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Investigating optimal levels of platform perch provision for windowed broiler housing

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Research Highlights

- Broiler chickens were housed commercially with 0, 8, 10 or 12 platform perches
- Platform perches facilitated roosting and all available perches were used
- Broilers reared with access platform perches were less fearful
- Higher levels of perch provision allowed for a higher level of flock roosting
- However, there were no significant health benefits to 12 perches vs 8 perches

Abstract

Broiler chickens show a preference for platform perches over traditional bar perches. Further information is needed on the optimal provision of these perches in order for them to be successfully installed in commercial systems. This study was designed to compare a control and three practical levels of platform perch provision. Four commercial houses on one farm were fitted with either 1) no perches, 2) 8 perches (0.5m² of space per 1000 birds), 3) 10 perches (0.6m²/1000 birds) or 4) 12 perches (0.7m²/1000 birds). The study was repeated over four production cycles, with 28 000 mixed-sex Ross 308 broilers placed in each house.

Observations of enrichment use, broiler behaviour, walking ability and litter quality were taken during weeks 2,3,4,5 and 6. Production data was also acquired post-slaughter. Perch occupancy, perching attempts and perching duration were used to assess enrichment use weekly. Broiler emotional state was determined through observations of play behaviour during a walk-through, and observations of fearfulness using avoidance testing, intensity of vocalisations (Db) and latency to approach a tray of peat. Platform perches were used fully at all levels of provision, with equal levels of occupancy, perching duration and perching attempts seen in each perch treatment ($p>0.05$). Lower levels of avoidance behaviour were seen in all perch treatments compared to the control ($p<0.05$), suggesting a reduced fearfulness, but there was no difference in vocalisations, latency to approach peat, or play behaviours ($p<0.05$). There was no effect of treatment on average gait scores, although fewer birds were categorised with the most severe abnormalities in the highest level of perch provision. Platform perches had no effect on activity levels, production parameters or litter quality ($p<0.05$). Suspended platform perches that are raised as birds age are successful at facilitating normal roosting behaviour and increase the floor space available in latter weeks. Higher levels of perch provision led to a higher level of flock roosting, and access to perches led to reduced avoidance behaviour. However, a higher level of perch provision tested did not result in an improvement to any health or welfare parameters compared to lower provision levels, and there were no clear beneficial effects of perches on activity levels or walking ability.

Keywords: fearfulness; play; enrichment; roosting; poultry

1. Introduction

In response to a sustained public interest in broiler welfare, certain suppliers are adopting housing standards that surpass legislative requirements. Their farms may belong to quality assurance schemes (e.g. RSPCA, 2019) or the suppliers can develop their own higher welfare standards (e.g. Moy Park, 2019). These systems are typically still intensive but require some combination of lower stocking densities, natural light, perches, straw bales and/or pecking devices. Although biologically relevant for poultry, the typical bar perches provided in broiler housing are poorly used and do not appear to improve many welfare parameters (LeVan et al., 2000; Bailie and O'Connell, 2015; Kiyma et al., 2016). Recently, several studies have revealed that broilers show a preference for platform style perches, which require less balancing and are more suitable for their heavy conformation (Norrington et al., 2016; Bailie et al., 2018; Malchow et al., 2018). Introducing perches that attract a high level of use may benefit broilers by satisfying a natural motivation, encouraging more diverse motor patterns in young birds and reducing the time they spend in contact with wet litter, which could improve leg health and severity of contact dermatitis (Ventura et al., 2010; Kiyma et al., 2016; Kaukonen et al., 2017a,b). Natural roosting behaviour also allows for extended periods of undisturbed rest and can reduce the levels of fearfulness in a commercial house (Yngvesson et al., 2018; Baxter et al., 2019). There is also a tendency for higher levels of play behaviours in enriched conditions (Baxter et al., 2019; Vasdal et al., 2019), which may be a useful indicator of a positive environment.

Although platform perches appear to be an attractive alternative to traditional bar perches, there is a lack of information available for industry on how much perching space is required. The aim of this study was to make a thorough assessment of the welfare of fast-growing broilers reared under commercial conditions with different levels of platform perch provision. Our highest provision level of 12 perches (0.7m² per 1000 birds) represented the maximum that was considered

feasible for this type of suspended platform on commercial farms. Two lower levels of provision, 10 perches (0.6m² per 1000 birds) and 8 perches (0.5m² per 1000 birds), were also tested to determine whether these lower and more economical levels would also facilitate perching and provide welfare benefits. There was an interest in knowing whether broilers would use all the perches at the highest provision level and whether there would be an incremental effect on welfare benefits as the number of perches increased. We hypothesised that higher levels of perch provision would lead to improvements in welfare parameters compared to lower levels and no perches. Level of enrichment use was assessed through measures of perch occupancy, time spent perching and the number of perching attempts. Behavioural observations of activity levels and walking ability were used to identify any benefits of access to perches to facilitate exercise. Broiler emotional state was also assessed by measuring strength of fear responses, latency to engage with a novel substrate, intensity of vocalisations and levels of play behaviour. Understanding the potential impact of platform perches on litter quality and productivity was also important, with data on mortality, body weights and contact dermatitis acquired post-slaughter.

2. Materials and Methods

2.1 Animals and housing

This trial was conducted on one Moy Park affiliated farm in Northern Ireland, between May and November 2018. Approximately 28 000 mixed-sex Ross 308 broiler chicks were placed as-hatched in each of four commercial houses. The trial was repeated over four production cycles, involving 16 flocks of birds. The houses were metal framed (86 m by 20 m) with an available floor area of approximately 1680 m². Stocking density did not exceed 30 kg/m². Broilers were partially depopulated around day 30 and the remaining birds were cleared around day 36-

42. Straw pellets were provided as litter. All houses were provided with 46 plastic wrapped chopped straw bales to be distributed as enrichment. Natural light was provided from Day 4 until clearing between 07:00 h and 21:00 h. Artificial light was also supplied according to EU regulations (Council Directive 2007/43/EC). All houses were heated using centrally controlled indirect heating systems, with temperature and humidity maintained automatically to breeder guidelines.

