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Effects of the environmental enrichment on pigs' behavior and performance

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ABSTRACT - The study evaluates the influence of environmental enrichment on behavior, leucometry, and performance of commercial pigs. Thirty-two hybrid pigs (Landrace × Large White × Pietran), at 69 days of life, were divided into four groups and subjected to different environmental stimuli: concrete floor, with no enrichment (C); floor bedding with wood chips (CM); concrete floor, with mobiles (MO); floor bedding with wood chips and the presence of mobile (CM + MO). The study collected behavioral data of the animals during 84 days, through the growing and finishing phases, each lasting 42 days, assessing the animals' position and behavior by the instantaneous scan sampling method. The animals received *ad libitum* water and a specially formulated feed following the nutritional requirements for growing and finishing phases. The study considered daily feed intake, daily weight gain, and feed conversion. Group CM in the growing phase showed prolonged standing position periods and demonstrated a greater exploration of their environment (2.1%). Groups MO and CM + MO, in the growing phase, demonstrated extended periods of interaction with the offered enrichments (10.8±2.1 and 9.1±2.8%, respectively). Piglets in the finishing phase housed in pens with floor bedding with wood chips and those housed in pens with floor bedding with wood chips and the presence of mobile (tires and chains) showed longer interaction time with enrichments (4.8 and 5.4%, respectively), compared with the other groups C and Mo. Group C remained overall the longest in a standing position in both breeding phases. There was no effect on the animals' leukogram. Environmental enrichment with wood shavings (as beddings) and hanging mobiles improves behavioral aspects of piglets in the growing and finishing periods.

Keywords: animal welfare, floor bedding, mobiles, stress, swine

1. Introduction

The post-World War II agriculture industrialization brought about many radical changes in farming methods. The increase in the number of animals gathered in intensive breeding has been the chief mark of the farming evolution (Gonyou, 1994; Broom and Fraser, 2010). Over time, studies have been undertaken on animal well-being concepts (Broom and Molento, 2004), focusing on the animal's ability to adjust to the environment (Broom, 1991), the housing condition (Galhardo and Oliveira, 2006), and their life quality (Frajblat et al., 2008).

Nowadays, in industrialized pig farming, animals are housed in stalls without any environmental stimulation, causing chronic stress (Oliveira et al., 2016), which leads to a reduced immune response of animals, predisposing them to disease and loss in production performance (Dickson, 2017). However, to be successful, this also requires a substantial change of management, with careful animal care, lower stocking densities, improved air and water quality, and the provision of a stress-free environment, which most farmers in existing systems find very difficult to achieve (Nalon and De Briyne, 2019).

Pork production in Brazil has grown considerably. Nowadays, Brazil is one of the largest producers worldwide (ABPA, 2019), thus, the interests of producers to expand into more demanding markets, such as China, the US, and the EU, and consequently, a higher focus on animal well-being issues. The Normative Instruction No. 113 publication, of December 16, 2020, establishing good management practices and animal welfare in commercial pig farms, consolidates the trends that several Brazilian companies have already adopted in terms of respect for well-being in pig farming (ABPA, 2021).

Environmental enrichment consists of a series of procedures and equipment that modify the physical and social space of confined animals, improving life quality by attending to the species' natural behaviors (Coleman and Novak, 2017), and as a consequence, allowing for an overall goal to increase livestock production and product quality. Furthermore, by enhancing animal welfare, it is believed that an increase in cognitive abilities will contribute to easing livestock management, boost the immune system, and decrease stress and fear towards the caretakers (Hausberger et al., 2019).

Vanheukelom et al. (2012) found beneficial effects on both piglets' and sows' welfare by providing opportunities to engage in explorative behavior, nest-building, and social interactions and improving maternal responses. These positive effects can also extend into the growing phase (Telkänranta et al., 2014). Examples of materials for environmental enrichments include wood chips, chains, ropes, and tires (Mkwanazi et al., 2019). Thus, the integration of environmental enrichment techniques in livestock production systems is steadily growing and is producing satisfactory results, as mentioned before (Oliveira et al., 2016).

This study evaluates the influence of environmental enrichment techniques on the behavior, leucometry, and growing performance of pigs during two different phases (growing and finishing).

2. Material and Methods

The research followed the orientations on animal welfare as the institutional committee on animal use (073/09). The experiment was performed in Campos dos Goytacazes, Rio de Janeiro, Brazil, located at 21°45'15" latitude and 41°19'28" longitude, with an elevation of 13 m.

