BEHAVIORAL RESPONSES OF PIGS FINISHED IN DEEP BEDDING AND CONVENTIONAL BED SYSTEMS

Pedro I. S. Amaral[1*], Alessandro T. Campos[2], Roberto da C. Esteves Junior[1], Gabriella F. Esteves[1], Tadayuki Yanagi Junior[2], Maria E. C. R. Leite[1]

[1*]Corresponding author. José do Rosário Vellano University - UNIFENAS/ Alfenas - MG, Brasil.
E-mail: pedroivosodre@gmail.com | ORCID ID: https://orcid.org/0000-0002-2366-2088

ABSTRACT

The objective of this study was to characterize the thermal environment and evaluate the behavior of finishing pigs housed in deep bedding and conventional systems. The work was carried out in the Department of Animal Science of the Federal Institute of Education, Science and Technology of Southeast Minas Gerais, Rio Pomba campus. Three pens were used in an installation for breeding pigs in their finishing phase. Two pens contained deep bedding, with wood shavings and rice husks. The remaining pen was a conventional system. The behavior of the piglets was observed from 8 a.m. to 5:30 p.m., noting the behaviors with the use of an ethogram, while data relating to the thermal environment in the stalls were automatically collected using data loggers. Thermal environment data for all systems presented thermal stress conditions. Regarding behavioral variables, animals in conventional systems had a higher frequency of visits to feeders, while animals in the deep bedding system were more active and visited the drinking fountains more frequently. Despite the higher level of activity of the animals in the deep bedding system, it is not possible to confirm that the deep bedding provides a better degree of well-being for the animals under thermal stress conditions.

INTRODUCTION

It is estimated that by the year 2024, pork production in Brazil may reach an all-time high of 4.3 million tons, principally due to the greater acceptance of meat by Brazilian consumers, who consume about 3.7 million tons. Along with domestic growth, it is expected that Brazilian exports will benefit from stronger international demand, the current devaluation of the Brazilian real, and the low cost of rations, due to the abundance of corn and soybean crops. (OECD, 2015). The pig farming industry has grown in the last few years and is projected by the Food and Agriculture Organization (FAO) to continue to expand for the foreseeable future. As the industry develops, there will need to be more attention focused on the environmental impacts of pig farming, since an increase in the concentration of animals will require compliance with soil and water conservation standards. Otherwise, the sector's growth may aggravate environmental problems, especially in regions where animal densities are already high and where greenhouse gas (GHG) emissions, as well as liquid and solid waste discharges per unit area, have already reached critical levels (Santos et al., 2014; Frigo et al., 2017).

In these places, the use of composting to manage waste can be an effective solution if done in an acceptable way, respecting aeration requirements and substrate ratios. Wang et al. (2017) found that composting pig manure from housing systems is able to reduce GHG emissions considerably more than storing residues in liquid manure.

The deep bedding pig breeding system arises precisely to fill this gap, since the maintenance of the animals on a bed of substrate allows for the absorption of external waste, promoting *in situ* composting. In addition, the system confers the possible advantage of increasing animal welfare from the bedding, which represents environmental enrichment (Caldara et al., 2012). In this sense, deep bedding influences animal behavior, and when compared to conventional systems, it promotes greater

interaction between animals, resulting in a reduction of stereotypies (Mkwanazi et al., 2019; Maes et al., 2019).

According to Laishram et al. (2018), pigs housed in deep bedding have lower susceptibility to diarrhea, inappetence, fevers, and eye and skin infections compared to those in conventional housing systems, due to increased immunocompetence.

The deep bedding system is characterized by the presence of a crucial layer of material that acts as a thermal insulator, which despite hindering heat exchanges, can still contribute to the heating of the environment because of the energy generated and released in the composting processes of the material used. Therefore, the use of deep bedding can be potentially damaging to pig farms in tropical climates, since it can increase thermal stress and substantially reduce the welfare of the animals housed (Meng et al., 2015).

