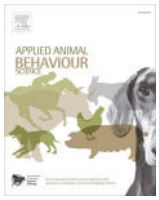
Applied Animal Behaviour Science 305 (2026) 107214



Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim



Use of a breed with a slower growth rate had greater beneficial effects on broiler welfare than environmental enrichment

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ARTICLE INFO

Keywords:
Chicken
Growth rate
Behaviour
Fearfulness
Play

ABSTRACT

Use of slower-growing breeds and environmental enrichment are both factors considered to be beneficial for broiler welfare and are often included in extensive production systems. The aim of this study was to determine the effects of a combination of these factors on broiler welfare and behaviour, by comparing a faster- and slower-growing breed with or without environmental enrichment. The trial was carried out under semi-commercial conditions with 5 pens per treatment combination. A 2 × 2 factorial design was applied with the treatments, a faster-growing breed (Hubbard JA787) versus a slower-growing breed (Hubbard S757N) and no enrichment (NE) or environmental enrichment (EE; dustbathing area, wooden barrier perch, and lucerne bale in a net). Broilers were placed on the same day and housed until ~2.2 kg slaughter weight, day 42 for JA787, day 63 for S757N. All broilers received the same diet and management. Measurements included behaviour in the home pen, fearfulness and play behaviour tests, litter quality at 0.5 kg, 1.1 kg, and 1.9 kg body weight, welfare indicators (gait score, footpad dermatitis, hock burn, cleanliness and skin lesions at 2 kg body weight), and performance. No interactions between breed and environmental enrichment were found, only main effects of breed or environmental enrichment. In the home pen, JA787 expressed less locomotion, standing, foraging and more inactive behaviours than S757N ($P < 0.01$). Both breed and environmental enrichment had limited effects on response to human approach and novel object tests, indicating that any treatment effects on fearfulness were not clearly detected. In a test situation, JA787 broilers showed more play behaviours than S757N ($P < 0.05$), and NE broilers showed less play than EE broilers ($P < 0.05$). Within the EE treatment, more S757N birds were observed on perches, while more JA787 broilers were observed near the bale ($P < 0.02$). For the welfare indicators, overall JA787 birds had worse scores for cleanliness, gait, footpad dermatitis and hock burn compared to S757N ($P < 0.01$) and no differences were found for litter quality scores. In conclusion, the use of a slower-growing breed showed more beneficial effects on broiler welfare compared to environmental enrichment, which only had minor beneficial effects. Both breeds made use of enrichments, indicating the broilers were motivated to use them. However, when aiming to improve welfare in extensive production systems, choosing a slower-growing breed is a key factor to include to achieve welfare benefits.

1. Introduction

In broiler production, there is an increasing pressure to improve animal welfare standards. Broiler welfare has received increased attention over the years due to the intense genetic selection for rapid growth rates and feed efficiency (Hartcher and Lum, 2020). While this has led to improved production (Zuidhof et al., 2014) it has come at the cost of animal welfare and led to several welfare challenges for fast-growing broiler breeds. Faster-growing breeds are at risk for compromised health and welfare, including higher risk for cardiovascular disease, leg disorders and lameness (Shim et al., 2012; Hartcher and Lum, 2020; Riber and Wurtz, 2024). These issues also inhibit their behavioural repertoire, resulting in reduced activity levels, and reduced ability to exhibit natural behaviours such as foraging (Riber and Wurtz, 2024).

To address these welfare concerns, the use of slower-growing broiler breeds is increasing, especially in Europe (Vissers et al., 2019). Some higher welfare labels, such as Better Life in the Netherlands (Beter Leven keurmerk, 2024), and the European Chicken Commitment (European

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https://doi.org/10.1016/j.applanim.2026.107214
Received 17 June 2026; Received in revised form 3 October 2026; Accepted 5 October 2026
Available online 6 October 2026
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Chicken Commitment), already require slower-growing breeds due to the higher welfare associated with these breeds, and extensive systems often implement slower-growing breeds as well. Slower-growing broilers have been found to have a better walking ability, lower incidence of hock lesions, better cleanliness scores, and lower mortality rates, when compared to fast-growing strains (Baxter et al., 2021; Dixon, 2020; Rayner et al., 2020) while also behaving differently to fast-growing breeds; spending more time walking, standing, and foraging and less time eating and sitting (Wallenbeck et al., 2016; Dixon, 2020).

Applying environmental enrichment is a common strategy to enhance broiler welfare and is often used in extensive production. By increasing the environmental complexity and providing opportunities to perform species specific behaviours, enrichments are associated with a higher prevalence of behaviours linked to positive affective states, such as play, ground scratching, and wing shaking (Riber et al., 2018; Anderson et al., 2021; Jacobs et al., 2023; Vas et al., 2023). Environmental enrichment can also increase overall activity and exploratory behaviours in both fast- and slower-growing breeds compared with unenriched environments (de Jong et al., 2021) and has been linked to reduced fear responses in behavioural tests (Baxter et al., 2019). However, the extent of these effects is not always consistent and may be variable depending on breed.

Different types of environmental enrichments have been studied, including perches (Bailie et al., 2018; Ventura et al., 2010), platforms (Norring et al., 2016; Kaukonen et al., 2017), straw bales (Bailie and O'Connell, 2014; Bailie et al., 2013), and dustbathing substrates (Baxter et al., 2018), although mostly focusing on fast-growing broilers. As slower-growing broilers are increasingly used, it is important to assess their responses, as the welfare effects of enrichments observed in fast-growing broilers may not translate directly to slower-growing breeds. Some studies report limited effects of enrichment on certain welfare outcomes (de Jong et al., 2021) and variation between breeds (Dawson et al., 2021).

A limited number of studies have directly compared fast- and slower-growing broilers, indicating that slower-growing birds interact with enrichments more frequently than fast-growing breeds when observed at the same age (Dawson et al., 2021; de Jong et al., 2021). For example, the use of perches has been found to be higher in slower-growing breeds (Baxter et al., 2021). These differences in enrichment use found in relatively few comparative studies, along with known differences in behaviours and activity, highlight the importance of determining whether the use and impacts of environmental enrichments differs between faster- and slower-growing breeds.