Thirty-two commercially available hybrid (Landrace × Large White × Pietran crossbred) pigs were used, 16 males and 16 females. Male pigs were surgically castrated at seven days of age; all pigs started the experiment at 69 days of age and with an average weight of 26.24±5.44 kg. The animals were housed in a cement ceiling covered stable, 3.5 m in height, with brick-walled bays, measuring 2.10 × 2.08 × 0.93 m (length × width × height), fitted with brick-built feeders, measuring 0.44 × 0.15 × 0.09 m (length × width × height), and a pacifier type water dispenser. Two pigs were housed per pen.

The animals were distributed in a randomized block design into four treatments with four repetitions. Each pen corresponded to one experimental unit. The treatments were arranged in a 2 × 2 factorial scheme combining bedding and hanging mobiles usage in the pens. The control consisted of concrete floor, with no enrichment, and the other treatments received floor bedding with wood chips (CM); concrete floor, with mobiles (MO); and floor bedding with wood chips and the presence of mobile (CM + MO).

The CM treatment consisted of a bed that was composed of wood shavings (25 cm height), which were changed every ten days and covered the entire pen floor. The MO treatment consisted of a pen composed of mobiles (a tire that was on the loose floor, an iron chain, and a suspended tire that reached the ground level in the central position of the pen) that were not renewed in the experiment and did not represent any risk to animals. The CM + MO treatment consisted of a pen composed of all the enrichments described in the CM and MO treatments.

The animals received a formulated feed, meeting all nutritional requirements during the growing and finishing phase (Rostagno et al., 2017). Water and feed were offered *ad libitum* during the entire experimental period. The stable environmental conditions were monitored throughout the trial period by a digital thermohygrometer (Model7666.02.0.00, Cotronic Technology Ltd, Incoterms, China), with an accuracy of 1°C ± 5%. Relative humidity was monitored with internal and external sensors coupled to the black globe. The equipment was maintained at the middle point of the stable at half the animals' body height. The average minimum and maximum temperatures were 18.23±1.80 and 23.01±1.20 °C, respectively. The black globe thermometer measured the temperature, which average value was 18.67±1.33 °C.

The experimental period lasted 84 days (total period), divided into two phases, each one lasting 42 days: growing phase (69-111 days of age) and finishing phase (112-154 days of age). The behaviors were monitored on ten distinct days—days 1, 9, 17, 26, and 35 of each phase. The assessments were performed using images obtained through video cameras placed on the upper part of the pen and directly connected to a device equipped with a DVD recorder and LCD monitor (Neocam, model H.264DVR, São Paulo, Brazil). The recorded images were stored in the memory of the monitoring device and later used for the assessments. The images were visualized using the CyberLink video software to evaluate the behavioral activities frequency. The film footage was analyzed uninterrupted by a single observer performing the behavioral records at the morning (8:00 to 10:00 h) and afternoon (14:00 to 16:00 h) shifts. The observer recorded each animal's identity and its activities. The behavior of the swine pair was analyzed together, and each bay was considered an experimental unit. The description of behavior was based on Pandorfi et al. (2006) and adapted for this study (Table 1).

At the end of each phase (growing and finishing), after weighing, blood was sampled from animals of each experimental unit via jugular vein puncture. Animals were randomly chosen, and in the next phase, the same animal was sampled. Three mL of jugular blood was collected using BD® brand sterile disposable syringes and needles (25 × 8 mm). The samples were filled into vacuum tubes containing

Table 1 - Ethogram of commercially available piglets crossbred (Landrace × Large White × Pietran) concerning position, location, and behavior

Behavioral observations	Description
Standing	Standing in the stall
Lateral recumbency	Laying on the side
Floor	Located on the floor
Feeder	Located next to the feeder
Pacing	Walking around the stall
Eating	Ingesting feed from the feeder
Rooting	Exploring the floor or parts of the installation with the nuzzle
Still (inactive)	Open eyes, without any motion
Animal interacts with the environment	Playing environment enrichment items
Urinating	Urinating
Defecating	Defecating
Scratching	Rubbing body parts against stall construction
Sleeping	Laying on the floor, with eyes closed, in the stall area
Drinking	Ingesting water from the water fountain
Vocalizing	Producing sound and grunts
Biting	Abnormal behavior, chewing parts of the installation

10% EDTA (VACUETTE®), then identified, homogenized, transported on ice-packs to the pathology laboratory, and stored under refrigeration until further use.