To address these concerns, the objective of this study was to characterize the thermal environment and evaluate the behavior of finishing pigs housed in deep and conventional bed systems. The research also intended to verify the effect of different bedding materials on ethological parameters of the herd.

MATERIAL AND METHODS

The present study was carried out in the Department of Animal Science of the Federal Institute of Education, Science and Technology of Southeast Minas Gerais, Rio Pomba campus during the months of November and December 2016. The municipality of Rio Pomba is located in a forest region in Minas Gerais and has an average altitude of 437 m, with coordinates of latitude 21° 16' 45″ " S and longitude 43° 10' 30″″ W. According to Köppen's classification, the climate of the region is CWA (temperate, with rainy and hot summers) (Sousa et al., 2017).

The facility used for breeding pigs in the growth and finishing phases had an east-west orientation with 2.50 m ceilings, a two-story roof covered with 6 mm fiber cement tiles and external white walls. Walls were constructed of masonry with brick (0.25 m thick), internal and external walls of masonry with a height of 1.1 m were made of half bricks (0.15 m thick), containing bricks with six holes and armed concrete pillars.

Three pens were used in the study: one for each treatment: a deep bedding system with wood shavings (WS), a deep bedding with rice husk (RH), and a conventional bed system with concrete floors and water sheets (CON). Each pen had an approximate size of 6.0 × 4.0 m and a total area of 24 m², including concrete platforms that were 1.5 × 4.0 m wide and equipped with a semi-automatic feeder with four feed sites and two pacifier-style drinking fountains, each installed in metal.

Thermal environment

The data relating to the thermal environment in the stalls were automatically collected using Hobo dataloggers (model U12-013) with an accuracy of ± 0.5 °C.

The relative humidity, air temperature, and the black globe temperature were collected. For the latter, an external sensor was coupled to a datalogger, and was subsequently inserted into a black globe made manually from plastic lamps with a diameter of 150 mm and painted internally and externally with matte black spray paint. The globes were previously calibrated based on the criteria of the smallest

deviation in relation to the temperatures recorded by an Instrutherm globe thermometer model TGD-300, with operating temperatures ranging between -5 °C and 60 °C, resolution of 0.1 °C, and precision of 0.5 °C.

The sets of dataloggers and black globe sensors, one for each treatment, were positioned in the center of the stalls at 1.20 m from the floor (Sampaio et al., 2004). In order to characterize the thermal environment, in addition to the dry-bulb temperature and relative humidity data, the black globe humidity index (BGHI) was calculated using the [eq. (1)] proposed by Buffington et al. (1981).

$$BGHI= Tg + 0.36Tpo - 330.08 \qquad (1)$$

in which,

Tg: black globe temperature (K),

Tpo: dew point temperature (K).

The equipment was programmed to record data at five-minute intervals, from 8 a.m. to 5 p.m.. At the end of each day, the equipment was connected to a computer so that the information could be extracted.

The analysis was carried out in a randomized block design and split-plot scheme, while days were considered as the blocks, the treatments (floor types of the stalls) of the plots, in the subplot, and the data collection times.

The assumptions of normality were verified using descriptive statistics, with the observance of parameters such as mean, median, standard deviation, interquartile range, asymmetry, and kurtosis measures. Following the protocol established by Oliveira et al. (2015), an analysis of variance was performed via the Scott-Knott means test with 95% significance and using the "R" statistical package.

Behavioral Parameters

The behavioral parameters of the animals were observed and recorded for each treatment housing 15 animals, with a mean weight of 64.8 ± 6.7 kg, at termination. The treatments in which deep bedding was used contained a substrate layer that was 0.5 m deep, a value that is commonly used in commercial production systems. The beds were deposited at the beginning of the growth phase, when the animals entered the pen, with an average weight of 25 kg, where they remained for another 60 days until the beginning of data collection. This procedure was necessary for minimal incorporation of initial excrement into the study findings and made the results more reliable regarding the environmental profile of the bed system. Substrate replacement management was carried out at specific points in the pens, accommodating for water accumulation or excretions.