Both slower-growing breeds and environmental enrichments are commonly applied in more extensive systems to improve welfare. However, there is limited knowledge on their combined impact on welfare outcomes. Therefore, further insight into their combined effects is needed. The aim of the current study was to determine the effects of breed and environmental enrichments on behaviour and welfare. Two broiler breeds were used with a high contrast in growth rate, a faster-growing breed Hubbard JA787 (~50 g/d) and a slower-growing breed Hubbard S757N (~29 g/d) in combination with or without environmental enrichment. Environmental enrichment consisted of a perch, dust bath, and lucerne bale in net, as these promote species specific behaviours (Riber et al., 2018). It was hypothesized that the slower-growing breed (Hubbard S757N) would exhibit more active behaviours and positive welfare outcomes, whereas faster-growing broilers (Hubbard JA787) would show lower activity levels, leading to poorer welfare indicators (hock burn, footpad dermatitis). With the addition of environmental enrichment further contributing to increased activity levels and positive welfare outcomes for both breeds.

2. Materials and Methods

2.1. Ethical Approval

The experiment was approved by the institutional Animal Welfare Body (Experiment number 201.D-0002.003, approval date 27–03–2023).

2.2. Animals, housing and treatments

The present study was carried out in the broiler facility at Agrifirm Experimental farm, Laverdonk, Heeswijk-Dinther, The Netherlands. A 2 × 2 factorial design was applied, using 1840 faster-growing broilers, Hubbard JA787 (JA787) and 1840 slower-growing broilers, Hubbard S757N (S757N), half female and half male. Day-old chicks (50% female/50% male distribution) of both breeds were assigned to either an environmentally enriched (EE) pen or a pen with no enrichment (NE). Thus, four treatment groups were present in the study: environmentally enriched (EE) x Hubbard JA787 (JA787); no enrichment (NE) x Hubbard JA787 (JA787); environmentally enriched (EE) x Hubbard S757N (S757N); no enrichment (NE) x Hubbard S757N (S757N). Treatment groups were randomly assigned to a pen within 1 of the 5 blocks (containing 4 pens) across 2 rows in the climate controlled experimental room. One row with 2 blocks (8 pens) and the other with 3 blocks (12 pens). In total, the room contained 36 pens, the other 16 were used for another broiler chicken trial that was ongoing at the same time (de Jong et al., unpublished).

All chicks were obtained from a commercial hatchery (Morren, Lunteren, the Netherlands). Day-old JA787 chicks originated from a 47-week old parent stock, S757N chicks from a 36 week old parent stock. Each pen included 184 broilers with a target stocking density of 30 kg/m^2 at depopulation. Pens were 13.5 m^2, 4.45 m length x 3.14 m wide and closed off with a 1.3 m high net to prevent broilers from escaping. All pens were bedded with wood shavings, 1 bale per pen (approx. 1.48 kg/m^2). The set temperature at the start of the experimental period (day 0) was 35 °C, gradually decreasing until reaching temperature of 19–21 °C from day 42 and onwards. Relative humidity was kept between 40% and 60% from day (d) 0–7 of age, from d 14 of age and onwards it was kept between 50% and 70%. In all pens, broilers were provided *ad libitum* feed and water via 5 commercially available pan feeders (one feeding line) and 24 nipple drinkers with cups (two drinking lines). The broilers had a light - dark regimen as follows: d 0, 24 h light; d 1–6, 20 light:4 dark (between 02:00–06:00); from day 7 of age and onwards 18 light: 6 dark (between 00:00–06:00). Light intensity was at least 40 lux at animal height until d 7, thereafter 20 lux was provided at animal height.

All broilers received a standard four phase diet program according to the Better Life concept formulated and produced by ABZ (Leusden, The Netherlands). A starter (d 0–14, raw protein content 200 g/kg), grower 1 (d 14–25, raw protein content 186 g/kg), grower 2 (d 25–35, raw protein content 175 g/kg) and finisher (d 30 onwards, raw protein content 173 g/kg) with coccidiostats added to all diets (starter and grower: Maxiban (Elanco)), and finisher: Sacox (Huvepharma)). All broilers were vaccinated according to the following vaccination schedule: Innovax Nd IBD (Gumboro), Marek Rispens, and IB primer at the hatchery and IB at d 14 by the animal caretakers.

Mortality was registered as found dead or culled due to health problems and every dead or culled broiler was weighed. Broilers were delivered to the slaughterhouse at a body weight of approximately 2.2 kg; at d 42 for JA787 and d 63 for S757N.

The EE pens were provided with enrichments in the form of a lucerne bale in a net (firmly pressed with straps, 20 kg) hanging from a wooden beam along the short side of the pen, a dustbathing area of approximately 3 m^2 with a 2–3 cm layer of peat at the backside of the pen, separated from the litter area by a wooden beam as a perch (3 m in length on the ground). Lucerne bales were to be replaced when a quarter of the bale was left; the date, pen number and amount were to be noted

by the research facility. When half of the dustbathing area was packed, peat was added or replaced; the amount added or replaced was similar for all pens, with the date noted by the facility. The perch height was 10 cm at the start and increased by 2 cm on d 14 and on d 29. Supplementary Figure 1 provides an overview of the layout of NE and EE pens.

The quality of day old chicks was checked in accordance to the protocol described by (da Silva et al., 2021); only healthy chicks were placed. Mean body weight, body weight gain, feed intake, feed conversion ratio (FCR), and mortality were measured per feeding phase. Pen weight was continuously monitored by an automatic weighing scale in each pen. At placement, d 15, d 30 and d 45 approximately 25 males and 25 females per pen were weighed manually to check the accuracy of the automatic weighing scale. At depopulation all birds were counted and weighed at pen level.

2.3. Behavioural observations and tests

Home pen behaviours and behavioural tests for fearfulness (Forkman et al., 2007) and play behaviour were performed at pen level on three occasions by 1 observer, according to the approximate weight of the birds: at 0.5 kg (JA787: 16 d; S757N: 21 d), 1.1 kg (JA787: 28 d; S757N: 36 d), and 1.9 kg (JA787: 38 d; S757N: 59 d). Actual body weight at observation days slightly differed from the target body weight for observations and are presented in Supplementary Table 1.

2.3.1. Behavioural observations

Direct behavioural observations were conducted using scan sampling by 1 observer in a randomly selected area of roughly 3 m^2 of each pen with feeders and drinkers but without the enrichments. The observer stood in front of the pen with a clear view of the observation area, allowing a 5 min habituation period before recording behaviours. Observations took place once in the morning, between 8:30–12:30 and once in the afternoon, between 13:30–16:00, observing an entire block containing each treatment (4 pens), before moving onto the next block. The number of birds in the area performing certain behaviours (Table 1), was recorded sequentially as a series of 5 instantaneous scans, with the following scan beginning directly after the completion of the previous scan.

2.3.2. Human approach test

A human approach (HA) test was conducted following the recording of use of enrichments. In a similar area in both NE and EE pens (area of pen without enrichments), the observer walked between the drinker and feeder line toward the back of the pen, turned around and started observations. The number of birds within a semi-circle 50 cm in front of the observer was immediately counted and recorded every 30 s for 3 min. Additionally, the latency for the first chicken to enter the 50 cm semi-circle was recorded.