Piglet's blood samples were examined with a hematology cell counter, model MS4 (Melet Schloesing Laboratories®, France). Blood smears were prepared and stained with a Panotic dye (Newprov®) for future leucometry analysis. Upon completing the automated count, a differential count and evaluation of the blood cells via blood smear were performed using an optical microscope (1000X).

The offered food, their leftovers, and waste were included in determining the average feed intake in the growing and finishing phases. All animals were weighed at the beginning and the end of each development phase (growing and finishing), allowing us to determine the average weight gain in these phases. The feed conversion was obtained by the average feed intake to mean weight gain ratio in both growing and finishing phases. After the growing and finishing phases, backfat thickness of pigs were measured. For this, the Aloka ultrasound equipment (SSD-500 model) and a linear transducer of 3.5 MHz (UST 5011 model) with accuracy of 92.1% were used according to Souza's (2011) methodology.

2.1. Statistical analysis

The animals were distributed in a factorial experimental design of randomized blocks (2 × 2) with four treatment groups and four repetitions; the pen was considered one experimental unit, totaling 16 units. Two animals were used per experimental unit, totaling eight animals per treatment.

The resulting data of behavior, leukogram, and performance of the animals were subjected to the Lilliefors test, verifying the normality of distribution. Afterward, the data were subjected to analysis of variance (F test), at 5% probability, using the SAEG program (Statistical and Genetic Analysis System), version 9.1 (2006). Tukey's test assessed the significance of the differences between the results at $P<0.05$. The trend effect was considered in the range of P-values between 0.05 and 0.10. The resulting values for the behavior measures were converted into a percentage and represented in tables.

3. Results

During the growing phase, the pigs housed in CM remained most of the time standing ($P<0.05$) in the morning periods and only for short periods resting on the side, compared with animals in CM + MO (Table 2). This shows that a CM-treated pen would enable animals to be more explorative of their environment (2.1 vs. 0.6%), compared with animals accommodated in CM + MO ($P<0.05$) (Table 2). The animals displayed this behavior during both the morning and afternoon shifts.

The results demonstrate that pigs during the growing phase interacted more with enrichments MO and CM + MO than in the finishing phase, showing a lack of interest in enrichments over time (Figure 1 and Table 3).

There was no effect ($P>0.05$) on average number of white blood cells, eosinophils, neutrophils, lymphocytes, monocytes, and neutrophils:lymphocyte ratio of piglets housed in stalls with or without environmental enrichment of wood shaving bedding or mobiles during growing and finishing phases (Table 4). Although there was no significant effect, the results highlighted a trend in the number of neutrophils in the growing phase ($P = 0.07$), which may have influenced the mean neutrophils:lymphocytes ratio ($P = 0.059$), which is an essential parameter for evidence of stress in animals. In addition, there was a trend ($P = 0.068$) of eosinophilia in animals housed in the CM treatment in the finishing phase (Table 4).

There was no effect ($P>0.05$) of environmental enrichment on average feed intake, average weight gain, feed conversion, and backfat thickness of pigs during growing and finishing phases (Table 5). Although there was no significant effect, the results highlighted a trend ($P = 0.095$) of lower backfat thickness in pigs housed in CM and MO pens in the growing phase, showing that the use of environmental enrichment tends to improve performance parameters.

Table 2 - Average percentage (±SEM) of the observed behaviors of 32 piglets of commercially available hybrids (crossbred Landrace × Large White × Pietran) in the morning, afternoon, and total period during 42 days the growing phase