The floor was cleaned daily in the afternoon between 2 and 3 p.m. The water trough and the water accumulated at the bottom of the pen were drained once a day with the aid of slopes and by means of piping installed at one of the lateral ends of the pen. The material was then funneled to a dung system 70 m away from the facility, where it remained until it was used to fertilize pastures.

The behavior of the piglets was observed once a week over a period of four weeks, from 8 a.m. to 5:30 p.m. Observations were made by the same observer, discretely, from outside of the pens every 10 min. This was to ensure that the human interference was minimal. The behaviors of

five animals per pen that were previously differentiated using marking rods were recorded.

An ethogram of behavior was composed considering the recommendations of Amaral et al. (2014). The annotated behaviors and their characteristics are listed in Table 1.

TABLE 1. Ethogram applied in observations of finishing piglets.

Behavior	Characteristics
Lying down	Animal laying down
Eating	Head low, snout in feeder
Drinking	Head low, snout in water fountain
Exploring	Animal examining with their snout the floor floor, walls, bars or bowls
Interacting	Interacting with a companion in pens through snout contact
Sitting	Seated position on hind legs

The count of ethological behaviors was initially converted to the frequency of observation, or otherwise, to the percentage of performance of each behavior at an observed time. Subsequently, the data were analyzed using Friedman's non-parametric analysis, considering the hour factor as a block and the breeding system as the treatment.

To determine significant differences, the Wilcoxon–Nemenyi–McDonald–Thompson post-hoc test was used to identify the differences between the medians through multiple comparisons.

The data were analyzed using the "COIN" statistical packages (Hothorrn et al., 2008a), "MULTCOMP" (Hothorn et al., 2008b) of "R" software (R Core Team, 2020) and the application of a code for the post-hoc of "Tal Galili" published on r-statistic.com (http://www.r-statistics.com/2010/02/post-hoc-analysis-for-friedmans-test-r-code/).

In addition to the survey of behavioral patterns, postural patterns of all animals were observed every 30 min. Using the collected data, the activity index (AI%) was calculated following the procedure reported by Zong et al. (2014) using the frequency and time of observations that the animals were not lying down.

RESULTS AND DISCUSSION

Thermal environment

The data related to the thermal environment are presented in Table 2. It was found that the daily averages of BGHI were lower for treatments in overlapping beds with shavings and rice husks, than those of the conventional beds. It was not possible to observe differences between air temperatures, since they were found to be in the range of the general average at the evaluated times. However, the daily relative humidity average was lower in the treatment that contained an overlay bed with wood shavings than in the other groups.

TABLE 2 - Environmental variables observed in installations for finishing pigs with conventional flooring (CON) and with an overlapping bed system using wood shavings (WS) or rice husk (RH).

Hour	Variables								
	BGHI[1]			Temp. (Cº)[2]			RH (%)[3]		
	WS	RH	CON	WS	RH	CON	WS	RH	CON
08 hs	72,9a	73,2a	73,5a	24,5a	24,5a	24,6a	72,1a	75,5a	75,9a
09 hs	74,8a	74,7a	75,1a	26,0a	25,8a	26,1a	68,9a	70,7a	70,5a
10 hs	76,4a	76,4a	76,7a	27,5a	27,4a	27,5a	64,5a	65,6a	65,4a
11 hs	78,0a	78,0a	78,1a	29,1a	28,9a	29,0a	59,7a	60,0a	60,0a
12 hs	78,9a	79,0a	79,1a	30,0a	29,9a	30,0a	56,9a	56,9a	57,2a
13 hs	79,5a	79,7a	79,8a	30,5a	30,6a	30,7a	55,7a	55,3a	55,7a
14 hs	80,0a	80,0a	80,2a	31,1a	31,0a	31,1a	53,8a	53,3a	53,9a
15 hs	80,2a	80,4a	80,3a	31,4a	31,4a	31,4a	51,1a	51,0a	51,7a
16 hs	79,1a	79,2a	79,6a	30,4a	30,4a	30,7a	52,8a	53,5a	53,7a
17 hs	78,1a	78,2a	78,7a	29,5a	29,5a	29,9a	53,7a	54,7a	55,1a
Median	77,8b	77,9b	78,1a	29,0a	28,9a	29,1a	58,9b	59,7a	59,9a
CV (%)	1,43			3,71			7,13		

