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RESEARCH ARTICLE

Environmental enrichment using low walls and perches improves broiler welfare, without compromising productivity

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Abstract

The study evaluated the impact of different environmental enrichment strategies on the performance and welfare of commercially raised broilers. The research, conducted in Paraná, Brazil, involved 690 birds allocated to three types of environments: control, with a low wall, and with a perch. The performance of the birds was monitored through indicators such as feed conversion, live weight (plucked and eviscerated), and cut yields (wing, thigh, drumstick, breast, and back weight). There were no significant differences in feed conversion and yields between the environments, except for wing weight, which was higher in environments with a perch for males. Females raised in an environment with a low wall showed higher live and eviscerated weight, while thigh weight was lower in environments with a perch. Welfare variables, such as *Latency to Lie* and *Fluctuating Asymmetry*, showed no significant differences between the environments. However, females in the control and low wall environments had a higher incidence of calluses on their feet compared to those in the perch environment. Joint injuries (*Hock Health*) did not show significant differences between the types of enrichment. These results suggest that, although environmental enrichment may benefit some aspects of welfare, its impact on broiler performance and joint health needs to be better understood, particularly in relation to the long-term effects of different enrichment types on locomotor health, muscle development, and the prevention of joint injuries. Future studies should focus on the physiological mechanisms behind these effects, including the role of enrichment in reducing stress and promoting more natural behaviors that may influence bone density and joint function.

Keywords: Animal welfare; joint injuries; locomotor problems; zootechnical performance.

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1. Introduction

Consumer demand for management standards, welfare, and sustainable production practices in the poultry chain is increasing. Brazil, as the largest exporter of chicken meat, is on the right track to raising welfare levels. Structures added to the environment promote increased locomotor and behavioral activities, such as dustbathing, improving welfare (Elsayed et al., 2024). However, it is necessary to establish a scientific understanding of their productive and economic impact before implementing them in commercial poultry farms (Vas et al., 2023; Ghani et al., 2025).

The consolidation of the poultry production system occurred through advances in nutrition, health, management, and genetic improvement. Advanced breeding techniques have contributed to boosting production and meeting the demands of the global chicken meat consumer market (Vizzier-Thaxton et al., 2016). Currently, the results obtained in broiler chickens exceed 2 to 3 times greater efficiency in feed conversion and can weigh 4 to 5 times more compared to birds from the 1950s (Elsayed et al., 2024). However, on the other hand, this boost in growth resulted in an increase in leg deformities and a reduction in the physical capacity of the birds (Riber et al., 2018).

This efficient growth, in combination with the relatively high body weight and low activity level, has been associated with the development of leg problems: impaired walking ability and contact dermatitis on feet and hocks (Zahoor et al., 2022). Leg problems negatively affect broiler welfare because of pain and discomfort, leading to difficulties performing natural behaviors (Forslind et al., 2021). Foot callus, commonly known as contact dermatitis, is a chemical burn caused by the presence of urea in the litter, producing ammonia and causing damage to the plantar pad tissue (Dinev et al., 2019), a fact caused mainly by the inactivity of the birds. According to (Weeks et al., 2000), broilers persist in resting (sitting) for approximately 86% of their lifetime, contributing to lameness and pododermatitis.

Environmental enrichment can be defined as the modification of the environment of broiler chickens that aims to improve the welfare of the animals by providing a more complex and stimulating environment. The inclusion of enrichment aims to promote the expression of natural behaviors, such as exploring, foraging, perching, and dust bathing, reducing stress, scratching, pecking, and cannibalism (Zahoor et al., 2022). In addition, it can improve the birds' physical health and cognitive functions, reducing the incidence of aggressive behaviors and health problems related to confinement, such as leg injuries and locomotor problems (Tahamtani et al., 2018).

Implementing environmental enrichment must be practical, improve health, contribute to the specific behavior of birds, and be economically viable for the production system. Environmental strategies to enrich birds' environment can be classified as conventional, which are used in restricted areas with perches and objects to peck, and complex, which focus on the behavioral needs of birds (Van de Weerd et al., 2019).