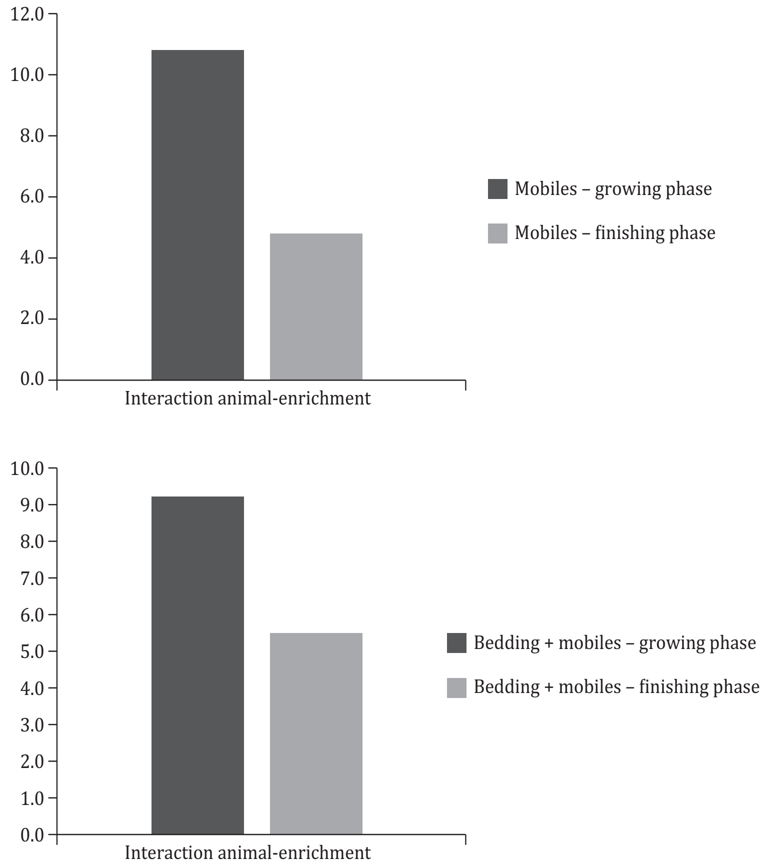
Behavior	Shift	Treatment[1]				P-value
		Control	CM	MO	CM + MO	
Standing	Morning	23.6±9.1ab	40.2±7.5a	27.7±5.3ab	19.1±3.3b	0.03
	Afternoon	34.8±6.7	42.2±8.0	37.6±5.3	35.1±1.8	0.50
	Total	29.2±5.3	41.2±7.0	32.6±5.0	30.1±3.1	0.25
Lateral recumbency	Morning	72.1±9.6ab	55.5±7.0b	68.8±6.3ab	76.8±4.7a	0.03
	Afternoon	58.5±4.8	50.3±6.9	55.5±5.5	56.5±6.9	0.49
	Total	65.3±4.3	52.9±5.8	62.2±5.1	63.5±5.1	0.77
Floor	Morning	77.5±10.9	74.7±5.1	86±3.5	88.9±3.8	0.25
	Afternoon	88.6±4.5	83.7±7.1	90±3.5	88.1±6.3	0.36
	Total	83±7.7	79.2±5.5	88±3.0	85.8±3.3	0.77
Feeder	Morning	22.5±10.9	25.3±5.1	14±3.5	11.6±3.7	0.27
	Afternoon	11.4±4.5	16.3±7.1	10±3.5	11.9±6.2	0.36
	Total	17±7.7	20.8±5.5	12±3.0	14.3±3.1	0.77
Pacing	Morning	1.6±0.4ab	2.1±0.4a	1.1±0.5ab	0.6±0.3b	0.04
	Afternoon	3±0.9a	3.2±0.5a	2.2±0.7ab	0.8±0.1b	0.03
	Total	2.3±0.6ab	2.7±0.4a	1.6±0.7ab	0.7±0.1b	0.02
Eating	Morning	14.6±6.6	20.7±4.0	12.4±3.2	6.1±5.0	0.14
	Afternoon	4.7±1.8	12.5±6.2	7.7±3.6	9.6±5.9	0.70
	Total	9.6±4.2	16.6±4.1	10±2.4	10.9±3.9	0.38
Nuzzling	Morning	10.1±2.5	14.8±2.1	9.3±3.7	8.7±3.0	0.30
	Afternoon	27.3±2.6	26.8±4.0	19.6±4.4	17.9±4.4	0.14
	Total	18.7±2.3	20.8±2.3	14.4±3.7	13.6±3.6	0.18
Inactive	Morning	18±5.6	20.7±4.8	16.8±3.5	23.3±4.0	0.61