2.2 Treatments

For each cycle, each house contained one of four treatments: 1) control (no perches), 2) 8 platform perches, 3) 10 platform perches, or 4) 12 platform perches (Figure 1). The treatment offered in each house was rotated, so that each house contained each treatment over the experiment.

The perches were steel rectangles, 3 m x 0.575 m (1.725m²), with white plastic grids and a steel perch frame with a depth of 10cm (Figure 2). In the 8, 10 and 12 perch conditions there was an available perch space of 13.8m² (0.49m² per 1000 birds), 17.3m² (0.62m² per 1000 birds) and 20.7m² (0.74m² per 1000 birds), respectively. The perches were suspended from steel cabling fitted along the house ceiling, and attached to one winch mechanism for each side. There were 12 perches installed in all houses, with the required number lowered to facilitate each treatment. Cabling closest to each perch was replaced with chain which allowed for individual adjustments to the perch level were possible by adjusting the hook position on the chain (Figure 2).

2.2.1 Perch protocol

To avoid interfering with initial feeding behaviour, all perches were lowered on day 7. The perches were initially suspended approximately 12cm from ground level which meant that the bottom of the steel frame was 2 cm from the ground. This allowed the perch to swing freely but prevented young chicks from getting

underneath the perches for safety reasons. Chicks could jump this height and were able to use the perches from day 7. From day 21, the height of the perches was raised to 15cm. At this height birds were still not able to go underneath the perches. On day 28 until slaughter, the perches were raised to 20cm. Broilers could jump onto perches and could use space under the perches at this height, effectively increasing the available floor area. These perch heights were manually checked and maintained twice a week by the observer.

2.3 Measurements

The farm was visited twice a week during weeks 2, 3, 4, 5 and 6. Each house was virtually split into 84 sections which were classified as either edge or central. An even number of edge and central locations were always chosen for observations. All video footage was taken using Camileo X-Sports cameras (Toshiba, Surrey, UK) and GeeKam action cameras (Shenzhen Bodalong Technology Co., Ltd, Guangdong, CN) mounted on 1 metre high wooden tripods. On the first day each week, measures of fearfulness, exploration, play behaviour and litter quality were taken. On the second day, the broilers were gait scored and observations of perch use and behaviour in unenriched areas were made.

2.3.1 Perch Use

Between 14:00 h and 17:00 h, video footage was taken of four perches. The four perches were randomly chosen from the 8 available perches that were present in all treatment houses (Figure 1). Each perch was recorded for half an hour, giving a total of 2 hours of footage per house per week. The footage was analysed using a combination of scan and focal sampling. Following a 10 minute settling period, the number of broilers on the perch was recorded every 5 minutes using instantaneous scan sampling (at 10, 15, 20, 25 and 30 minutes). After each of the five scans, the number of perching attempts were recorded using all occurrence

sampling for two minutes. These perching attempts were classified as either failed (the bird did not get onto the perch) or successful. Data was averaged to give one score for each of the four perches, per house, per week. To record time spent perching, the first five birds that successfully perched following the 10 minute settling period were observed until they ended the bout (by leaving the perch) or the end of the video.

2.3.2 Fearfulness

Once per week, fearfulness was measured between 9:00 h and 13:00 h using avoidance testing, vocalisations during a walk-through, and latency to approach a novel substrate. Avoidance testing was performed as in Baxter et al. (2018), with the observer approaching a randomly selected seated broiler from a distance of ~5 m. Once the bird withdrew its second foot, the distance between the observer and the bird's original location was measured (cm). Ten broilers were tested in each house, from ten random house sections without perches. Flight distances for the ten broilers were then averaged for each house, to give one score per house, per week.

Intensity of group vocalisations during a walk through were tested in four random locations. The observer walked 15 paces (~11m) from the centre of the chosen section towards the front or rear of the house. A handheld noise meter (Tacklife, Guangdong, CN) was held at hip height as the observer walked, with the "max" function engaged which recorded the maximum noise level (Db) reached. The four scores were averaged for each house, per week.

Latency to ground peck and dustbathe in moss peat was tested in four random locations per house. The observer placed a black metal tray (70 cm by 46 cm; Elli-Bo, Hampshire, UK) filled to a depth of ~3 cm with moss peat (Better Growing Ltd, Dungannon, UK) in the centre of the chosen section. Once the observer had

retreated to a distance of approximately 3 metres, the behaviour of broilers around the tray was observed for 5 minutes. Latency for a broiler to peck at the peat and latency until the first vertical wingshake (VWS) was recorded. If no birds pecked at the substrate or performed VWS then the maximum score of 5 minutes was recorded. The four scores were averaged for each house, per week.

2.3.3 Play behaviour

Play behaviours were stimulated using an observer walk through, as in Baxter et al. (2018). Between 13:00 h and 17:00 h, play was tested in four random locations per house, per week. The observer set up the camera and walked in front of and away from it, before walking back towards the camera. This cleared a space of broilers in that section and acted as a disturbance. The observer then left the house and cameras were left to record for 15 minutes before being moved to the next section.