Ghani et al. (2025) evaluated the effect of various environmental enrichment tools on performance, behavior, and welfare, identified a reduction in the incidence of toe injuries and footpad dermatitis. Similarly, Jong et al. (2022), assessing commercial broiler flocks, showed that the inclusion of environmental enrichment and lower stocking density contributed to reduced mortality, lower incidence of footpad dermatitis, and hock burns compared to birds conventionally raised without enrichment. Pedersen et al. (2020) incorporated multiple environmental alterations, including straw bales, vertical panels, elevated platforms, and increased distance between food and water. The authors decreased stocking density and found that increasing distance between resources increased tibiotarsus diameter. Vertical panels increased leg muscle width, but no other outcomes collected were impacted, and other environmental changes did not have an effect.

The use of obstacles between feeders and drinkers (Simsek et al., 2009) and perches and boxes in poultry sheds (Bailie et al., 2015) did not influence zootechnical performance compared to the conventional system. On the other hand, Bailie et al. (2015; 2018) showed that the health of the birds' locomotor system improved with the inclusion of enrichment strategies such as barriers, perches, ramps, and hay bales), since it stimulated movement. Another critical point is the socio-environmental aspect, in which the consumer market is more selective, preferring products that are not harmful to health, waste less energy, and come from systems concerned with the well-being of birds and the sustainability of production (Marchewka et al., 2013).

An intensive production system keeps birds confined in facilities, prioritizing the maintenance of the environment and meeting physiological needs with high zootechnical performance. The limited space and incentive keep the bird’s calmer without moving long distances. Environmental enrichment is proposed to change this reality. The inclusion of enrichment results in greater social interaction, cognitive stimulation, spatial learning, and motor activity for the animals, being closer to the natural environment for the animals compared to the environment offered in captivity (Kotloski et al., 2015).

This study aimed to measure the effect of using environmental enrichment strategies on a large scale in commercial broiler chicken farms. Specifically, we examined how these strategies impacted the chickens' growth, health, and movement.

2. Methodology

The study was conducted in the experimental aviary of the Federal Technological University of Parana, Dois Vizinhos, Paraná, Brazil. A total of 690 broiler chickens (345 males and 345 females), 42 g Cobb 500® chicks purchased from a commercial hatchery in the region, were raised until 42 days of age. The birds were housed in 30 pens, each measuring 1.75 m^2, with a stocking density of 13 birds/m^2. The pens had concrete floors overlaid with a 6 cm layer of wood shavings bedding and were separated by a 2 cm mesh screen, extending to a height of 0.8 m.

The methodology of this study strictly adhered to the ethical standards set by the National Committee on Animal Experimentation (CONCEA), following the guidelines established in the Normative Resolution 69, which regulates the relocation of animals in teaching or scientific research activities (Brasil, 2024). The protocols for lighting, feeding, temperature control, and other husbandry practices were rigorously followed according to the recommendations provided by the breeder company (Cobb, 2013).

The feeding program was divided into three stages: starter (0-10 days), grower (11-22 days) and finisher (23-42 days). The diets were produced and supplied by a commercial company in the region, according to the recommendations of the Cobb® line (Table 1). The lighting program used was recommended for the line itself: first day 24L:0D (L: light D: dark), second to seventh day 23L:1D, eighth to 28 days 12L:12D, continuing with a reduction of one hour per day until slaughter (42 days) of the birds.