	Afternoon	33.1±5.8	27±0.7	26.9±3.2	29.4±1.9	0.41
	Total	25.5±5.4	23.8±2.7	21.8±3.3	23.2±3.2	0.24
Animal × enrichment	Morning	0c	0.8±0.2bc	7.8±2.3a	4.7±1.3ab	< 0.01
	Afternoon	0b	1.5±0.6b	13.9±2.2a	8.7±2.3a	< 0.01
	Total	0b	1.1±1.1b	10.8±2.1a	9.1±2.8a	< 0.01
Urinating	Morning	0.5±0.3	0.7±0.1	0.5±0.1	0.3±0.03	0.23
	Afternoon	0.8±0.3	0.7±0.2	0.7±0.2	0.7±0.2	0.18
	Total	0.7±0.2	0.7±0.2	0.6±0.1	0.5±0.1	0.28
Defecating	Morning	0.2±0.1	0.3±0.1	0.6±0.1	0.6±0.03	0.07
	Afternoon	0.2±0.1	0.2±0.1	0.1±0.1	0.3±0.2	0.52
	Total	0.2±0.1	0.2±0.1	0.1±0.1	0.2±0.1	0.63
Scratching	Morning	0.2±0.03	0.4±0.3	0.2±0.1	0.2±0.1	0.33
	Afternoon	0.4±0.1	0.4±0.2	0.4±0.2	0.1±0.1	0.13
	Total	0.3±0.04	0.4±0.2	0.3±0.1	0.1±0.1	0.10
Sleeping	Morning	50.5±5.3	32.7±8.3	47.5±4.3	49.8±8.5	0.14
	Afternoon	21.5±2.2	20.3±5.6	22.6±4.0	24.9±9.1	0.16
	Total	36±3.0	26.5±6.4	35.1±2.1	34.9±7.5	0.41
Drinking	Morning	1.7±0.5	3.2±1.4	1.7±0.4	1.9±0.6	0.36
	Afternoon	1.1±0.2	1.3±0.3	1±0.2	1.1±0.4	0.35
	Total	1.4±0.3	2.3±0.8	1.3±0.3	1.6±0.5	0.39
Vocalizing	Morning	0.4±0.03	0.1±0.1	0.6±0.1	0	0.34
	Afternoon	0.5±0.1	0.6±0.4	0.3±0.2	0.2±0.1	0.78
	Total	0.2±0.1	0.4±0.2	0.2±0.2	0.7±0.1	0.36
Biting	Morning	0.4±0.1	0.2±0.2	0.2±0.1	0.2±0.2	0.74
	Afternoon	1.4±1.1	0.4±0.3	0.4±0.1	0.4±0.2	0.40
	Total	0.9±0.6	0.3±0.2	0.3±0.1	0.3±0.1	0.28