Video footage was analysed using all occurrence sampling of play behaviours in the 5 minutes after the walk-through. These play behaviours included frolicking (spontaneous running and turning with wing flapping) and sparring (acting out elements of an adult fight without significant contact; detailed ethogram in Baxter et al., 2018). Aggressive interactions were also recorded throughout (vigorous pecking or kicking that makes contact and may cause injury). The observation area was 1 m wide and extended 2 m away from the tripod, giving an observation area of 2 m². Data on total play behaviour, individual types of play, and levels of aggression were averaged per house, per week.

2.3.4 Activity

Between 13:00 h and 17:00 h, the behaviour of broilers in areas without perches or bales was recorded in four random sections of each house. Each area was filmed for half an hour, giving a total of 2 hours of footage per house per week. The

footage was analysed using scan sampling, with broilers observed within a 2m² area in the centre of the section. After a ten minute settling period, four scans were taken of the observation area per video, at 10, 15, 20 and 25 minutes. Over a 5 s period, the behaviour of birds was categorised as either active (performing any behaviour from a standing or walking position), sitting active (sitting and performing another behaviour, e.g. ground pecking, preening, dustbathing), sitting inactive (sitting without any other behaviours), or resting (birds with their head under their wing, resting on their chest or lying on their sides, with eyes closed when visible). The total number of broilers present was also used to calculate bird density per m².

2.3.5 Walking ability

In each house, 40 broilers were gait scored each week ($N = 3200$). Two broilers from each of twenty random (10 central and 10 edge) sections were scored using the Modified Gait Scoring Method (Garner et al., 2002). As in Baxter et al. (2017), the two broilers from each section were chosen using a numbered Perspex grid. The observer then walked slowly up to them, encouraging them to move away, and scored their walking ability from 0 (normal) to 5 (unable to stand).

2.3.6 Litter quality

Litter samples were taken from 8 random sections, two central and two edge. Sample locations were pre-determined using random number generators and litter was removed using a soil sampling tube (NHBS Ltd, Devon, UK), which consistently took 1 inch of litter. The samples were taken from four areas per section. The 32 samples were mixed and ~100 grams was dried at 70°C for 24 hours before being re-weighed and the % water loss calculated.

2.3.7 Production data

Production data were taken from farm records at the end of each production cycle. This included information on body weights, culls, mortality, contact dermatitis and % downgrades. Three types of contact dermatitis were measured at slaughter: footpad dermatitis, breast burn and hock burn. The entire flock was tested for hock burn and breast burn using computer visualisation and automatic grading, recording all lesions >3 mm. A random sample of 100 birds are monitored for footpad dermatitis manually by slaughterhouse staff on a scale of 0-2. Broilers were classified as a downgrade in the presence of contamination, ascites, emaciation, cellulitis, dermatitis, runting, perihepatitis or necrosis.

2.4 Statistical Analysis

All analysis was conducted on SPSS (v25). Linear mixed models (LMM) were primarily used for analysis, with Treatment and Week as fixed effects and House (within Cycle) as a random effect. Where the models returned a random variance output of 0 the model was simplified as stated. There was occasional missing data due to technical issues however this did not exceed 5% of the total data. Perch occupancy (N=227), total perching attempts (N=227), successful perching attempts (N=227) and latency to approach a novel substrate (N=320) were analysed using the LMM model above. Successful and failed perching attempts were log+1 transformed prior to analysis to improve model residuals. Failed perching attempts (N=227) and vocalisations (N=319) were analysed with Treatment and Week as fixed effects and Cycle as a random effect. Time spent perching (N=954), avoidance (N=799), total play (N=316), frolicking (N=316) and sparring (N=316) were analysed using a fixed effects model with Treatment and Week as fixed factors. Play data were log+1 transformed prior to analysis. For time spent perching, only birds that finished their perching bout within the half hour video were included in analysis (85% of bouts) to avoid under- or over-estimating the potential length of their perch time (as in Bailie and O'Connell, 2014). Activity data

were analysed using a fixed effects model with treatment, week and bird density (number of broilers in the observation area per m²) as fixed effects. Gait scores (N=4160) were ordinal, with ordered medians (from no perches to 12 perches). Therefore, a Kruskal-Wallis test with follow up Jonckheere's test was used to investigate trends in the data. Production data were analysed using a one-way ANOVA or Kruskal-Wallis test as appropriate, with treatment as the fixed factor. Means reported within analysis are Estimated Marginal Means (EMM) or where transformations have been applied, raw means (M) or back-transformed means (BtM) are presented for interpretation. Pairwise post-hoc comparisons were performed with Bonferroni correction. Significance was set at $p < 0.05$.

2.5 Results

2.5.1 Perch use

2.5.1.1 Time spent perching

The average time broilers spent perching overall (n=954) was 352 seconds, or 5 minutes and 52 seconds (95% CI [328.14, 375.96]; min=5s, max=30mins). There was no significant interaction between treatment and week, and no significant effect of treatment on length of time perching ($p > 0.1$). The age of the birds had a significant effect on the length of time they spent perching ($F(4,939)=41.1$, $p < 0.001$), with perch times increasing as they aged (estimated marginal means (EMM) week 2=213.5s [168.6, 258.4], week 3=219.0s [174.6, 263.5], week 4=397.4s [351.0, 443.7], week 5=529.7s [479.8, 579.6], week 6=598.1s [522.3, 673.8]). Perch time was significantly lower in week 2 compared to weeks 4,5 and 6, in week 3 compared to weeks 4,5 and 6, and in week 4 compared to weeks 5 and 6 ($p < 0.05$).