Table 1
Recommendation for feed formulation

Amount of feed/bird	Home 250 g	Growth 1000 g	Termination
Feeding period	0 to 10 days	11 to 22 days	23 to 42 days
Food structure	Crushed	Crushed	Crushed
Crude Protein (%)	21-22	19-20	18-19
Metabolizable energy (kcal kg^{-1})**	3035	3108	3180
Lysine (%)	1.32	1.19	1.05
Digestible Lysine (%)	1.18	1.05	0.95
Methionine (%)	0.50	0.48	0.43
Digestible methionine (%)	0.45	0.42	0.39
Met + Cis (%)	0.98	0.89	0.82
Digestible met + Cis (%)	0.88	0.80	0.74
Tryptophan (%)	0.20	0.19	0.19
Digestible tryptophan (%)	0.18	0.17	0.17
Threonine (%)	0.86	0.78	0.71
Digestible threonine (%)	0.77	0.69	0.65
Arginine (%)	1.38	1.25	1.13
Digestible arginine (%)	1.24	1.10	1.03
Valine (%)	1.00	0.91	0.81
Digestible valine (%)	0.89	0.81	0.73
Calcium (%)	0.90	0.84	0.76
Available phosphorus (%)	0.45	0.42	0.38
Chlorine (%)	0.17-0.35	0.16-0.35	0.15-0.35
Sodium (%)	0.16-0.23	0.16-0.23	0.15-0.23
Potassium (%)	0.60-0.95	0.60-0.85	0.60-0.80
Linoleic Acid (%)	1.00	1.00	1.00

*Adapted from: Supplement: Broiler Performance and Nutrition (Cobb, 2012). *AMEn values based on WPSA European Table of Energy Values for Poultry Feedstuff (3rd edition, 1989).

The 690 birds were distributed in 30 boxes, each box had 23 experimental units/birds. It was 6 groups x 5 replicates in the following groups: MC: males in a controlled environment and FC: females in a controlled environment; MM: males in an environment with a low wall - a low wall elevated from the bed, with 60 cm^2, composed of clay bricks and FM: females in an environment with a low wall; MP: males in an environment with a perch - a wooden base fixed to the bed with two adjustable metal rods and FP: females with a perch (Figure 1). The initial height of the perch was 3 and 5 cm. On 21 days, it increased to 5 and 7 cm, remaining until 42 days.

Zootechnical parameters were monitored weekly. All birds within the experimental units were weighed to determine their live weight, while the weight of deceased animals was recorded immediately after death. Dead birds were replaced until the fourth day of age. The feed was weighed before being placed in the feeders, and any surplus was measured weekly to calculate the weekly consumption for each pen.

For the assessments of foot calluses, joint injuries (*Hock Health*), prostration time (*Latency to Lie*), and tibial symmetry (*Fluctuating Asymmetry*), five birds were randomly selected per box for monitoring throughout the experimental period. These birds were identified with a ring on the right foot and marked with non-toxic paint on the back.

Lesions in the plantar pad (*paw callus*) were determined following the classification described by Pagazaurtundua & Warriss (2006), with a score of 0 for the absence of lesions and 1 for the presence of lesions in the plantar pad area. Assessments were performed on the left and right paws at 28, 35, and 42 days.

Joint injuries (*Hock Health*) were assessed according to the classification described by Kjaer et al. (2006), with scores of 0 for the absence of injuries and 1 for the formation of crusts and severe injuries. At 35 and 42 days, assessments were performed on the left and right paws separately.

Locomotor problems were assessed using the *Latency to Lie* methodology (Weeks et al., 2000), where the animals were placed in an environment with a layer of water, and the time until prostration was timed. Assessments were performed at 28, 35, and 42 days.

Lower limb symmetry (*Fluctuating Asymmetry*) was determined according to the methodology described by Moller (1999). Tibial length and diameter measurements were performed at the midpoint of the diaphysis using a digital caliper with a precision of 0.01 millimeters. Assessments were performed separately on the left and right legs at 28, 35, and 42 days.

At 42 days of age, the birds were sacrificed by cervical dislocation, followed by bleeding, scalding, plucking, and evisceration. The animals were measured for their plucked and eviscerated live weight to evaluate the carcass yield and the weight of the parts (wing, thigh, drumstick, breast, and back) to evaluate the cut yield, according to the methodology described by Mendes (1990). The ratio between the cold carcass and fasting weight calculated the carcass yield (%). The wing, thigh, drumstick, breast, and back yield (%) was obtained by the ratio between the weight of the parts and the fasting weight.