SEM - standard error of the mean.
[1] Control - concrete floor, with no enrichment; CM - floor bedding with wood chips; MO - concrete floor, with mobiles; CM + MO - floor bedding with wood chips and the presence of mobile.
a-c - Different letters in the same row differ significantly by Tukey's test at 5% probability.

Table 3 - Average percentage (±SEM) of the observed behaviors of 32 commercially available hybrid piglets (crossbred Landrace × Large White × Pietran) in the morning, afternoon, and total period during the 42 days of the finishing phase

Behavior	Shift	Treatment[1]				P-value
		Control	CM	MO	CM + MO	
Standing	Morning	18.3±10.1	18.7±0.6	27.9±8.3	19.3±2.5	0.70
	Afternoon	21.7±5.1	23.1±3.8	27.3±0.2	24.3±6.3	0.42
	Total	20.0±2.9	20.9±1.6	27.6±4.2	22.8±2.2	0.16
Lateral recumbency	Morning	79.8±10.0	77.1±1.1	68.0±7.2	78.2±3.0	0.42
	Afternoon	67.6±5.6	62.8±6.1	64.9±1.6	67.3±5.0	0.31
	Total	73.7±2.2	70±3.6	66.4±3.4	72.8±1.6	0.17
Floor	Morning	86.4±10.6	89.9±1.1	82.0±8.8	88.9±3.2	0.36
	Afternoon	91.4±2.0	93.3±1.4	93.8±0.9	92.0±1.4	0.82
	Total	88.9±4.3	91.6±1.3	87.9±4.4	90.5±1.1	0.39
Feeder	Morning	13.6±10.6	10.1±1.1	18±8.8	11.1±3.2	0.36
	Afternoon	8.6±2.0	6.7±1.4	6.2±0.9	8.0±1.4	0.82
	Total	11.1±4.3	8.4±1.3	12.1±4.4	9.5±1.1	0.39
Pacing	Morning	1.0±0.4	1.1±0.1	1.3±0.3	1.3±0.4	0.27
	Afternoon	1.6±0.4	1.8±0.6	1.8±0.5	1.5±0.3	0.15
	Total	1.3±0.2	1.5±0.3	1.5±0.4	1.4±0.2	0.21
Eating	Morning	12±9.0	10.7±0.6	18.6±8.2	10±2.4	0.60
	Afternoon	3.8±1.3	4.7±1.3	5.2±0.9	6.5±1.0	0.26
	Total	7.9±4.0	7.7±0.8	11.9±3.9	8.2±1.2	0.70
Nuzzling	Morning	6.5±1.8	6.8±2.0	7.6±2.2	8.4±1.6	0.30
	Afternoon	21.7±1.9	20.4±4.9	17.3±1.6	14.6±1.9	0.21
	Total	14.1±0.3	13.6±3.1	12.4±1.8	11.5±1.3	0.53
Inactive	Morning	20.9±4.6	23.6±2.2	16.9±2.1	21.9±1.1	0.25
	Afternoon	52±1.8a	45.5±5.0a	46.6±3.5a	31.7±2.7b	< 0.01
	Total	36.4±2.9a	34.6±3.2ab	31.7±4.0ab	26.8±0.9b	< 0.01
Animal × enrichment	Morning	0	2.4±1.6	2.3±0.9	3.7±1.7	0.13
	Afternoon	0b	2.1±0.9ab	7.3±0.9a	7.1±3.0a	< 0.01
	Total	0b	2.3±1.2ab	4.8±1.3a	5.4±1.9a	< 0.01
Urinating	Morning	0.6±0.4	0.2±0.1	0.2±0.1	0.4±0.1	0.30
	Afternoon	0.6±0.1	0.7±0.2	0.5±0.1	0.2±0.1	0.15
	Total	0.6±0.2	0.5±0.1	0.3±0.04	0.3±0.1	0.93
Defecating	Morning	0.2±0.1	0.4±0.1	0.4±0.03	0.6±0.03	0.26
	Afternoon	0.3±0.1	0.1±0.1	0	0.1±0.1	0.16
	Total	0.2±0.1	0.1±0.1	0.2±0.01	0.7±0.04	0.11
Scratching	Morning	0.1±0.1	0.2±0.1	0.1±0.1	0.2±0.1	0.74
	Afternoon	0.4±0.3	0.6±0.4	0.1±0.1	0.4±0.3	0.62
	Total	0.2±0.2	0.4±0.2	0.1±0.1	0.3±0.1	0.38
Sleeping	Morning	56.8±13.7	52.7±2.8	49.6±5.7	51.1±5.8	0.22
	Afternoon	13.5±5.2	18.7±10.6	16.0±5.8	31.7±5.8	0.19
	Total	35.1±5.1	35.7±6.5	32.8±0.2	41.4±2.8	0.41
Drinking	Morning	0.9±0.3	1.2±0.3	2.2±0.6	1.8±0.4	0.08
	Afternoon	0.5±0.1b	1.2±0.2ab	1.4±0.1ab	1.5±0.4a	0.03
	Total	0.7±0.1b	1.2±0.4ab	1.8±0.3a	1.7±0.2a	< 0.01
Vocalizing	Morning	0	0	0	0	-
	Afternoon	0.2±0.1	0.2±0.1	0.4±0.1	0.2±0.03	0.13
	Total	0.1±0.1	0.1±0.1	0.2±0.03	0.1±0.01	0.13
Biting	Morning	0.3±0.2	0.3±0.2	0.7±0.5	0.2±0.03	0.31
	Afternoon	0.6±0.3	0.5±0.4	0.5±0.4	0.1±0.1	0.78
	Total	0.5±0.2	0.4±0.3	0.6±0.4	0.7±0.03	0.42

SEM - standard error of the mean.
[1] Control - concrete floor, with no enrichment; CM - floor bedding with wood chips; MO - concrete floor, with mobiles; CM + MO - floor bedding with wood chips and the presence of mobile.
a-b - Different letters in the same row differ significantly by Tukey's test at 5% probability.



MO - concrete floor, with mobiles; CM + MO - floor bedding with wood chips and the presence of mobile.

Figure 1 - Behavior frequency (%) of activity interaction animal-enrichment of MO and CM + MO treatments during growing and finishing phases.