Table 1
Ethogram used for scoring individual behaviour during pen level scan sampling.

Behaviour	Detailed description
Eating	Having the head above or in the feeder or pecking at feed in the feeder
Drinking	Pecking at the drinking nipples or cup beneath the drinking nipple
Locomotion	Walking, running, jumping or hopping without performing any other type of behaviour
Inactive	Sitting or lying while not engaged in any other activities
Standing	Standing without performing any other type of behaviour
Ground pecking	Inactive and pecking at the ground, litter
Foraging	Pecking and/or scratching at the ground, litter while standing
Comfort	Preening (manipulating own feathers with the beak or paws), stretching, wing flaps, feather ruffles, shakes (outside context of dust bathing)
Dustbathing	Rubs head and body against the ground, pecks and scratches while lying on the side, distributes substrate over body or shakes off substrates from feathers
Aggressive behaviour	All elements of aggressive behaviour, such as hopping oriented towards another chicken, threatening (both upright position), leaping, kicking, wing flapping or aggressive pecking (pecking directed to the head)
Other	All other behaviours not described above (such as feather pecking, explorative pecking, etc)

2.3.3. Novel object test

A novel object (NO) test was carried out following the HA test in the same location. The observer presented the NO to the birds in a standardised manner, placing the NO on the floor and walking 1.5 m backwards. The number of chickens within 30 cm radius was immediately counted and every 30 s for three minutes. Additionally, the latency for the first chicken to be within 30 cm radius of the NO was recorded. The NO was a golf ball wrapped in aluminium foil (2.5 cm in diameter), block wrapped with coloured tape (10 ×4.8 ×2 cm) or a PVC tube wrapped with coloured tape (50 ×3.2 cm) at 0.5 kg, 1.1 kg and 1.9 kg, respectively.

2.3.4. Free-space test

Following the NO test, a free space test, adapted from the methodology used by (Liu et al., 2020), was used to identify play-behaviours. The observer entered the pen, walked between the drinker and feeder lines to the back of the pen, driving away as many birds as possible from the area. Then the observer turned and quietly walked out of the pen retracing their steps. The pen was recorded for 5 min using a digital camera mounted on a tripod. The videos were analysed using continuous all-occurrences sampling of specific play behaviours throughout the 5 min period. Behaviours recorded were, running, frolicking, wing flapping, and sparring, as defined in Supplementary Table 2.

2.4. Use of Enrichment

Following the scan sampling of behaviours, the use of the available enrichments was recorded by the observer. The number of birds were counted in a 30 cm radius around the lucerne bale, within the dustbathing area, and on the perches.

2.5. Clinical welfare assessments

At an average body weight of 2.0 kg (JA787: 41 d; S757N: 62 d), 30 birds (15 male/15 female) per pen were randomly selected for welfare measurements by one trained observer. These included gait score, footpad dermatitis (FPD), hock burns (HB), cleanliness and skin lesions according to the Welfare Quality protocol for broilers (Welfare Quality®, 2009). Gait was scored on a 0–5 scale, with 0 being a perfect gait, and 5 being unable to walk. FPD and HB were scored on a 0–4 scale, with 0 indicating no lesions present and 4 being severe FPD or HB. Cleanliness was scored on a 0–3 scale, with 0 being a clean plumage, and 3 being dirty on the feathers and skin of the bird. Skin was scored on a 0–2 scale, with 0 being no lesions, and score 2 being several visible lesions.

2.6. Litter scoring

Litter scoring was performed per pen when the broilers were at approximately the same weight across breeds: at 0.5 kg (JA787: 16 d; S757N: 21 d), 1.1 kg (JA787: 28 d; S757N: 36 d), and 1.9 kg (JA787: 38 d; S757N: 59 d). Scores were given via a visual evaluation, assessing friability and wetness of the litter. Scored 1–10, 1 = very bad, 10 = excellent. The protocol used was the same as in van Harn et al. (2009).

2.7. Statistical analysis

SAS Software version 9.4 was used for statistical analysis (SAS Institute Inc., Cary, USA) and data was analysed at pen level.

Performance data was analysed using linear mixed models consisting of fixed effects breed, enrichment and the 2-way interaction. Block (1−5) was included as random effect. Enrichment data was the number of broilers in proximity of an enrichment (lucerne bale) or using an enrichment (dust bath or perch) and was analysed using linear mixed models consisting of fixed effects breed, body weight and the 2-way interaction. Pen (1−20) and block (1−5) were included as separate random effects. Behavioural data was aggregated over the 5 subsequent scans and expressed as a percentage of broilers performing a certain behavioural category divided by the total number of broilers observed. Behaviours were merged into the following categories before analysis: ingestion (eating and drinking), locomotion, inactive, standing, comfort (comfort and dust bathing), foraging (foraging and ground pecking). Behavioural test (human approach test, novel object test, and free space test) data was expressed as the percentage of birds performing a certain behaviour divided by the total number of birds in the pen, the percentage of time for latencies compared to the duration of tests (3 min) and the average number of birds approaching the human or novel object over the whole test period. Behavioural data and behavioural test data were analysed using linear mixed models consisting of fixed effects breed, enrichment, target body weight, and all 2-way and the 3-way interaction. A backward regression procedure was used when fixed effects (i.e., 2-way and 3-way interaction) had $P > 0.1$, but breed*enrichment was always included. Pen (1−20) and block (1−5) were included as separate random effects. The normality of the data was assessed based on model residuals. Log-transformation was only performed for comfort and standing behaviour and behavioural test data were square root transformed to obtain normality of residuals. Values are presented as LSmeans ± SEM or as back transformed LSmeans ± SEM. Occurrences of aggressive and other behaviour were very low and were therefore excluded from statistical analysis. Post hoc pairwise comparisons were corrected by Tukey-Kramer adjustment. For interactions, we focused on significant differences within breed and within enrichment treatment at comparable total body weights.