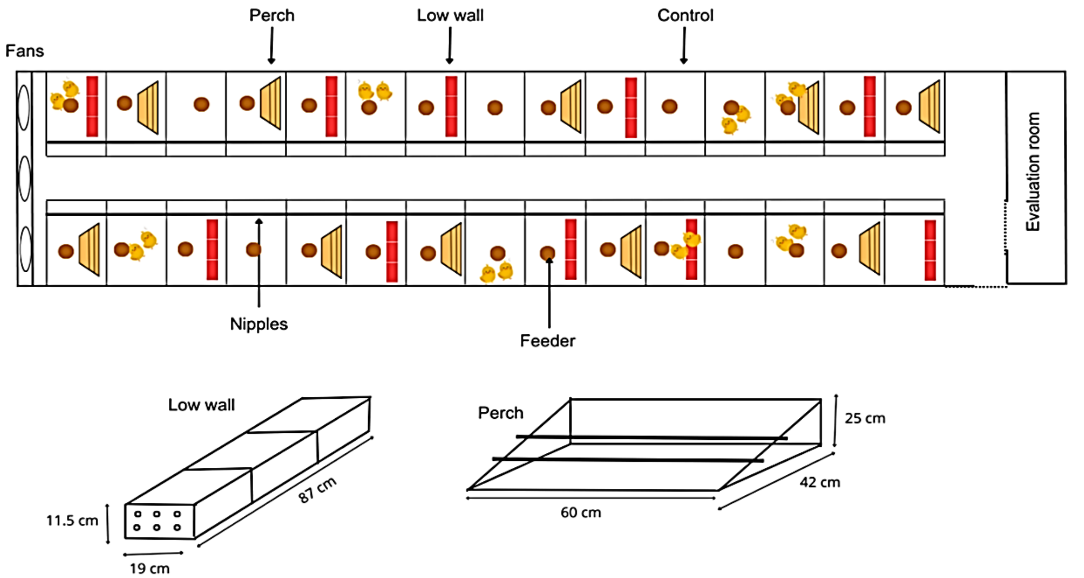

Figure 1. Exchematical drawing of the broiler house with the treatments: control, low wall enrichment and perch enrichment.

Data analyses were performed using R Studio software, determining data normality and homogeneity. Data were submitted to ANOVA, followed by the multiple comparison test of means using Tukey's test, and significance was assigned when ($p < 0.05$). Nonparametric statistics were applied to data that did not meet the assumptions of the statistical model (normality and homogeneity) using the Chi-square test ($p < 0.05$).

3. Results and discussion

The effects of performance indicators on birds housed in enriched environments are presented in Table 2. No difference ($p > 0.05$) was observed in feed conversion, weights (live, plucked, and eviscerated), and yields (carcass and leg) of male broilers between enriched and unenriched environments. The wing weight was significantly higher in an enriched environment with a perch compared to an environment with a low wall ($p \leq 0.05$). However, the presence of enrichment did not affect the weight of other cuts, including the thigh, drumstick, breast, and back.

Female broilers raised in an enriched environment exhibited several differences in performance (Table 2). Those reared with the inclusion of a perch had greater live weight and eviscerated weight. However, the thigh weight of females was lower in the perch-enriched environment ($p \leq 0.05$). In contrast, there were no significant differences ($p > 0.05$) in feed conversion, plucked weight, carcass and leg yields, or other cuts.

The findings suggest that environmental enrichment can have differential effects on the performance and welfare of broilers, depending on the type of enrichment and the gender of the birds. For male chickens, the introduction of environmental enrichment did not significantly impact overall performance, with the only notable effect being an increase in wing weight in birds raised in environments with perches. Consistent with previous studies by Bach et al. (2019) and Ruiz-Feria et al. (2014), feed conversion and body weight were not adversely affected by the barriers introduced in the environment. While an increase in energy consumption might be expected due to heightened physical activity, this did not compromise the birds' productive performance but enhanced their welfare (Elsayed et al., 2024).

For female broilers, enrichment with a low wall led to heavier overall body weight and greater thigh weight than birds in conventional and perch environments. This contrasts with findings from other studies, such as Aksit et al. (2017), which reported that increased physical activity negatively affected body weight development. Similarly, Ohara et al. (2015) observed that birds with lower weekly weight gain and overall lower body weight preferred perching instead of feeding.