Table 4 - Average number of white blood cells, eosinophils, neutrophils, lymphocytes, monocytes, and neutrophils:lymphocytes ratio of piglets housed in stalls with or without environmental enrichment, during growing and finishing phases

Variable	Treatment[1]				P-value	SE
	Control	CM	MO	CM + MO		
Growing						
Leukocytes (/mm^3)	14712.50	15412.50	13875.00	15650.00	0.209	2062.08
Eosinophils (/mm^3)	282.87	369.12	306.00	426.25	0.670	139.797
Neutrophils (/mm^3)	5493.62	7566.62	5332.00	8535.37	0.070	2331.61
Lymphocytes (/mm^3)	8258.25	6833.62	7779.62	5898.25	0.364	2230.46
Monocytes (/mm^3)	543.37	389.37	352.12	497.87	0.340	156.413
Neutrophils:lymphocytes	0.759	1.294	0.765	1.546	0.059	0.56336
Finishing						
Leukocytes (/mm^3)	14050	13937.5	14612.5	13937.5	0.090	2279.75
Eosinophils (/mm^3)	378.25	569.37	378.50	354.25	0.068	172.279
Neutrophils (/mm^3)	5038.25	4644.5	6141.12	4733.87	0.732	2119.81
Lymphocytes (/mm^3)	8287.25	8208.25	7591.5	8268	0.159	1854.47
Monocytes (/mm^3)	306.37	382.12	321.25	481.12	0.553	197.571
Neutrophils:lymphocytes	0.804	0.598	0.989	0.746	0.384	0.47500

SE - standard error.
[1] Control - concrete floor, with no enrichment; CM - floor bedding with wood chips; MO - concrete floor, with mobiles; CM + MO - floor bedding with wood chips and the presence of mobile.

Table 5 - Environmental enrichment effect on daily weight gain, daily feed intake, feed conversion, and backfat thickness of pigs during growing and finishing phases

Variable	Treatment[1]				P-value	SE
	Control	CM	MO	CM + MO		
			Growing			
Initial weight (kg)	26.29	27.23	26.34	25.11	0.083	5.44
Final weight (kg)	62.56	63.53	61.23	57.56	0.370	4.95
Average feed intake (g)	1952.07	1707.99	1851.61	1724.26	0.840	246.93
Daily weight gain (g)	863.5	864.25	830.75	772.75	0.860	91.39
Feed conversion	2.27	2.01	2.23	2.24	0.689	0.28
Backfat thickness (mm)	10	9	8	10	0.095	2
			Finishing			
Final weight (kg)	101.71	101.45	98.03	92.13	0.142	6.71
Average feed intake (g)	2664.3	2540.21	2448.94	2407.99	0.592	283.15
Daily weight gain (g)	932	902.75	876.25	823	0.165	71.52
Feed conversion	2.87	2.85	2.81	2.92	0.243	0.37
Backfat thickness (mm)	12.38	11.63	13.63	14.75	0.101	3.95

SE - standard error.
[1] Control - concrete floor, with no enrichment; CM - floor bedding with wood chips; MO - concrete floor, with mobiles; CM + MO - floor bedding with wood chips and the presence of mobile.

4. Discussion

The comparison between the behavior of the animals housed without enrichments and those housed with the prolonged and intensive interaction with mobiles (MO and CM + MO; $P<0.05$) explained the more extended inactivity of the animals in the control group (Table 3). One possible explanation for the behavior of the animals of the CM treatment (growing phase/morning shift), to maintain most of the time standing and pacing, might be the a lack of entertainment and distraction, compared with animals housed with mobiles (MO and CM + MO), which demonstrated more interaction with their offered enrichment, than just with bedding. The interaction animal-enrichment can be justified by the fact that these animals did not interact with any enrichment before this experiment, that the mobiles represent a novelty in the stalls, attracting the piglet's attention, leading to expected behavioral changes. Behavioral and physiological changes, due to a stimulus such as a novelty in the form of a mobile, are essential responses to environmental enrichment and have high relevance in promoting animal welfare (Pizzutto et al., 2008).