For welfare and litter scores, a different statistical approach was used to assess the effects over multiple scores. Gait, footpad dermatitis, hock burns, cleanliness and skin lesion scores were analysed with ordinal regression using R package ordinal (R version 4.3.2). Some scores were aggregated or removed before analysis (for gait, score 0 + 1, score 4 and 5 did not occur, for footpad dermatitis and hock burns, score 4 did not occur, and for skin lesions, score 1 + 2). The fitted models included nested random intercept for block and pen and were fitted using the function clmm. For fixed effects, a full model was fitted first including breed, enrichment, sex, all 2-way and the 3-way interaction. Litter scores did not fit the ordinal regression model and were therefore analysed separately for each weight and breed combination using a exact Wilcoxon-Mann-Whitney rank-sum tests due to the limited sample size and low variability of the data. Using backward selection, the interactions that are not significant were dropped ($P > 0.05$), except for breed*enrichment which was always included. For each score, the selected model was used for further inference. R package emmeans was used to calculate the mean effect per breed/enrichment/sex. These estimates were centred and shown on the logit scale used when fitting the ordinal regression model. Subsequently, pairs of estimates were tested. Post hoc pairwise comparisons were corrected by Tukey-Kramer adjustment. Similar to the behaviour data, we focused on significant differences within breed and within enrichment.

3. Results

3.1. Performance

No interactions between breed and environmental enrichment, nor a main effect of enrichment, was observed on any of the measured performance parameters. Mortality did not differ between breeds. JA787 had higher body weight ($P < 0.001$), daily growth ($P < 0.001$), feed intake ($P < 0.001$), and a lower feed conversion ratio ($P < 0.001$) compared to S757N. Performance results are summarised in Supplementary Table 3.

3.2. Behaviour

3.2.1. Behaviour in the home pen

There were no interactions between breed and environmental enrichment nor a main effect of enrichment on behaviours in the home pen (Table 2). Only one significant interaction between body weight and breed was found for ingestion (combined eating and drinking) ($P < 0.001$). At 1.9 kg, JA787 broilers showed more ingestion behaviour than S757N broilers ($P < 0.001$). Table 2 presents the behavioural data averaged across all body weights. JA787 broilers showed less locomotion ($P < 0.001$), standing ($P < 0.001$), foraging behaviours ($P < 0.05$), and more inactive behaviour ($P < 0.001$), as compared to S757N broilers. No significant breed effect for comfort behaviour was found.

3.2.2. Human approach test

For the latency to approach the human, a three-way interaction between body weight, breed, and enrichment ($P < 0.05$) was found (Fig. 1, Panel A). No interactions between breed and environmental enrichment or main effects of enrichment or breed were found. After adjusting for multiple comparisons, no differences were found at the same body weights.

For the average number of birds that approached the human during the test, a significant interaction between breed and enrichment ($P < 0.05$) and between body weight and breed ($P < 0.05$) was observed. No main effects of breed or environmental enrichment were observed. When housed in NE pens, less JA787 broilers approached the human compared to S757N broilers (Fig. 2, Panel B) ($P < 0.01$). This breed difference was not observed within the EE pens. Additionally, at 1.1 kg, less JA787 broilers approached the human as compared to S757N (Fig. 2, Panel A) ($P < 0.01$).

3.2.3. Novel object test

A three-way interaction between body weight, breed, and environmental enrichment was found for the latency to approach the novel object (Fig. 1, Panel B) ($P < 0.01$) and for the average number of broilers approaching the object (Fig. 1, Panel C) ($P < 0.05$). No interactions between or main effects of breed or environmental enrichment were observed. At 1.1 kg, S757N housed in NE pens, had a longer latency to approach compared to those in EE pens (Fig. 1, Panel B). After adjusting for multiple comparisons, no differences were found at the same body weight for the average number of birds approaching the novel object.

3.2.4. Free space test

During the free space test, an interaction between body weight and breed was found for running ($P < 0.001$) and frolicking ($P < 0.05$) (Fig. 1, panel A). At 1.9 kg, more JA787 broilers were observed running than S757N. More JA787 also were observed frolicking compared to S757N at both 0.5 kg and 1.9 kg (Fig. 3, panel A). Breed was significant for sparring with more sparring behaviour seen in JA787 broilers compared to S757N (Fig. 3, panel B). Birds housed in the NE pens showed less frolicking ($P = 0.03$) and sparring ($P < 0.05$) behaviours than those housed in the EE pens (Fig. 3, Panel C). No interaction or main effects of breed and environmental enrichment were found for wing flapping.

3.3. Enrichment Use

There was a difference in breed for the use of the lucerne bale and the perches, with JA787 using the lucerne bale significantly more ($P < 0.01$) with 10.7 ± 0.4 birds near the net as compared to 5.3 ± 0.4 birds for S757N (Fig. 4, Panel A). For perch use, there was an interaction between breed and body weight, JA787 used the perch less than S757N,

Table 2
Effects of breed, enrichment and breed*enrichment interaction on home pen behaviours averaged across body weights for Hubbard JA787 and Hubbard S757N. NE = no enrichment, EE = environmental enrichment.

	Behaviours (%)						
		Ingestion[a]	Locomotion	Inactive	Standing[d]	Comfort[b,d]	Foraging[c]
Breed*Enrichment							
	JA787 * NE	19.7	4.1	57.6	3.5	3.6	6.8
	JA787 * EE	20.0	4.9	55.8	4.4	3.8	6.9
	S757N * NE	20.3	6.4	41.6	7.2	3.9	9.7
	S757N * EE	20.0	6.8	35.3	7.2	3.6	12.3
	SEM	2.4	0.7	3.6	1.2	1.3	1.6
Breed							
	JA787	19.8	4.5	56.7	4.0	3.7	6.9
	S757N	20.2	6.6	38.5	7.2	3.7	11.0
	SEM	1.6	0.5	2.7	1.1	1.2	1.1
Enrichment							
	NE	20.0	5.3	49.6	5.0	3.7	8.3
	EE	20.0	5.9	45.6	5.7	3.7	9.6
	SEM	1.6	0.5	2.7	1.1	1.2	1.1
P-value							
	$P_{breed*enrichment}$	0.90	0.75	0.51	0.41	0.81	0.42
	P_{breed}	0.90	**< 0.01**	**< 0.01**	**< 0.01**	0.97	**< 0.01**
	$P_{enrichment}$	0.99	0.28	0.24	0.36	0.99	0.41

[a] Sum of eating and drinking
[b] Sum of dustbathing and comfort behaviour
[c] Sum of foraging and ground pecking
[d] Transformed data are back transformed