Means followed by different letters on the same line differ from each other by the Scott–Knott test (P < 0.05).
[1]black globe humidity index; [2]dry bulb temperature; [3]relative humidity.

The general average temperature was close to 29 °C with relative humidity between 59 and 60% for all treatments. As expected, between 2 pm and 3 pm, the highest temperatures and highest BGHI values were recorded, at higher than 80.

The thermal environment data revealed that all evaluated finishing pigs, regardless of treatment, were in a state of thermal stress. The thermoneutral zone for finishing pigs reaches its maximum limit at 72 (Cecchin et al. 2019).

Behavioral Parameters

The results relating to animal behavior and the AI% are presented in Table 3. The values shown refer to the medians per hour of the frequencies of observation of each behavior. For the AI%, the values represent the percentage of time per day allocated to any behavior, except lying down.

TABLE 3. Frequency of behavioral patterns observed in finishing pigs, housed in a concrete floor pen (CON), a deep bedding system with wood shavings (WS) and a deep bedding system with rice husks (RH).

Behavior	Bedding system		
	RH	WS	CON
	Frequency (%)		
Lying down	79.03a	75.76a	77.55a
Drinking	2.48ab	3.89a	1.06b
Eating	7.79b	7.26b	11.19a
Exploring	8.19a	8.48a	7.78a
Interacting	1.39a	1.62a	0.61a
Sitting	1.12a	2.99a	1.81a
Activity index	44.44a	36.39ab	30.00b

Medians followed by different letters differ by the Friedman test ($p < 0.05$).

There was no significant difference in the frequency of observations of the following behavioral patterns: "lying down," "exploring," "interacting," and "sitting." However, the behavioral patterns associated with "drinking" and "eating" were influenced by the adopted breeding system ($p < 0.05$).

The "drinking" behavior, defined by the ethogram as when the animal placed its head to the drinking fountain, regardless of whether or not there was a voluntary act of drinking, was highest for the pigs in the deep bedding system with the wood shavings substrate, followed by those in the composite bed of rice husk, and finally those in the compact floor system ($p < 0.05$).

The observed difference between the treatments can be explained from the point of view of the microclimate generated in the area of the drinkers. Unlike the concrete floor, where the low surface thermal inertia allows for superior heat exchange between the animal and the floor, deep bedding leads to difficulties in maintaining homeostasis, especially during the hottest times of the day, by reducing or preventing heat exchanges through conduction with the ground.

Thus, at these times, the animals sought to lie down on the small concrete area intended for food and water. On the platform, the areas of greatest competition for rest were those around the drinkers, where the microclimate was benefited by the cooling of the air and the floor due to the water that sometimes spilled. Associated with this, it was observed that the animals laid down and projected their heads inside the drinking fountain as a way to promote improvements in their physiological condition. However, they did not use the cold water expelled by the pacifier type triggers and the water accumulated in the metal shells.

In contrast to what was observed in the present study, Caldara et al. (2012) affirm that pigs housed in a bed system overlaid with shavings, coffee husks, or a compact

floor, do not present differences in the frequencies of visits to drinkers.