The use of the low wall as environmental enrichment contributed to an increase in the thigh weight of broiler pullets. Bailie et al. (2018) reported improvements in the legs of birds subjected to the inclusion of forms of environmental enrichment (perches, ramps, and straw bales) in the facilities. The contribution of enrichment to muscle and skeletal development, morphometry, and weight of the parts (thigh, drumstick, legs, and feet) is mainly due to greater mobility and intensification of physical activities (Silva et al., 2021).

Table 2
Effects of environmental enrichment on the performance of male and female broilers

Parameter	Environmental Enrichment			p-value
	Control	Wall	Perch	
Male				
Feed conversion [1]	1,652	1,623	1,671	0.08
Live Weight (kg)	2505.00	2491.67	2598.67	0.29
Plucked Weight (kg)	2337.83	2284.33	2416.50	0.09
Gutted Weight (kg)	1889.20	1853.07	1930.47	0.38
Carcass Yield (%)	75.48	74.39	74.29	0.67
Ham Yield (%)	21.81	20.98	21.63	0.25
Wing Weight (g)	192.07ab	188.77b	197.77a	0.05
Thigh Weight (g)	260.30	252.33	266.07	0.12
Thigh Weight (g)	285.67	270.37	295.47	0.07
Breast Weight (g)	617.43	598.93	651.83	0.10
Back Weight (g)	432.97	431.87	449.20	0.35
Female				
Feed conversion [2]	1,633	1,641	1,663	0.17
Live Weight (kg)	2167.33b	2344.33a	2163.00b	0.01
Plucked Weight (kg)	2013,69	2095.80	2012.50	0.09
Gutted Weight (kg)	1634.20b	1697.37a	1619.70b	0.02
Carcass Yield (%)	75.42	72.52	74.91	0.13
Ham Yield (%)	21.19	20.24	21.04	0.18
Wing Weight (g)	176.73	176.57	175.60	0.97
Thigh Weight (g)	218.00	222.40	218.03	0.66
Thigh Weight (g)	241.13ab	251.37a	236.57b	0.04
Breast Weight (g)	556.17	586.93	551.87	0.06
Back Weight (g)	370.40	384.70	371.87	0.31

Means followed by distinct letters in the row differ by Tukey's test ($p < 0.05$).
[1] Feed conversion males: $0.8651 + 0.367x - 0.0331x^2$ (R^2: 0.96).
[2] Feed conversion females: $0.7236 + 0.5376x - 0.0905x^2$ (R^2: 0.97).

The relationship between feed conversion and weeks of growth exhibited a quadratic effect ($P \leq 0.05$) in both male and female broilers. Although females demonstrated better feed conversion efficiency, the rate of increase in feed conversion ratio (FCR) was more pronounced in females (0.5376) compared to males (0.367) as the weeks progressed, followed by a more marked deceleration in the increase.

No difference was observed among the control, low wall, and perch groups regarding *Latency to Lie* for either males or females (Table 3). This might indicate that the type of environmental enrichment did not influence the lying behavior of broilers.

The results related to the *Latency to Lie* variable indicate that there are significant differences in the response between male and female broiler chickens, depending on the age and type of environmental enrichment applied.

Latency to Lie measurements for both male and female chickens were not statistically significant. For males, the regression equation suggests that Latency to Lie initially increases with age (days) but begins to decrease as age advances (indicating a quadratic effect). For females, the equation shows an inverse behavior, where *Latency to Lie* initially decreases with increasing age, but begins to increase again at older ages (also indicating a quadratic effect).

The *Latency to Lie* test is a behavioral assessment used to measure the time it takes for a bird to sit after being placed in a standing position on a sheet of warm water. The test evaluates broilers' leg health and motor behavior (Weimer et al., 2020). The birds naturally find contact with the warm water unpleasant, as their behavior typically reflects an aversion to it.