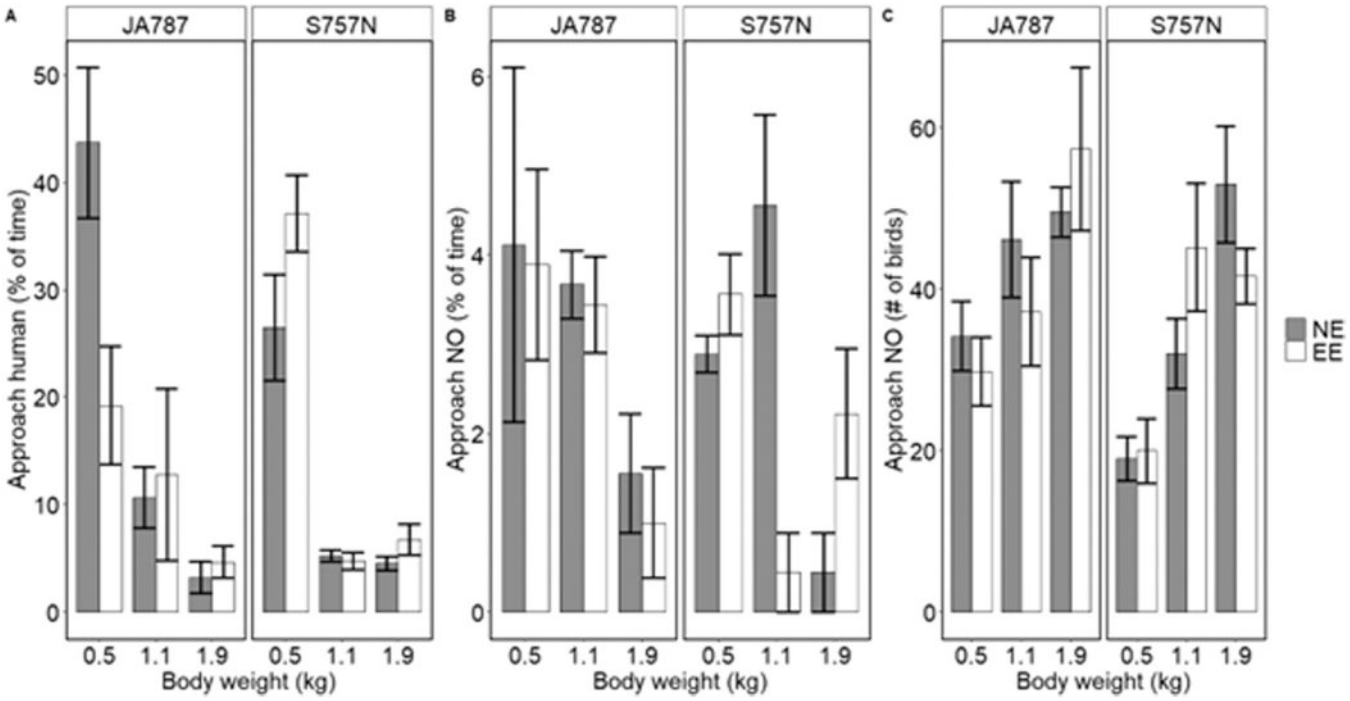


Fig. 1. Behavioural responses of Hubbard JA787 and Hubbard S757N in the human approach and novel object tests across three body weights. Panels show A) latency to approach a human, B) latency to approach a novel object, and C) number of birds approaching the novel object.

at 0.5 kg, 1.1 kg and 1.9 kg ($P < 0.01$) (Fig. 4, Panel B). Dust bath use did not differ between breeds. Supplementary Table 4 presents the mean number of broilers, averaged over body weights for use of each environmental enrichment.

3.4. Litter quality

No breed by environmental enrichment interaction was detected for either litter looseness or moisture and did not differ between breeds or enrichment. See Supplementary Figure 2 for the distribution of scores observed at each body weight for both breeds and enrichment.

3.5. Clinical welfare scores

A breed x enrichment x sex interaction was detected for gait ($P < 0.001$) and skin lesion scores ($P < 0.01$). JA787 broilers had a higher (worse) gait scores than S757N birds housed in both EE and NE pens ($P < 0.001$). EE broilers had higher gait scores, only in JA787 females ($P = 0.046$) with no additional effect of EE observed in males or S757N birds. For skin lesions, JA787 birds overall had higher (worse)

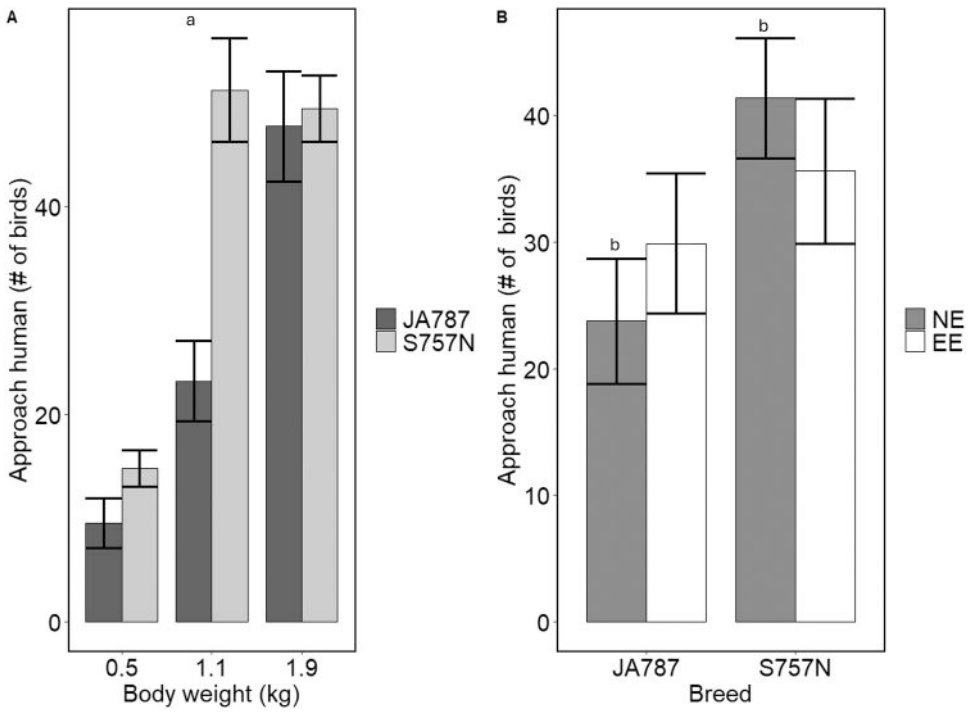


Fig. 2. Mean number of birds of each breed, Hubbard JA787 and Hubbard S757N observed approaching a human shown across A) body weights, 0.5, 1.1, 1.9 kg. and B) with NE = no enrichment or EE = environmental enrichment. a: indicates $P < 0.05$ difference between breeds at 1.1 kg, b: indicates $P < 0.05$ differences between breeds housed in NE.