According to Cordeiro et al. (2007), it was not possible to verify the differences between water consumption (L/day) for pigs housed in a conventional or deep bedding system. However, the authors indicated that among the bedding materials analyzed, there was greater water consumption by piglets housed on the substrate of wood shavings than by those housed on rice husks.

inconsistent to the present study, Hötzel et al. (2009) found differences in the behavioral pattern of "drinking" for piglets around 120 days of age, with the highest values being associated with the animals in the deep bedding systems with wood shavings; however, there was no difference with regards to the total evaluation period and water consumption between treatments.

The high frequency of visits and the act of projecting the head toward the drinking fountain, triggering the system without drinking water properly (drinker-playing) (Chen et al., 2020), as seen in the bed systems, especially in pens with wood shavings substrate, can be interpreted as stereotypies or obsessive behavior (Maia et al., 2013; Massari et al., 2015).

The frequency of the behavioral pattern of "eating" was higher in the concrete floor pen ($p < 0.05$), followed by the composite systems of deep bedding.

The higher frequency of the "eating" variable does not necessarily imply higher or lower feed consumption, but the frequency of visits to the feeder. In this sense, the lower values observed for the deep bedding can be analyzed through two prisms. First, it can be inferred that the monotonous environment of the pen in a conventional system favored the animals' greater frequency of visits to the feeders because this is one of the few compensatory activities to which the piglets had access. Alternatively, one can interpret the lower frequencies of visits to the feeder observed in the treatments with bedding as a response to the

thermal stress induced by these environments. Despite the data of the thermal environment (BGHI) indicating a higher average value for the conventional system (p <0.05), it is worth mentioning that in all the evaluated systems, thermal stress was present (BGHI> 72) and in the water slide system and concrete floors, the animals have alternatives that are not possible in the overlay bed system, such as heat exchange via conduction with the floor and access to the water slide itself. If this hypothesis is true, animals housed in an overlay bed may need to make physiological adjustments, such as a reduction in consumption aimed at decreasing the production of metabolic heat resulting from the caloric increase in diet.

Pigs housed in the concrete floor system (11.19%) showed higher frequencies than those housed in the deep bedding systems (< 8%) for the behavior pattern "eating." According to the results of Debreceni et al. (2014), the "eating" behavior was observed at an average frequency of 16%. This value is corroborated by Amaral et al. (2014), who observed frequencies around 15.48%–18.75% during daytime. In addition to the thermal environment data, these results may indicate the effect of thermal stress, in different proportions for the systems studied.

In contrast to the results of this study, Hötzel et al. (2009) did not observe differences between the frequencies of the behavior "eating" between the deep bedding systems with wood shavings or rice husks, and the concrete floor. However, in that study, the average temperature was 22.3 °C, which is considerably lower than the 29 °C observed in the present study.

Piglets may exhibit changes in their behavior patterns depending on the environment in which they are kept. Massari et al. (2015) state that "eating" behavior has an inverse relationship with air temperature and a strongly positive relationship with exploratory behaviors and agonistic interactions, since exploratory behaviors are often related to the search for food.

However, in the present study, given the low variation in the thermal parameters and the homogeneity of the exploratory behaviors among the different treatments, these statements were not verified.

According to Caldara et al. (2012), corroborating our results, the highest frequency of visits to the feeder was of animals confined to concrete floors, to the detriment of piglets housed in pens with beds. The data of the thermal environment also indicated values of BGHI greater than 72 for animals housed in deep bedding and within the thermoneutral zone for animals housed in the conventional system.

In addition, the authors mention that even with the increased frequency of visits to the feeders, it was not possible to verify the difference in the average feed consumption between the systems. Based on this fact, the increase in frequency of visits to the feeders was attributed to the monotonous environment and the lack of environmental stimulus provided by the concrete floor in relation to the deep bedding. In this scenario, the feeders are configured as objects capable of promoting compensatory reactions, becoming the source of food and are practically the only structure present in the pens, except for the walls and floor.