2.5.1.2 Perch occupancy

There were broilers present on the perches during all observations, with an average of 23 birds (95% CI [22.2, 24.7]; Min=1, Max=74), or 11.5 birds per m², observed on the perches at any one time. Perch occupancy was not significantly affected by treatment and there was no treatment by week interaction ($p>0.5$). However there was a significant effect of age on perch occupancy ($F(4,203.4)=51.1$, $p<0.001$), with perch occupancy increasing between weeks 2 and 3, and then gradually decreasing until the final week (EMM week 2=19.9 [-7.0, 46.9], week 3=30.3 [3.0, 57.6], week 4=26.0 [-1.3, 53.1], week 5=25.8 [-1.5, 53.1], week 6=11.4 [-20.2, 43.0]). Occupancy was highest in week 3, with pairwise comparisons showing significant differences between all weeks except for weeks 4 and 5 ($p<0.05$).

2.5.1.3 Perching attempts

There was a significant interaction between treatment and week for the number of successful perching attempts recorded ($F(8,209.1)=2.46$, $p=0.015$). Simple effects analysis revealed that there was a difference in successful perching attempts during week 2, but not during weeks 3,4,5 and 6 of the cycle. For week 2 only, there were a higher average number of perching attempts recorded in houses containing 8 perches, compared to those with 10 or 12 (Figure 3). The number of failed perching attempts was significantly affected by week ($F(4,209.8)=42.43$, $p>0.001$), but not by treatment ($p>0.9$), with the number of failed perching attempts reducing as birds aged (Figure 4). There was no significant interaction between treatment and week ($p>0.05$). The total number of perching attempts were similarly affected by week ($F(4,222)=133.74$, $p<0.001$) but not by treatment ($p>0.05$). Pairwise comparisons revealed no significant difference between weeks 2 and 3, but significant differences between all remaining weeks, with average perching attempts reducing over time (week 2 M=11.76 [5.6, 17.8], week 3 = 14.06 [8.1, 20.1], week 4=6.53 [0.5, 12.5], week 5=3.90 [-2.1, 9.9], week 6=0.85 [-5.2, 6.9]).

2.5.2 Fearfulness

2.5.2.1 Avoidance behaviour

Overall, there was an average distance of 271.5cm reached before broilers withdrew. Both treatment ($F(3,779)=8.35$, $p<0.001$) and week ($F(4,779)=6.13$, $p<0.001$) had a significant effect on broiler withdrawal distance. Birds in all of the perch conditions had significantly shorter average withdrawal distances compared to the control, which indicates that an observer was able to get significantly closer to broilers when the birds were housed with access to perches (Figure 5). Over time, there was an unstable effect of age on withdrawal distances, with the shortest avoidance distances in week 3 and 6 (Figure 6). There was no significant interaction between treatment and week ($p>0.05$).

2.5.2.2 Vocalisations

There was no effect of treatment on the volume of broiler vocalisations during a walk through (0 perches $M=95.02$ [74.0, 116.1], 8 perches $M=94.08$ [73.2, 115.0], 10 perches $M=94.23$ [73.2, 115.3], 12 perches $M=95.18$ [74.1, 116.2], $p>0.05$), and no treatment*week interaction. Broiler age had a significant effect on vocalisation volume ($F(4,296)=44.71$, $p<0.001$), with decibel level generally increasing over time (week 2 $M=89.27$ [59.2, 119.4], week 3 $M=92.69$ [62.6, 122.8], week 4 $M=95.45$ [65.4, 125.5], week 5 $M=99.19$ [69.4, 128.8], week 6 $M=96.61$ [66.5, 126.7]). Pairwise comparisons showed all weeks were significantly different ($p<0.05$) from one another except for weeks 4 and 6.

2.5.2.3 Latency to approach a novel substrate

Overall, it took an average of 215 seconds (95% CI [191.52, 238.75]), or 3 minutes and 35 seconds, for birds to approach and peck at the novel peat substrate. There was no significant effect of treatment on their latency to approach peat ($p>0.2$).

There was a significant effect of age, with birds taking less time to approach the substrate over time (week 2 $M=278.81$ [-94.9, 652.6], week 3 $M=244.38$ [-129.4, 618.1], week 4 $M=208.72$ [-165.0, 582.5], week 5 $M=139.50$ [-234.3, 513.3], week 6 $M=112.27$ [-261.5, 486.0]). Pairwise comparisons revealed a significant difference between week 2 and weeks 4, 5 and 6 ($p<0.001$), between week 3 and weeks 5 and 6 ($p<0.001$), and between week 4 and weeks 5 and 6 ($p<0.001$). There were only 5 occasions (12 perches = 3, 0 perches = 2) when a bird began vertical wingshaking within the five minute period.

2.5.3 Play behaviour

An average of 14.85 (95% CI [13.27, 16.43]) bouts of play behaviour were observed in the five minute period after broilers were disturbed with a walk-through, with an average of 8.13 [7.10, 9.15] bouts of frolicking and 6.73 [5.98, 7.47] bouts of sparring recorded. There were only 2 episodes of aggression observed. The number of perches available in the house did not have a significant effect on the amount of total play, frolicking or sparring recorded ($p>0.1$). Age had a significant effect on levels of total play ($F(4,296) = 29.42$, $p<0.001$), frolicking ($F(4,296) = 16.73$, $p<0.001$) and sparring ($F(4,296) = 29.13$, $p<0.001$). Levels of play tended to increase over time, peaking in week 4 and reducing again until week 6 (Table 2). There were no interactions between treatment and week.