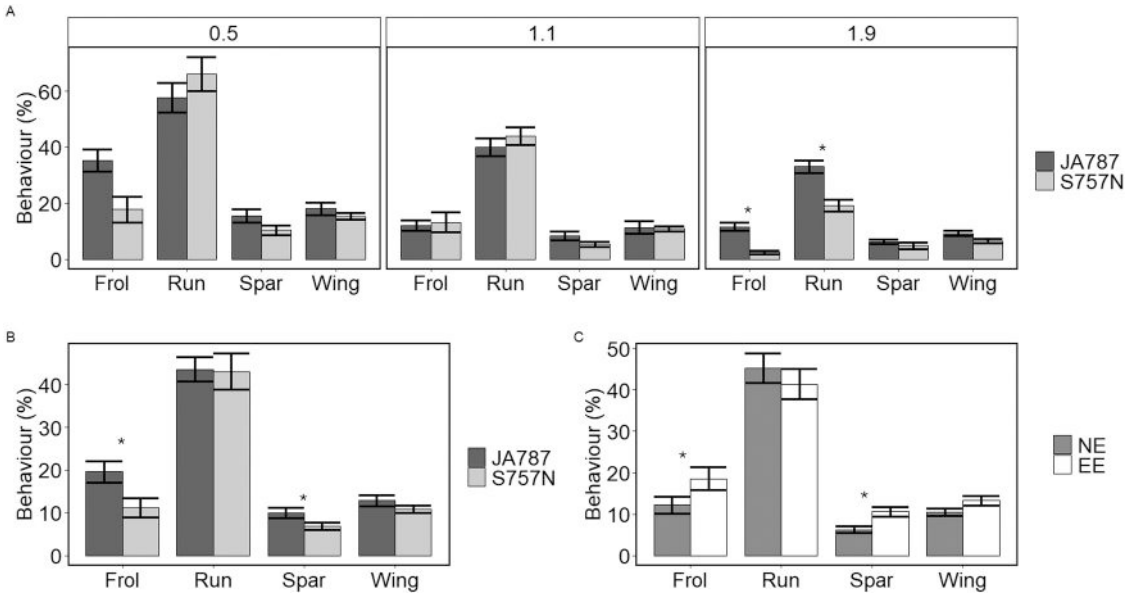


Fig. 3. A) Play behaviours response during the free space test for Hubbard JA787 and Hubbard S757N body weights: 0.5 kg, 1.1 kg, 1.9 kg. B) Breed effect on play behaviours averaged over body weights. C) Enrichment effect NE = no enrichment, EE = environmental enrichment, on play behaviours averaged over body weights. Behaviours presented as the mean percentage of broilers observed performing play behaviours during the free space test ± SE. Frol = frolicking, Run = running, Spar = sparring, Wing = wing flapping. *: A) indicates $P < 0.05$ difference between breeds at body weights, B) indicates $P < 0.05$ difference between breeds, C) indicates $P < 0.05$ differences between NE and EE.

scores than S757N birds. In JA787 females, EE had more severe skin scores ($P = 0.046$), whereas EE had no significant effect in JA787 males or in S757N birds of either sex. Across EE and NE pens, and sexes, JA787 birds consistently had higher (worse) gait and skin lesion scores than S757N birds (Fig. 5). A significant breed x sex interaction was found ($P = 0.026$) for cleanliness, with both JA787 males and females having worse scores for cleanliness compared to S757N ($P < 0.001$). FPD and hock burn were influenced by main effects of breed and environmental enrichment. JA787 broilers had higher scores for both FPD ($P < 0.001$) and hock burn ($P < 0.001$) than S757N broilers, and EE pens had lower i.e. better scores (FPD, $P < 0.001$; hock burn, $P = 0.002$) for both FPD and hock burn compared to NE pens.

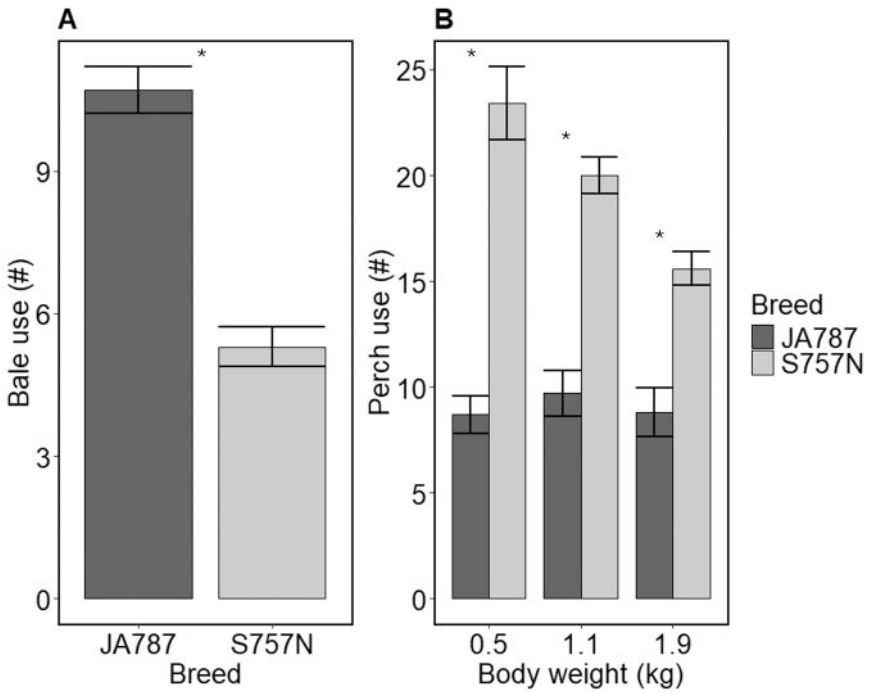


Fig. 4. A) Mean ± SEM number of birds using the bale per breed, Hubbard JA787 and Hubbard S757N averaged across body weights. B) Mean ± SEM number of birds using the perch per body weight compared by breed, Hubbard JA787 and Hubbard S757N. *: indicates $P < 0.05$ difference between breeds.