These results are also in agreement with those of Morrison et al. (2003), who ascertained a greater number of visits to the feeder in the conventional system when compared to animals in the deep bedding. In addition, the authors indicated that the duration of the "eating" event for animals housed in the deep bedding system was longer than that of those in the conventional system.

The activity index of the animals was highest for those in the deep bedding system with rice husk substrate (p <0.05). However, it was not possible to detect significant differences between the bedding materials used. The animals housed in the concrete-floored pen were less active than the other animals.

The results for the activity index indicate that active behaviors increased in animals housed in deep bedding systems, especially with rice husk substrate.

The values used to calculate the activity index took into account all animals housed in each pen, and therefore, this variable tends to be more accurate than the calculation of behavioral patterns. Thus, despite the insignificance observed among the frequencies of some of the active behaviors present in the applied ethogram (p > 0.05), the activity index indicates that the deep bedding environment may be more attractive because it provides more periods of leisure to the animals, and consequently, better animal welfare.

The results observed for the deep bedding system with rice husk are mainly due to its physicochemical (composition and granulometry) characteristics. The material, even after combining with excretions and compacted by the permanence of the piglets, remained aerated, with little or no formation of aggregates of easy mechanical action and, consequently, allowed more intense explorations by the animals.

According to Sanes et al. (2015), rice husk in nature is composed of high levels of silica, which hinders the action of microorganisms and maintains the structure of the material. Due to its chemical and structural composition, rice husk is known to be a material with high potential for compressive strength (Pereira et al., 2015).

These characteristics were not observed in the deep bedding system with wood shavings. The deposited material did not present uniform granulometry, besides producing substantial amounts of particulate matter with compressive action due to trampling. Along with this, high organic load and moisture from the waste are added, and as a result, there is a highly compacted material at some points with high resistance to drilling. In this case, exploratory activities are limited, as the animals are unable to root around because of the mechanical resistance acquired by the bed surface, reducing the gains in animal welfare advocated by technology and considerably increasing the labor requirement necessary for the practice of revolving and disintegrating the substrate.

The values for the frequencies of the "lying down" pattern did not differ between treatments. This result is possibly due to the thermal stress in which all animals, regardless of treatment, were experiencing. Authors such as Kiefer et al. (2010), Debreceni et al. (2014), and Massari et al. (2015) indicate that this behavioral pattern is closely related to the thermal environment and that animals under heat stress increase their time spent lying down. The strong positive correlation between the thermal and behavioral variables is due to the animals' attempt to increase heat exchange with the floor, which is cooler, in addition to reducing the production of metabolic heat by avoiding activity.

Debreceni et al. (2014) state that pigs are less active when exposed to high temperatures, and in such cases, they resort to lying in cool areas, preferably on non-bedded floor surfaces. This justification further corroborates the hypothesis previously presented for the results of the "drinking" behavioral pattern.

However, there is considerable variation in the frequencies observed in different sources in the literature. This is due to the vastness of the behavioral spectrum of the animals and their sensitivity to a range of variables such as breeding models, breeding stage, animal density, genetics, temperature, air, and social environment. For example, Amaral et al. (2014) showed that pigs subjected to natural light, 16 h of light and 23 h of light presented frequencies of 67.59%, 71.30%, and 68.55% of the time spent lying down during the daytime. The results of Caldara et al. (2012), working with deep bedding with shavings (~60%), bark (~65%), and compact floor (~55%), reveal even lower frequencies.

Guy et al. (2002) found that piglets housed in straw-floored pens tend to display the behavioral pattern of spending more time lying down, but in an active way. In contrast, animals confined in slatted stalls were more inactive.

We observed no significant difference in the "exploring" behavioral pattern. This is probably due to the lack of distinction in the nature of exploratory behavior, since a higher frequency of exploration is expected in the pens of the deep bedding system.

Our results differ from those of Caldara et al. (2012), who indicated more exploration in concrete floor treatments. However, in addition to exploration of the pen and commonly used equipment, the authors included other behavioral patterns in the same variable, such as interactions between individuals with the snout, regardless of the nature of the contact.