Table 3
Effects of environmental enrichment on *Latency to Lie* and *Fluctuating asymmetry* (FA) in broiler chickens

	Control	Wall	Perch	p-value
Male				
Latency to Lie [1]	412.00	390.56	395.42	0.71
FA length [2]	0.0146	0.0185	0.0066	0.19
FA diameter	-0.0041	-0.0037	-0.0032	0.98
Female				
Latency to Lie [3]	413.10	365.72	368.63	0.42
FA length	0.0219b	0.0363a	0.0211b	0.01
FA diameter	0.0055	0.0001	0.0009	0.60

Means followed by distinct letters in the row differ by Tukey's test ($p < 0.05$).
Regression equation of Interaction (Days x Enrichment).
[1] *Latency to Lie* males: $493.20 + 138.55x - 79.50x^2$ (R^2: 1.00).
[2] *Fluctuating asymmetry* length males: $0.8956 + 0.1441x - 0.0366x^2$ (R^2: 1.00).
[3] *Latency to Lie* females: $1161.43 - 649.12x + 111.28x^2$ (R^2: 1.00).

In the present study, resistance to prostration was similar between male and female chickens, differing from Santos et al. (2022), who identified a longer standing time in females (489.9 s) than in male chickens (373.9 s), suggesting that differences in bird body weight contributed to differences in resistance to prostration. In addition, the differences in *Latency to Lie* between the birds tested in different studies may be related to the genetic potential of chicken development; even in birds with similar live weight, bird resistance may become more evident, indicating a negative effect of body conformation on leg strength in faster growth.

The interaction between age and environmental enrichment showed distinct patterns for *Latency to Lie* in male and female broilers, indicating that these groups may respond differently to growth and rearing conditions. Male chickens showed an initial increase in resistance to lying down in the water slide test as muscle development and body weight increased, followed by a decrease in *Latency to Lie* as they reached adulthood, suggesting a decline in mobility. In contrast, female pullets tended to lie down more quickly with age, potentially due to more balanced muscle development or slower weight gain than males. These findings highlight the importance of considering sex-specific responses when assessing the impact of environmental enrichment on broiler welfare.

Singh et al. (2021), in their evaluation of resistance to prostration in birds with both rapid and slower growth but similar live weights, found that broilers with faster growth exhibited weaker leg strength. This difference was attributed to the larger size of the pectoral muscles in fast-growing birds, which increases the energy demand required to maintain a standing posture for extended periods (Tickle et al., 2018).

Males demonstrated greater resistance to prostration during the early stages of development but experienced a decline in leg strength as growth progressed. Conversely, females exhibited lower resistance in the initial phase, with increased leg strength as they developed. These findings are consistent with those of Dixon (2020), who attributed the observed differences to males having higher live weights and faster growth rates than females.

In a way, the *Latency to Lie* test may have limitations in determining the resistance to prostration of birds since the aversion to sitting on the water surface and the stimulus to stand up may differ between the lineages and the sex of the birds.

There was no significant difference in the *Fluctuating Asymmetry* (FA) of male broilers for length and diameter between the different types of enrichment. The FA for length of female birds was statistically higher in the low wall group (0.0363) compared to the Control (0.0219) and Perch (0.0211) groups. There was no significant difference in the FA for diameter of female birds (P: 0.60). The regression equations indicate that the *Latency to Lie* response in broilers is affected by the interaction between age and environmental enrichment, with distinct patterns observed between males and females.

Fluctuating Asymmetry (FA) is calculated by the difference between the right and left paws' tibia based on the measurements mean. The present study performed FA measurements for tibia length and diameter. According to Moller (1999), phenotypic measures such as *fluctuating symmetry*, which are related to performance, have significant implications for evolutionary studies. These measurements can serve as covariates in performance studies, particularly about treatments such as population density and levels of parasitism. This approach allows researchers to assess the effects of treatments on the development of asymmetry during growth or on changes in asymmetry as animals develop. Bizeray et al. (2002) did not identify significant differences in FA for leg length or diameter of broiler chickens. In our case, greater symmetry was found for female birds in the control and perch treatments concerning enrichment with a low wall.