The experimental results point out the interaction of the animals with enrichment, especially in the afternoon, and it seems that they preferred to interact with hanging mobiles than with wood shavings. Oliveira et al. (2016) showed that pigs in the nursery phase explored more of their environments with wood chips only compared with wood chips and mobiles in the morning shift. Grandin and Johnson (2010) reported that pigs in a semi-natural environment spent much time investigating the environment. This behavior is part of a pig's natural behavioral repertoire and exploratory profile, developing actions of looking, smelling, licking, digging, and chewing on objects (Maia et al., 2013).

The extended time standing of pigs in the control treatment, in finishing phase, can be explained by lacking the nuzzle stimuli behavior (exploratory stimulus), as no bedding is available, different from the use of bedding and mobiles (tires and chains), which besides stimulating the curiosity, motivate to play, encouraging them to bite on the tires and chewing on the chains. The interactions with the environmental enrichments reported in the present work, during the growing and finishing phase, differ from what had been reported by Van de Weerd et al. (2006). In their study with pigs during the growing and finishing phase, comparing the use of substrates and mobiles as enrichments, the authors claimed that the preferred enrichment by animals were substrates, as they can be used as bedding, mainly straw, that would induce an investigative behavior, typical of the species. Additionally, these materials may be changed daily, maintaining their new character and attraction.

The main issue with many point-source objects is that the behavior seen as a result of the interaction is often short-lived, and for pigs, it is mainly intrinsically reinforced (such as exploration). The interaction with enrichment is intrinsically motivated in the absence of a relationship between behavior and an external consequence such as food (Tarou and Bashaw, 2007), so a pig will lose interest following exploration of an object when it has lost its novelty (Van de Weerd et al., 2003; Trickett et al., 2009) and habituation occurs. Furthermore, if point-source enrichment is too small or of limited quantity, this will restrict availability (Van de Weerd et al., 2006), mainly when grouped pigs synchronize their interactions with enrichment (Bulens et al., 2015; Zwicker et al., 2015). Recent studies confirm lower interaction with logs presented on the floor versus a hanging log, possibly caused by soiling with feces (Giuliotti et al., 2019). However, the study on this issue by Beaudoin et al. (2019) found that cleaning (plastic and rubber) objects did not affect the pigs' interaction with them.

Guy et al. (2013) combined four different enrichment materials for pigs during the growing phase: suspended objects (sisal rope and metal chain) and two substrates (sawdust and wood chips). The authors observed a more significant interaction of animals with the rope, followed by the chain, then sawdust, and at last the wood chips. These results are similar to the observations of the present study, where the animals interacted more with the mobiles than with wood chips. The authors also described the reduction of the interest of the animals in the mobiles throughout the experiment. Although pigs interacted with the enrichment objects due to their novelty, the interest usually declined over a few days (Van de Perre et al., 2011). Thus, even the repetition of cycles of different objects may not be enough, as re-introducing the same object after several weeks is usually not as effective as the initial interest in novel objects would be (Van de Perre et al., 2011).

Paes et al. (2012) reported that changes in immune cell counts might indicate chronic stress, but we did not observe these changes in our study. The low utilization of this indicator in scientific studies can be due to employing other direct indicators to specify stress in pigs. For example, Tönepöhl et al. (2012) found that pigs during the growing phase, housed in environments with no enrichment, were more aggressive and had a higher cortisol level, consequently presenting severe injuries, detrimental to the carcass quality.

In the present study, despite the tendency to reduce backfat thickness in pigs in the growing phase, there was no effect of environmental enrichment on the performance of pigs in the two phases (growing and finishing). These results differ from those found by Oliveira et al. (2016), which pointed out improvements in the pigs' performance during the nursery phase, as environmental enrichment was present.

5. Conclusions

Environmental enrichment with wood shavings (as beddings) and hanging mobiles improved behavioral aspects of piglets in the growing and finishing periods. Furthermore, there was no change of the piglets' leukogram during the growing and finishing phases or any interference in the evaluated performance parameters.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: R.F. Oliveira. Data curation: R.F. Oliveira. Formal analysis: R.F. Oliveira and R.H.R. Moreira. Investigation: R.F. Oliveira, R.T.R.N. Soares, R.H.R. Moreira, R.P. Andrade, D.A. Rosenfield and C.S. Pizzutto. Methodology: R.F. Oliveira and R.T.R.N. Soares. Project administration: R.F. Oliveira. Supervision: R.F. Oliveira. Visualization: R.F. Oliveira. Writing – original draft: R.F. Oliveira. Writing – review & editing: R.T.R.N. Soares.

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