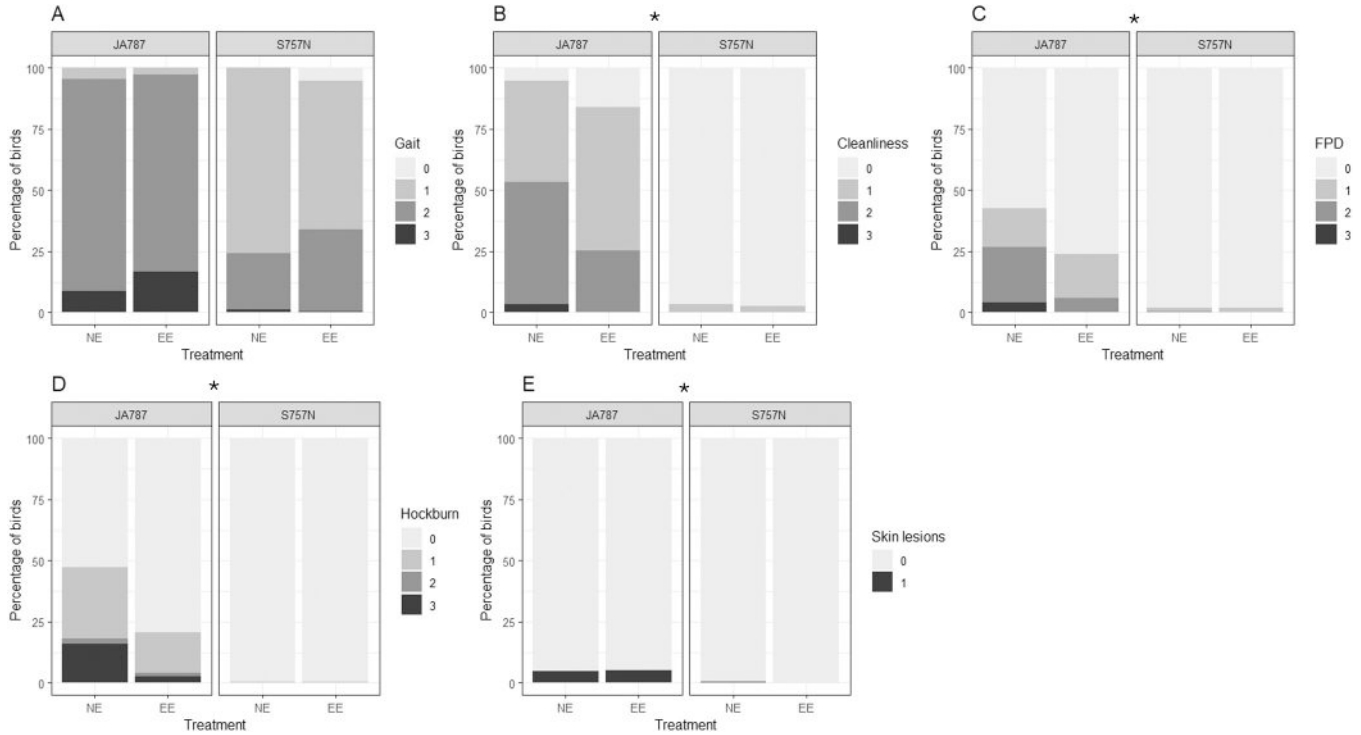


Fig. 5. Mean percentage of broilers within each score for A) Gait B) Cleanliness C) Footpad dermatitis (FPD) D) Hock burn (HB) E) Skin lesions, for both breeds, Hubbard JA787 and Hubbard S757N and environmental enrichment, NE = no enrichment, EE = environmental enrichment. *: indicates $P < 0.05$ difference between breeds. Sex effects are not shown.

4. Discussion

This study aimed to evaluate how broiler breed and environmental enrichment interact with respect to behaviour and welfare. It was anticipated that slower-growing broilers provided with environmental enrichment would show the most positive behaviour and welfare outcomes. Significant breed x enrichment interactions were not detected for the measured outcomes in this study. However, there were only five pens per treatment combinations which may have limited the statistical power to detect interaction effects and therefore, there is the possibility that breed-specific responses to enrichment were present but remain undetected. The results, however, suggest that there were more main

effects of breed than interaction effects or main enrichment effects. Thus, using a slower-growing breed was the predominant factor influencing welfare outcomes in this study. Slower-growing broilers performed more active behaviours, showed less fear responses and play, used perches more and bales less, and had better clinical welfare scores than the faster-growing broilers used in the present study. Environmental enrichment had limited effects, however broilers housed with enrichment showed more play behaviour and had better clinical welfare scores. Thus, both the use of a slower-growing breed and providing environmental enrichments were beneficial for broiler welfare.

The growth rate contrast between breeds in this study was substantial, however both strains grew comparatively slower than breeds typically studied and used in conventional systems. The slower-growing strain used, Hubbard S757N (~29 g/day) grows on the slower end of the range and is typically associated with slow-growing breeds used in extensive systems such as Label Rouge in France (Hubbard, personal communication). While the faster-growing breed, Hubbard JA787, has a growth rate of ~50 g/day, growing slower than conventional fast-growing genotypes such as Ross 308 (~60 g/day) and is usually applied in higher-welfare indoor production systems (Hubbard, personal communication). This is important when interpreting the findings, as many studies report behavioural and welfare differences between breeds with higher growth rates than those studied here (Wallenbeck et al., 2016; Baxter et al., 2021; van der Eijk et al., 2022). Additionally, due to this difference in growth rate, comparisons between breeds were done at similar body weights rather than at a similar age and should be considered when interpreting breed differences.

4.1. Behaviour observations

In our study, faster-growing broilers showed lower levels of locomotion, time spent standing, and foraging alongside increased levels of time spent inactive, indicating an overall reduction in activity compared to slower-growing broilers. This may be due to physical and energy constraints associated with rapid growth, and are known to reduce mobility (Vasdal et al., 2018; Dixon et al., 2020). Although, observations were conducted at similar body weights as opposed to similar ages, thus the difference in age may also have played a role. However, previous studies consistently confirm similar patterns of lower levels of activity in fast-growing broilers, with walking, standing, foraging less and eating and sitting more compared to slower-growers (Dixon, 2020; Rayner et al., 2020; van der Eijk et al., 2022). However, these studies use breeds with different growth rates compared to the current study, 30 g/day versus 60 g/day (Dixon et al., 2020), 45 g/day versus 49 g/day versus 63 g/day (Rayner et al., 2020), and 50 g/day versus 60 g/day (van der Eijk et al., 2022) whereas breeds with a slower growth rate as applied in the current trial are often not included. Despite studies using comparatively faster-growing breeds than in the current study, a similar trend was observed with breeds with the slowest growth rate performing the most active behaviours.

Environmental enrichment did not have an effect on the overall behaviours of either breed. Enrichment use was not likely limited due to space limitations as relatively low stocking densities were included (30 kg/m^2), allowing for full use of enrichments. The lack of enrichment effects contrasts previous studies where addition of enrichments influenced activity levels (de Jong et al., 2021; Vas et al., 2023). However, addition of enrichments may have a smaller effect when stocking density is relatively low, as enrichments had stronger effects in more restrictive environments (Riber et al., 2018). Indicating that broilers in the current study may have had sufficient space to perform desired behaviours whether environmental enrichment was present or not. The relatively moderate litter quality scores recorded in all pens in the present study could indicate that the litter was suitable for performing foraging and dust bathing behaviour, leading to no difference to be detected in these behaviours.