2.5.4 Activity

The number of perches provided did not have a significant effect on the percentage of birds observed sitting inactive ($p>0.5$), sitting active ($p>0.7$), resting ($p>0.8$) or active ($p>0.1$) within the unenriched observation areas. There was also no interaction between treatment and week, and no significant effect of bird density ($p>0.05$). However, the level of sitting inactive ($F(4,163)=8.10$, $p<0.001$), sitting active ($F(4,163)=8.51$, $p<0.001$) and active behaviours ($F(4,163)=11.04$, $p<0.001$)

did vary as birds aged. There was a general increase in inactivity and decrease in activity. Pairwise comparisons showed a significantly lower percentage of birds were observed sitting inactive in week 2 compared to weeks 3,4,5 and 6 (week 2 $M=39.24\%$ [35.35, 43.12], week 3 $M=48.80\%$ [44.86, 52.74], week 4 $M=50.33\%$ [46.26, 54.40], week 5 $M=52.01\%$ [48.06, 55.96], week 6 $M=54.72\%$ [49.82, 59.61]). Levels of sitting active were significantly higher in week 2 compared to weeks 3, 5 and 6 (week 2 $M=19.16\%$ [16.60, 21.73], week 3 $M=12.88\%$ [10.27, 15.48], week 4 $M=13.14\%$ [10.45, 15.83], week 5 $M=13.68\%$ [11.07, 16.29], week 6 $M=7.65\%$ [4.41, 10.88]).

There was significantly higher proportion of birds performing active behaviours in weeks 2 and 3 compared to weeks 5 and 6, and in week 4 compared to week 6 (week 2 $M=13.58\%$ [11.12, 16.04], week 3 $M=11.66\%$ [9.17, 14.16], week 4 $M=8.37\%$ [5.79, 10.94], week 5 $M=6.51\%$ [4.01, 9.01], week 6 $M=2.38\%$ [-0.72, 5.48]).

2.5.5 Walking ability

Broiler gait scores were not significantly affected by the number of perches provided, $N = 4056$, $H(3) = 2.056$, $p > 0.1$. There was also no significant effect of perch level on walking ability within weeks ($P > 0.05$), however age did significantly affect overall gait score ($N = 4056$, $H(4) = 1238$, $p < 0.001$). Jonckheere's test revealed a significant trend in the data, with gait score worsening as birds aged ($J = 4,532,165$, $z = 35.7$, $p < 0.001$, $r = 0.56$). The distribution of gait scores within weeks and overall are displayed in Table 1.

2.5.6 Litter Quality

Litter moisture was not significantly affected by treatment ($F(3,16) = 0.22$, $p = 0.878$) and there was no significant interaction ($p > 0.05$). Week did have a significant effect on litter moisture ($F(4,64) = 64.64$, $p < 0.001$), with the wetness of

litter increasing until week 5 ($M \pm$ standard error: week 2 = 20.52 ± 1.12 , week 3 = 25.10 ± 1.12 , week 4 = 33.91 ± 1.12 , week 5 = 34.94 ± 1.12 , week 6 = 31.067 ± 1.12). Pairwise comparisons indicated no significant difference between week 4 and week 5, and week 4 and week 6, with significant differences between all other pairwise comparisons ($p < 0.05$).

2.5.7 Production data

Over the 16 flocks (4 houses over 4 cycles), there was an average of 2.75% [2.32, 3.07] mortality and a cull rate (leg culls and other culls) of 0.47% [0.41, 0.54]. An average of 1.95% [0.71, 3.18] broilers showed evidence of hockburn, 5.89% [3.88, 7.89] of pododermatitis and 0.27% [0.21, 0.33] dermatitis. Broilers reached a slaughter weight of approximately 2.2kg in an average of 39 ± 2 days. There was no significant effect of treatment on final bird weight, mortality (%), culls (%), hockburn (%), pododermatitis (%) or dermatitis (%) ($p > 0.1$).

3. Discussion

This study was designed to evaluate the health and welfare outcomes of fast-growing broiler chickens housed under commercial conditions with either no perches, 8 perches, 10 perches or 12 platform perches. In enriched houses, broilers were consistently observed using the perches (100% of 1124 instantaneous scans), which further confirms their suitability for broiler chickens (Norrington et al., 2016; Bailie et al., 2018; Malchow et al., 2018). The number of perches provided did not influence perch occupancy, indicating that broilers used all perches available at the highest provision levels. Broilers showed significantly less avoidance behaviour, suggesting a reduced fearfulness, when housed with any level of platform perch provision compared to the barren control. None of the levels of platform perch provision tested had a significant effect on other measured

parameters of health and welfare, including activity levels, reaction to novelty, play behaviour, walking ability and production parameters.

Recognition of broilers' limited perching ability and calls for more appropriate perch designs for poultry housing are not new (Faure and Jones, 1982; LeVan et al., 2000). However, a positive rearing environment has become increasingly important to consumers and retailers are responding by updating their housing systems. Modern broilers remain motivated to roost and consistently show a strong preference for platforms over traditional perches (Norrington et al., 2016; Bailie et al., 2018; Malchow et al., 2018). In the current study, broilers were observed perching in all observations, with an average of 11.5 birds per m² using the platforms at any one time. For comparison, an average of 0.4 birds per 10m length of perch were found to roost on the wooden bars (Norrington et al., 2016). Broilers also spend considerably longer on platform perches, with an average of 6 minutes observed in the current study compared to 2 minutes on bar perches (Bailie and O'Connell, 2015). Perch occupancy, perching attempts and perching time were unaffected by the number of platform perches installed, suggesting that additional perches were used fully and would lead to a higher flock level of roosting. There were similarly no adverse effects of platform perch provision on productivity or mortality.