Weight can influence locomotor activity as heavier birds perform activities less frequently but are not affected by bone characteristics. This suggests that weight does not affect symmetry in tibial length and diameter (Dukic-Stojcic et al., 2011).

Results in Table 4 indicate that there were no differences ($p > 0.05$) in the incidence of arthritis, wing myopathy, aerosacculitis, and dermatosis between groups of male and female commercial broiler chickens raised in a conventional environment compared to those raised in environments enriched with a low wall or a perch.

The inclusion of environmental enrichment did not differ between treatments for variables related to arthritis, aerosacculitis, dermatosis, and wing myopathy, either for male or female chickens. Arthritis refers to inflammation of the joints of broiler chickens (Oh et al., 2010), a condition that causes losses in productive performance and bird welfare. Arthritis can be caused by bacterial and viral infections, nutritional deficiencies, trauma, genetic predisposition, and bird inactivity, and is one of the factors responsible for health problems and the condemnation of birds in slaughterhouses (Oliveira et al., 2016). Possibly, the low incidence of arthritis in birds is related to their activity, preventing them from remaining inactive for a longer period.

Thus, these results indicate that the enriched environments did not pose any risk or contain objects that could harm the carcasses. It should be noted that these condemnations, in some cases, may be related to the loading, transportation, and slaughter of the birds.

Table 4
Effects of environmental enrichment on the incidence of condemnations (Chi-Square Test) in broiler chickens

	Male				Female			
	Control	Wall	Perch	*p-value*	Control	Wall	Perch	*p-value*
Arthritis								
No injury	26	23	19	0.11	25	22	19	0.22
With injury	4	7	11		5	8	11	
Myopathy								
No injury	10	11	12	0.87	10	14	12	0.57
With injury	20	19	18		20	16	18	
Aerosacculitis								
No injury	4	6	9	0.28	8	5	6	0.63
With injury	26	24	21		22	25	24	
Dermatosis								
No injury	14	22	17	0.11	19	14	17	0.43
With injury	16	8	13		11	16	13	

Means followed by distinct letters in the row differ by Tukey's test ($p < 0.05$).

The frequencies of foot calluses are summarized in Table 5. No differences were observed in male broilers in lesions on either the right or left feet across the control and enriched environments with a low wall or perch when assessed at 28, 35, and 42 days of rearing. However, in females, the incidence of lesions differed significantly ($P \leq 0.05$) at 35 and 42 days, following a consistent pattern on both the right and left feet. Females raised in the control and low wall environments exhibited a higher frequency of foot callus lesions than those raised in the perch-enriched environment.

The prevalence of plantar dermatitis was low ($p \leq 0.05$) in female broiler birds raised in an environment with a low wall at 35 and 42 days of age, a fact that can be explained by the fact that the female birds used the low wall to rest, which was effective in improving the health of the birds' feet. Foot calluses show their first clinical signs in the second and third week of the birds' growth (Taira et al., 2014). Still, such symptoms can be delayed in dry litter or a non-humid environment, a determining factor in the incidence of foot calluses. Therefore, it is a determining factor that the birds are active to reduce the possibility of early onset of foot lesions since, as the birds age, the tendency is to minimize movement, and the behavior of climbing obstacles is reduced by the increase in body weight, allowing an increase in the incidence of foot calluses. Findings by Tahamtani et al. (2020) confirm that enrichment using elevated platforms and reduced stocking rates contributed significantly to the health of the birds' feet.

In addition to issues of management, facilities and bird welfare with the use of tools for environmental enrichment, the genotypes currently used on a commercial scale (Ross 308, Cobb 500 and Hubbard Classic) have demonstrated significant differences in the occurrence of plantar lesions in birds (Martins et al., 2016), confirming the thesis that good management practices and welfare associated with the potential of genetic predisposition can contribute to the reduction of lesions in the plantar pads (Škrbić et al., 2015).

