During the experimental period, thermal conditions inside the rabbit house, represented by the THI, were milder at 6 am than at 12 pm and 6 pm. This pattern was also reflected in the ET and RR of these animals, which were lower at 6 am. Regarding the behaviours observed, it was clear that the animals exhibited a higher frequency of behaviours indicative of thermal stress for most of the day, as they were housed in conditions outside their thermoneutral zone.

REFERENCES

Arveaux, P. 1991. Density in fattening cages. *Cunicultura* **16**, 90-107. (in Portuguese).

Barros, T.F.M. 2011. *Performance and behavior of growing rabbits in enriched cages.* Dissertation MSc in Animal Science. Faculdade de Medicina Veterinária e Zootecnia, Botucatu, SP, 66 pp. (in Portuguese).

Díez, C., Sánchez-García, C., Pérez, J.A., Bartolomé, D.J., González, V., Wheatley, C.J., Alonso, M.E. &Gaudioso, V.R. 2013. Behavioural activity of wild rabbits (oryctolagus cuniculus) under semi-natural rearing systems: establishing a seasonal pattern. *World Rabbit Sci.* **21**, 263–270.

Dominick, D., Juahir, H., Latif, M.T., Zain, S.M. & Aris, A.Z. 2012. Spatial assessment of air quality patterns in Malaysia using multivariate analysis. *Atmospheric Environment* **60**, 172–181. Oxford.

Ferreira, W.M., Machado, L.C., Jaruche, Y. De G., Carvalho, G.G., Oliveira, C.E.A., Souza, J. D'a.S. & Caríssimo, A.P.G. 2012. *Practical manual of rabbits.* Bambuí. Ed. do autor, 75 pp. (in Portuguese).

Hernández, P., Pla, M., Oliver, M.A. & Blasco, A. 2000. Relationships between meat quality measurements in rabbits fed with three diets of different fat type and content. *Meat Science* **55**, 379–384.

Lau, J., Hung, W.T. & Cheung, C.S. 2009. Interpretation of air quality in relation to monitoring station's surroundings. *Atmospheric Environmetric* **43**(4), 769–777.

Lebas, F., Coudert, P., Rochambeau, H. & Thebault, R.G. 1996. *The rabbit: breeding and pathology*. Roma: FAO. 225 pp. (in Spanish).

Linden, R. 2009. Grouping Techniques. *Revista de Sistema de Informação da FSMA*, Macaé, **4**, 18–36 (in Portuguese).

Machado, L.C. 2012. Opinion: panorama of the Brazilian cuniculture. *Revista Brasileira de Cunicultura* **2**, 1.(in Portuguese).

McNitt, J.I., Cheeke, P.R., Patton, N.M. & Lukefahr, S.D. 1996. *Rabbit production*. 7th ed. Danville, Illinois: Interstate, 477 pp.

Mcnitt, J. I., Cheeke, P.R., Patton, N.M. & Lukefahr, S.D. 1996. *Rabbit production*. 7th ed. Danville, Illinois: Interstate, 477 pp.

Morisse, J.P., Boilletot, E. & Martrenchar, A. 1999. Preference testing in intensively kept meat production rabbits for straw on wire grid floor. *Applied Animal Behaviour Science* **64**, 71–80.

R Development Core Team. 2018. R: a language and environment for statistical computing. Vienna: *R Foundation for Statistical Computing*.

Santos, F.B. 2010. *Rabbit breeding: feasibility analysis to generate a company aimed at raising 500 rabbits per month in Feira de Santana*. Monography (Bachelor in Business Administration). Universidade Estadual de Feira de Santana, Feira de Santana-BA, 93 pp. (in Portuguese).

Thom, E.C. 1959. The discomfort index. *Weatherwise* **12**(2), 57–60.

Verga, M., Luzi, F. & Carenzi, C. 2007. Effects of husbandry and management systems on physiology and behavior of famed and laboratory rabbits. *Hormones and Behavior* **52**, 122–129.

Zeferino, C.P., Moura, A.S.A.M.T., Fernandes, S., Kanayama, J.S., Scapinello, C. & Sartori, J.R. 2011. Genetic group×ambient temperature interaction effects on physiological responses and growth performance of rabbits. *Livestock Science* 177–183.