Broiler age affected all aspects of perch use. Individual bouts of perching became longer over time, which is the opposite trend to their perching behaviour on bar perches (Bailie and O'Connell, 2015), but is consistent with an increase resting behaviour in older birds (Tickle et al., 2018). Similar perch occupancy levels, with a peak in week 3, were found in recent observations of Ross broilers on elevated structures (Malchow et al., 2018). Bailie et al. (2018) found no age effect on occupancy or perching attempts in broilers using similar platforms when observing birds in weeks 3,4 and 5, suggesting the most significant age effects are seen in young and slaughter age birds. Older broilers may have found it more difficult to

jump onto the perches when they were raised to their maximum height of 20cm. However, this maximum height was reached in week 5, and there was no dip in occupancy between weeks 4 and 5. As such, the week 6 reduction in occupancy is probably a result of reduced mobility or a reduction in motivation to perch due to the increase in energy required for active behaviours (Tickle et al., 2018). It is possible that reducing the height of the perches for week 6 may increase use, however the birds would not be able to move underneath the platforms, removing the advantageous increase in floor space.

Broilers in all of the perch treatments showed a reduction in avoidance behaviour compared to the barren control. In a previous smaller study with comparable methodology (Baxter et al., 2019), shorter avoidance distances were observed in houses fitted with platform perches and dust baths. The study only looked at broilers in week 5, however it did suggest that increases in environmental complexity may temper broiler escape reactions in a commercial house. Literature on the effect of perches on broiler fearfulness is limited, and wide variation in housing methods make comparisons difficult. A shorter duration of tonic immobility (TI), which indicates reduced fearfulness, has been observed in broilers experimentally housed with elevated platforms (Tahamtani et al., 2018). Access to bar perches does not have a similar effect on TI durations for broilers (Bizeray et al., 2002; Ventura et al., 2010) but did appear to benefit the more mobile broiler breeders (Brake et al., 1994). As with the majority of previous perching trials, it is likely that results are often confounded by broilers inability to use traditional perches. Although this reduction in avoidance suggests an improvement in emotional state, there was no increase in play behaviour in the presence of platform perches. Play was, however, easily stimulated by a walk-through and aggression was minimal, as often reported (e.g. Estevez et al., 1997; Pettit-Riley et al., 2002; Baxter et al., 2019).

There was no accompanying effect of perch provision on latency of broilers to approach a tray of peat or on the intensity of their vocalisations when approached by an observer. Although well validated in laying hens (Jones, 1996), the usefulness of novel object tests for broilers is less clear. Increasing the complexity of housing has rarely altered broilers willingness to engage with a novel object (Bailie and O'Connell, 2015; Pichova et al., 2016; Jong and Gunnik, 2019). Fast-growing broilers may be limited in the amount of energy available for exploration (Lindqvist et al., 2006). Slower growing broilers, for example, have longer durations of TI, indicating heightened fearfulness, but are more likely to approach a coloured stick than Ross 308s (Lindholm et al., 2016). Novel objects used in these tests are also rarely biologically relevant (e.g. coloured sticks and traffic cones), which may reduce broilers' motivation to engage with them. In the current study, we attempted to combine novel object testing with a known attractive substrate. Broilers show a strong preference for peat (Baxter et al., 2018), even with no previous experience of it (Wichman and Keeling, 2008). However, the results of this study do not support evidence that platform perches either reduce broilers fear of novelty or increase their levels of exploration. Broilers did take less time to approach the peat over time, which may indicate a reduction in fearfulness as birds aged. Litter quality also reduced in later weeks, which may have increased their motivation to seek out alternative foraging and dustbathing substrates. Intensity of vocalisations were similarly unaffected by perch provision but did increase with age, peaking in week 5. While the avoidance test measures the distance before a bird reacts to a perceived threat of an approaching human, the vocalisations measure the intensity of reactivity of birds already in the immediate vicinity of an observer. Although we did not identify individual sound frequencies, the recorded vocalisations were likely to be alarm calls, rather than, for example, food calls (Marx et al., 2001). Intensity of vocalisations has been used in laying hen research to investigate acoustic differences between feather pecking and non-feather pecking hens

(Bright, 2008). There is potential for vocalisations to be a non-invasive way of monitoring flock welfare (Fontana et al., 2016), however we found no evidence that intensity of alarm calls following a disturbance is associated with differences in platform perch provision.

Consistent with previous research, broiler walking ability, levels of activity and litter quality deteriorated as birds aged (Kaukonen et al., 2017a,b; Tickle et al., 2018; Baxter et al., 2019). Although attracting a high level of use, we detected no clear benefits of platform perches on average walking ability. There were, however, fewer birds observed with the most severe gait abnormalities in the houses with the highest level of perch provision. The broilers in the current study had relatively good gait scores, with 94% displaying a score of ≤ 2 in week 6. This general low prevalence for leg weakness and perhaps other management factors, including low stocking density (Dawkins et al., 2004), may have reduced the size of any positive effect of platform perches. Kaukonen et al. (2017b) found that access to platforms led to an improvement in walking ability and a reduction in tibial dyschondroplasia in flocks with an average of 30% showing gait scores of ≥ 3 by slaughter age. Their study also provided higher platforms with ramp access, rather than lower platforms that can be jumped onto as in the current study, and their platforms covered 10% of the floor space. It is possible that ramps offer an additional dimension of movement, encouraging a more diverse locomotion pattern in young birds which contributed to an improvement in leg health (Kaukonen et al., 2017b). The overall floor space occupied was also significantly more than the 0.8%, 1.03% and 1.23% of floor space covered in the present study. This relatively low level of perch provision may have made it more difficult to detect a flock level effect, however we were limited by the practicalities of providing enrichments on commercial farms and the levels provided in this study appeared to more closely align with typical industry provision in the UK (Red Tractor, 2018).