In addition to the breeds present in this study, the relatively low stocking density applied (30 kg/m^2) may have influenced the behaviour. Lower stocking densities can positively affect behaviour regardless of growth rate (van der Eijk et al., 2022). However, under the low stocking density applied here and in that trial, breed still had a great effect with slower-growing broilers showing more active behaviours and less fear. Indicating that the use of the slower-growing breed in practice is important even when using lower stocking densities.

4.2. Behaviour tests

When housed in pens without enrichment, more slower-growing broilers approached a human during the human approach test, whereas this breed difference was not observed in pens with environmental enrichment. This is in contrast to (Lourenço da Silva et al., 2021), where the presence of enrichments reduced fear responses. Possibly due to slower-growing broilers being more inclined to explore novel stimuli when there are no alternative forms of stimuli present, as is suggested by their higher levels of exploratory behaviour (Rayner et al., 2020). However, during the novel object test, broilers with environmental enrichment had a shorter latency to approach the novel object, suggesting the response to objects and humans may differ. Fewer faster-growing broilers approached the human than slower-growing broilers, perhaps due to the higher activity levels typically observed in slower-growing broilers, which may increase the likelihood of approach during the test and may reflect differences in fear (Forkman et al., 2007) or an increased motivation to explore. However, it is not always clear whether reduced approach behaviours reflects increased fearfulness or physical limitations that may restrict the ability to approach the observer (Vasdal et al., 2018; Rasmussen et al., 2022; Jacobs et al., 2023). No breed differences were observed for number of birds approaching during the novel object test confirming earlier research (Baxter et al., 2021), perhaps indicating lower levels of fear towards a novel object compared to a human observer. This study compared two breeds with faster growth rates than in our study (50 g/day versus 60 g/day), indicating that several broiler breeds may react to the novel object test similarly.

Faster-growing broilers showed more play behaviours than slower-growing broilers. This contrasts previous studies, reporting higher levels of play in slower-growing breeds compared to fast-growing broilers (Baxter et al., 2021; Rayner et al., 2020). These discrepancies may reflect differences in the breeds being used or the methodology used to assess play. As breeds were compared at equivalent body weights as opposed to the same age, differences in age may have influenced levels of play behaviour, potentially contributing to breed differences in the present study and to inconsistencies with previous research. Additionally, play behaviour in the current study was stimulated in a test situation creating free space, while others observed play behaviour under normal housing conditions (Rayner et al., 2020). However, our findings are in agreement with Rasmussen et al. (2024), similarly reporting that broilers with a faster growth rate played more than those with a slower growth rate. (Rasmussen et al., 2024) suggested that difference in age, sudden availability of free space, and fewer prior opportunities to express play behaviours may have led to a higher rebound response in faster-growing broiler, which may also explain the observed difference in play in the current study. Perhaps slower-growing broilers exhibit a higher baseline level of play, therefore not responding as strongly in a test situation, whereas, faster-growing broilers play less, responding more when given the opportunity (Baxter et al., 2021).

Additionally, environmental enrichment was found to promote play behaviours, broilers in these pens frolicked and sparred more, perhaps due to enrichment supporting a positive affective state (Baxter et al., 2018) in these broilers. The test situation however does not fully compare to baseline play in the flock, therefore it needs to be determined whether these are correlated.

4.3. Enrichment use

More faster-growing broilers were observed near the lucerne bales than the slower-growing broilers, whereas slower-growing broilers have generally been reported to interact with more with environmental enrichment (Riber et al., 2018; de Jong et al., 2021; Rayner et al., 2020). One explanation may be related to differences in motivation and physical ability, slower-growing broilers generally have a stronger preference to perch (Baxter et al., 2021; Riber et al., 2018) and are more capable of using elevated structures such as perches (Baxter et al., 2021), which may reduce the time spent near the lucerne bales. Faster-growing broilers were observed being more inactive overall in the present study, and were potentially using the lucerne bale as a hiding or resting place resulting in higher use of this enrichment. As the proximity to the bales was scored, it is not clear whether the breeds differed in their pecking behaviour towards the bale. No differences were observed in dust bath use between faster- or slower- growing broilers, however this enrichment was well used by both breeds, indicating that this is an important enrichment regardless of growth rate (Baxter et al., 2018).

4.4. Clinical scores

Faster-growing broilers scored higher, i.e. worse for recorded welfare indicators. This is consistent with findings indicating similar outcomes for walking ability, hock lesions, and cleanliness when comparing faster- and slower-growing breeds (Nicol et al., 2024; Dixon, 2020; Rayner et al., 2020; Baxter et al., 2021; van der Eijk et al., 2023). The increased levels of inactivity, and reduced use of perches observed in the faster-growing breed may have increased contact with litter, leading to worse scores for cleanliness, footpad dermatitis and hock burn (de Jong et al., 2014), although no differences in litter quality were found. Faster growth rates are also associated with poorer walking ability, and worse gait scores (Riber and Wurtz, 2024). Although the faster-growing broilers had worse gait scores, overall, scores were relatively good, with no birds having scores higher than score three, indicating no birds had a severe impairment or inability to walk (Welfare Quality® (2009)). Potentially, due to the faster-growing breed still having a slower growth rate compared to the conventionally used fast-growing broilers with growth rates of $>$ 60 g/day.

5. Conclusion

Using a slower-growing broiler breed improved broiler welfare, while environmental enrichment had limited effects. Despite this, enrichments were well used by both breeds in this study, indicating that they likely meet their behavioural needs and broilers were motivated to use them. This experiment confirms that the use of breeds with slower growth rates is an important step to promote welfare in extensive broiler production systems, with enrichment providing an additional resource but not compensating for use of breeds with faster growth rates. Broiler production systems aiming for higher welfare on-farm should prioritise adopting breeds with slower growth rates with environmental enrichment incorporated as a complementary resource.

CRediT authorship contribution statement

Teresa Johansson: Writing – review & editing, Writing – original draft, Validation. **Jerine A.J. van der Eijk:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Henk Gunnink:** Writing – review & editing, Data curation. **Stephanie Melis:** Writing – review & editing, Data curation. **Theo van Hattum:** Writing – review & editing, Data curation. **Ingrid C. de Jong:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was part of the mEATquality project (https://meatquality.eu/) “Linking extensive husbandry practices to the intrinsic quality of pork and broilermeat”, funded by the European Union’s Horizon 2020 Research and Innovation Programme (Grant Agreement No. 101000344). We thank Hubbard Breeders for supplying the chickens and the staff of the experimental facility for their care and management of the birds. The authors would like to thank Dennis te Beest for analysis of the litter quality data and feedback on the manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2026.107214.

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