The data indicated no significant differences ($p > 0.05$) in the incidence of hock lesions among the control, fence, and perch groups in commercial broilers at 35 and 42 days of age for both males and females (Table 6). These results suggest that the types of environmental enrichment used in this study, including the fence and perch, did not have a noticeable effect on the Hock health of commercial broilers.

No differences were identified in joint injuries due to the use of environmental enrichment in the facilities. The results corroborate those found by Kjaer et al. (2006), who tested a housing environment with simple and problems are associated with contact dermatitis (hock burn, foot calluses) and are mainly caused by lack of physical exercise, the accelerated growth of birds, and the high presence of ammonia in the environment (Riber et al., 2018; Dinev et al., 2019).

Environmental enrichment is an effective tool that positively impacts the psychological well-being of birds and supports the health of their locomotor system, as broilers quickly adapt to the conditions of their rearing environment (Bailie & O' Connell, 2014). This was demonstrated by Ohara et al. (2015), who observed improved bird locomotion and a reduction in plantar dermatitis when using hay bales as enrichment. However, this contrasts with the findings by Sans et al. (2014), who reported no significant differences when using perches, trays, and suspended objects as enrichment tools. Their results align with the findings of our study.

Table 5
Effects of environmental enrichment on the incidence of foot calluses (Chi-Square Test) in broilers

	Males				Females			
	Foot Callus (28 days)							
Right paw	Control	Wall	Perch	*p-value*	Control	Wall	Perch	*p-value*
No injury	22	25	22	0.57	15	21	18	0.29
With injury	8	5	8		15	7	12	
Left paw								
No injury	20	23	20	0.62	15	21	17	0.28
With injury	10	7	10		15	9	13	
	Foot Callus (35 days)							
Right paw								
No injury	17	10	13	0.19	12b	19a	10b	0.05
With injury	13	20	17		18a	11b	20a	
Left paw								
No injury	15	9	11	0.27	12b	19a	10b	0.05
With injury	15	21	19		18a	11b	20a	
	Foot Callus (42 days)							
Right paw								
No injury	16	16	13	0.67	11b	20a	9b	0.01
With injury	14	14	17		19a	10b	21a	
Left paw								
No injury	14	13	11	0.73	10b	20a	9b	0.01
With injury	16	17	19		20ª	10b	21a	

Means followed by distinct letters in the lines differ by Tukey's test ($p < 0.05$).

Table 6
Effects of environmental enrichment on broiler chickens' *Hock Health* (Chi-Square Test)

	Males				Females			
	Hock Health (35 days)							
Right paw	Control	Wall	Perch	*p value*	Control	Wall	Perch	*p value*
No injury	11	9	4	0.11	18	14	14	0.49
With injury	19	21	26		12	16	16	
Left paw								
No injury	13	8	6	0.13	15	15	12	0.67
With injury	17	22	24		15	15	18	
	Hock Health (42 days)							
Right paw								
No injury	5	4	2	0.48	13	12	8	0.37
With injury	25	26	28		17	18	22	
Left paw								
No injury	3	3	5	0.66	7	11	8	0.50
With injury	27	27	25		13	19	22	

4. Conclusions

Environmental enrichment, using low walls and perches, did not significantly affect the zootechnical performance of broilers, but influenced the symmetry of the lower limbs and the locomotor behavior of the birds, especially in females. The inclusion of environmental enrichment can improve specific aspects of bird welfare, such as locomotor health, without compromising productivity.

Future studies should investigate the long-term effects of different enrichment strategies on the musculoskeletal development and metabolic health of broilers, as well as their economic feasibility in large-scale production systems.

Author contribution

C. H. F. Zago-Dias: Conceptualization, Writing — original draft. **A. Signor-Mendes:** Conceptualization, Methodology, Funding acquisition, Supervision. **E. R. Dias:** Investigation, Writing — review and editing. **T. Venturini:** Investigation, Resources, Writing — review and editing. **R. R. A. Borquis:** Writing — original draft, Resources, Supervision. **I. de Alencar-Nääs:** Methodology, Writing — review and editing.

Conflict of Interest Statement

Authors have no conflict of interest to declare.

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