4. Conclusions

Broilers showed a consistent motivation to perch and all perches in the highest provision treatment were used fully, which suggests additional perches will lead to a higher level of flock roosting. There was no negative effect of high levels of perch provision on any production parameters and their presence reduced the intensity of avoidance behaviours, which may indicate an improvement in emotional state. However, there was no effect of platform perches on broiler walking ability, activity levels or carcass quality. Contrary to our hypothesis, there was no sliding increase in measured welfare parameters as the level of perch provision increased. Although successful at satisfying a behavioural priority for broilers, there was no clear evidence that providing 0.7m² of perching space per 1000 birds provided leg health benefits over lower levels of provision.

Ethics statement

All methods described in this paper were approved by the School of Biological Sciences (Queen's University Belfast) Research Ethics Committee (reference number QUB-BE105

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References

- Bailie, C. L., & O'Connell, N. E. (2015). The influence of providing perches and string on activity levels, fearfulness and leg health in commercial broiler chickens. *animal*, 9(4), 660-668.
- Bailie, C. L., Baxter, M., & O'Connell, N. E. (2018). Exploring perch provision options for commercial broiler chickens. *Applied animal behaviour science*, 200, 114-122.
- Baxter, M., Bailie, C. L., & O'Connell, N. E. (2019). Play behaviour, fear responses and activity levels in commercial broiler chickens provided with preferred environmental enrichments. *animal*, 13(1), 171-179.
- Bizeray, D., Estevez, I., Leterrier, C., & Faure, J. M. (2002). Influence of increased environmental complexity on leg condition, performance, and level of fearfulness in broilers. *Poultry Science*, 81(6), 767-773.
- Brake, J., Keeley, T. P., & Jones, R. B. (1994). Effect of age and presence of perches during rearing on tonic immobility fear reactions of broiler breeder pullets. *Poultry science*, 73(9), 1470-1474.
- Bright, A. (2008). Vocalisations and acoustic parameters of flock noise from feather pecking and non-feather pecking laying flocks. *British poultry science*, 49(3), 241-249.
- Dawkins, M. S., Donnelly, C. A., & Jones, T. A. (2004). Chicken welfare is influenced more by housing conditions than by stocking density. *Nature*, 427(6972), 342.
- Estevez, I., Newberry, R. C., & De Reyna, L. A. (1997). Broiler chickens: a tolerant social system. *Etologia*, 5(1).
- Faure, J. M., & Jones, R. B. (1982). Effects of sex, strain and type of perch on perching behaviour in the domestic fowl. *Applied Animal Ethology*, 8(3), 281-293.
- Fontana, I., Tullo, E., Scrase, A., & Butterworth, A. (2016). Vocalisation sound pattern identification in young broiler chickens. *animal*, 10(9), 1567-1574.
- Garner, J. P., Falcone, C., Wakenell, P., Martin, M., & Mench, J. A. (2002). Reliability and validity of a modified gait scoring system and its use in assessing tibial dyschondroplasia in broilers. *British poultry science*, 43(3), 355-363.
- Jones, R. B. (1996). Fear and adaptability in poultry: insights, implications and imperatives. *World's Poultry Science Journal* 52, 131-174.
- Kaukonen, E., Norring, M., & Valros, A. (2017a). Evaluating the effects of bedding materials and elevated platforms on contact dermatitis and plumage cleanliness of commercial broilers and on litter condition in broiler houses. *British poultry science*, 58(5), 480-489.

- Kaukonen, E., Norring, M., & Valros, A. (2017b). Perches and elevated platforms in commercial broiler farms: use and effect on walking ability, incidence of tibial dyschondroplasia and bone mineral content. *animal*, 11(5), 864-871.
- Kiyama, Z., Küçükyılmaz, K., & Orojpour, A. (2016). Effects of perch availability on performance, carcass characteristics, and footpad lesions in broilers. *Archives Animal Breeding*, 59(1), 19-25.
- LeVan, N. F., Estevez, I., & Stricklin, W. R. (2000). Use of horizontal and angled perches by broiler chickens. *Applied Animal Behaviour Science*, 65(4), 349-365.
- Lindholm, C., Calais, A., Jönsson, J., Yngwe, N., Berndtson, E., Hult, E., & Altimiras, J. (2015). Slow and steady wins the race? No signs of reduced welfare in smallerbroiler breeder hens at four weeks of age. *Animal Welfare*, 24(4), 447-454.
- Lindqvist, C., Zimmerman, P., & Jensen, P. (2006). A note on contrafreeloading in broilers compared to layer chicks. *Applied Animal Behaviour Science*, 101(1-2), 161-166.
- Malchow, J., Berk, J., Puppe, B., & Schrader, L. (2018). Perches or grids? What do rearing chickens differing in growth performance prefer for roosting?. *Poultry science*, 98(1), 29-38.
- Marx, G., Leppelt, J., & Ellendorff, F. (2001). Vocalisation in chicks (*Gallus gallus dom.*) during stepwise social isolation. *Applied Animal Behaviour Science*, 75(1), 61-74.
- Moy Park (2019). Moy Park: The farming way. Available from: <https://www.moypark.com/uploads/general/farmingway-booklet.pdf> (Accessed 09/04/2019).
- Norring, M., Kaukonen, E., & Valros, A. (2016). The use of perches and platforms by broiler chickens. *Applied Animal Behaviour Science*, 184, 91-96.
- Pettit-Riley, R., Estevez, I., & Russek-Cohen, E. (2002). Effects of crowding and access to perches on aggressive behaviour in broilers. *Applied Animal Behaviour Science*, 79(1), 11-25.
- Pichova, K., Nordgreen, J., Leterrier, C., Kostal, L., & Moe, R. O. (2016). The effects of food-related environmental complexity on litter directed behaviour, fear and exploration of novel stimuli in young broiler chickens. *Applied Animal Behaviour Science*, 174, 83-89.
- Red Tractor (2018). Poultry Guidance: Windows and Enrichment. Available from: https://assurance.redtractor.org.uk/contentfiles/Farmers-6941.pdf?_=636669856339249334 (Accessed 27/01/2020).
- RSPCA (2019). RSPCA Assured. Available from: <https://www.rspcaassured.org.uk/about-us/> (Accessed 09/04/2019).
- Tahamtani, F. M., Pedersen, I. J., Toinon, C., & Riber, A. B. (2018). Effects of environmental complexity on fearfulness and learning ability in fast growing broiler chickens. *Applied Animal Behaviour Science*, 207, 49-56.