According to Hötzel et al. (2009), for the pigs housed in pens with deep bedding and rice husk, the subdivision of the category of exploratory behaviors showed less activity related to the manipulation of objects, as a consequence of the stimuli coming from the bed substrate.

Exploratory behaviors are natural to pigs, and in many cases, are related to the search for food in their natural environment and, therefore, constitute an important criterion in the analysis of animal welfare in breeding systems. In a study of an outdoor production environment, it was found that the frequency for this category should be higher than 15% of the observations to meet ethical standards (Nakamura et al., 2011).

The findings presented here for the "interacting" pattern did not show a significant difference between the treatments.

According to Hötzel et al. (2009), the "interacting" behavior was subdivided into "playing", "fighting", and "oral-nasal contact" Thus, the contrast between the beds and the concrete floor showed higher frequencies of positive interactions and lower frequencies of "oral-nasal contact" in the deep bedding system, which implies a lower incidence of vices such as biting the tail, ears, and belly button.

Similarly, the results of Guy et al. (2002) also indicated a lower incidence of tail biting for animals housed in deep bedding compared to animals on concrete floors.

These results are corroborated by Braga et al. (2006), who in a literature review affirm that the provision of materials for exploratory behavior reduce problems of stereotyped behaviors related to cannibalism, as the deep bedding system aids.

The standard "sitting" behavior evaluated by Hötzel et al. (2009) did not differ between deep bedding systems and concrete floors. However, the values noted by Hötzel et al. (2009) were significantly higher than those reported in this study were, varying between 6.1% and 7.6% of the observations, compared to our observed range of 1.2% to 2.99%.

Nonetheless, these results are consistent with those of Amaral et al. (2014), who observed a variation of 1.71% to 2.75% for seated animals. Even lower values were reported by Debreceni et al. (2014), who observed the pattern "sitting" in 1% of the observations.

Guy et al. (2002) did find a difference between the evaluated systems. The animals housed in the deep bedding presented a lower frequency of sitting behavior. However, this was only perceptible due to the subdivision proposed for the postural pattern in active or inactive individuals. Therefore, the referenced result was found for only the "sitting inactive" behavior.

The results for the AI% revealed higher frequencies for animals housed in the deep bedding with rice husk, as compared to those housed in the conventional system, but the values did not differ from those observed in the wood shaving substrate. This fact is corroborated by Guy et al. (2002), who assert that piglets in deep bedding systems spend more time on exploratory behaviors such as examining the floor, moving around the pen area, urinating and defecating, and social activities as compared to animals housed in slated stalls.

In Figure 1, the AI% dynamics are plotted in relation to the observation times and the corresponding treatment. Regarding the evaluation schedules, it should be noted that the highest values of activity occurred in the late afternoon.
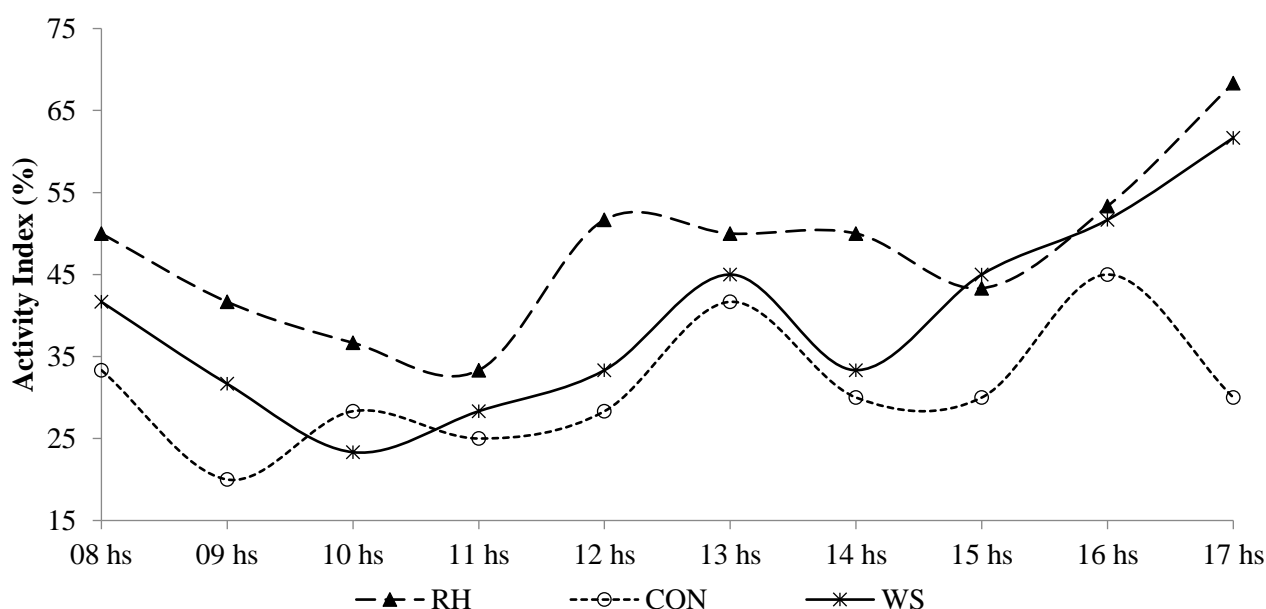
FIGURE 1. Activity index for pigs housed in cages with rice husk (RH), wood shavings (WS) and concrete floor (CON), according to the hours of observation.

In contrast, the pigs showed minimal activity in the morning, starting at 9 a.m. in the conventional system, at 10 a.m. in the deep bedding and at 11 a.m. in the rice husk substrate system. This result is supported by the findings of Saha et al. (2010), that identified minimum activity in the morning for pigs housed in pens with partial wooden floors, in a closed shed.

At about 1 p.m., a peak in activity was observed, followed by a brief decline in activity until 3 p.m. This is due to the handling of feeding and cleaning pens that occur at that time. Therefore, it can be alleged that the entrance of the employees into the pens promoted agitation in the pigs. However, this increase in the index of activity was quickly overtaken by a rest period, coinciding with the hottest time of the day, between 2 and 3 p.m.

The animals housed in the pen with deep bedding and rice husk showed the highest activity indices a majority of the time, except at 3 p.m., when there was a slight increase in the activity of the animals housed in the wood shaving system. Conversely, the animals housed in the conventional system showed the lowest activity indices, except at 10 a.m., when the lowest value for the index was in the bed system with wood shavings.

The literature suggests the use of the activity index as a satisfactory tool for measuring animal welfare, since this variable has a well-defined pattern of two peaks (one in the morning and another stronger peak in the late afternoon). Therefore, automated systems for assessing activity have been developed. Von Jasmund et al. (2020) affirm that activity level changes due to stressors, such as diseases or heat.

In this study, we observed higher frequencies of activity in deep bedding systems than in the other two systems, as well as a higher frequencies of the behavioral pattern of "drinking". Andersen et al. (2020) alleged a relationship between the frequency of drinking and activity level for pigs. Thus, even if drinking behavior is not subdivided into ingesting water and drinker playing, this pattern can be considered a favorable measure of welfare, due to its positive correlation with the level of activity.

CONCLUSIONS

Higher values of BGHI were found in the thermal environment of the conventional system, although thermal stress was identified in all rearing systems and throughout the evaluated period.

Regarding behavioral variables, animals in conventional systems had a higher frequency of visits to feeders, while animals in an overlapping bed system are more active and visit drinking fountains more frequently.

Despite the higher level of activity of the animals in the deep bedding system, mainly in the system with substrate of "rice husk," it is not possible to assert that the overlapping bed provides a better degree of well-being for the animals under thermal stress conditions.

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