- Tickle, P. G., Hutchinson, J. R., & Codd, J. R. (2018). Energy allocation and behaviour in the growing broiler chicken. *Scientific reports*, 8(1), 4562.
- Vasdal, G., Vas, J., Newberry, R. C., & Moe, R. O. (2019). Effects of environmental enrichment on activity and lameness in commercial broiler production. *Journal of Applied Animal Welfare Science*, 22(2), 197-205.
- Ventura, B. A., Siewerdt, F., & Estevez, I. (2010). Effects of barrier perches and density on broiler leg health, fear, and performance. *Poultry Science*, 89(8), 1574-1583.
- Wichman, A., & Keeling, L. J. (2008). Hens are motivated to dustbathe in peat irrespective of being reared with or without a suitable dustbathing substrate. *Animal behaviour*, 75(4), 1525-1533.
- Yngvesson, J., Wedin, M., Gunnarsson, S., Jönsson, L., Blokhuis, H., & Wallenbeck, A. (2017). Let me sleep! Welfare of broilers (*Gallus gallus domesticus*) with disrupted resting behaviour. *Acta Agriculturae Scandinavica, Section A—Animal Science*, 67(3-4), 123-133.

Tables and Figures

Table 1. Distribution of the frequencies of gait score¹ (%; N=4160)

Treatment	Week 2					
	GS0	GS1	GS2	GS3	GS4	GS5
No perches	51.4	48.1	0.5	0	0	0
8 perches	43.4	56.3	0.5	0	0	0
10 perches	43.4	56.7	0	0	0	0
12 perches	38.5	60.6	1	0	0	0
	Week 3					
	GS0	GS1	GS2	GS3	GS4	GS5
No perches	15.4	77.9	6.7	0	0	0
8 perches	18.8	75.5	5.8	0	0	0
10 perches	17.3	78.4	4.3	0	0	0
12 perches	19.2	72.6	7.7	0.5	0	0
	Week 4					
	GS0	GS1	GS2	GS3	GS4	GS5
No perches	1	79.8	18.8	0	0	0.5
8 perches	1	81.7	14.9	1.4	0.5	0.5
10 perches	1.9	82.7	14.4	0	1	0
12 perches	1	83.2	15.4	0	0.5	0
	Week 5					
	GS0	GS1	GS2	GS3	GS4	GS5
No perches	0	68.3	28.4	2.4	0.5	0.5
8 perches	0	70.7	26.9	1.4	0	1
10 perches	0.5	69.2	28.4	1	0.5	0.5
12 perches	1.4	68.8	27.4	2.4	0	0
	Week 6					
	GS0	GS1	GS2	GS3	GS4	GS5
No perches	0	50	41.3	7.7	0.5	0.5
8 perches	0	55.1	40.4	3.8	0.6	0
10 perches	0	55.8	40.9	2.9	0.5	0
12 perches	0	57.7	36.5	5.8	0	0
	Overall					
	GS0	GS1	GS2	GS3	GS4	GS5
No perches	13.6	64.8	19.1	2.0	0.2	0.3
8 perches	13.3	68.5	16.5	1.2	0.2	0.3
10 perches	12.6	68.6	17.6	0.8	0.4	0.1
12 perches	12.7	69.1	16.6	1.5	0.1	0

Table 2. Play behaviour over time, raw means (M) and backtransformed means (BtM [95% CI]) are presented for interpretation. Mixed models analysis conducted on log10+1 data. Different letters denote significance between weeks.

		Age of broiler chickens					P value
		Week 2	Week 3	Week 4	Week 5	Week 6	
Total play N=316	M	7.07	22.38	21.86	13.63	9.31	<.001
	BtM	3.50a [2.5, 4.6]	17.16b [13.5, 21.8]	17.62b [13.8, 22.4]	8.84c [6.8, 11.4]	6.19c [4.7, 9.0]	
Frolicking N=316	M	4.89	13.11	10.84	7.13	4.66	<.001
	BtM	2.61a [1.9, 3.5]	8.40b [6.6, 10.7]	8.48b [5.8, 10.8]	4.75c [3.6, 6.1]	3.23ac [2.4, 4.2]	
Sparring N=316	M	2.19	9.27	11.02	6.50	4.66	<.001
	BtM	1.18a [0.75, 1.72]	7.59b [5.92, 9.69]	7.97b [6.23, 10.17]	3.81c [2.86, 4.98]	2.72c [1.99, 3.63]

Figure 1. Schematic of perch placement within the commercial houses for the four treatments: 1) 0 perches, 2) 8 perches, 3) 10 perches, 4) 12 perches. Black crossed rectangles refer to lowered perches, grey crossed rectangles refer to perches that have not been lowered. Solid vertical lines are drinking lines and broken vertical lines are feeder bulb lines. Oval breaks in the outer lines of the house refer to door placement.

Figure 2. Suspended platform place installed in a commercial house. Perches are suspended by steel cabling attached to a winch mechanism, with chain connecting the cable to the perch to allow individual adjustments. This image was taken during the final week of the cycle, and as such the perch has been raised to 20cm and birds are able to use space underneath the perch.

Figure 3. Average successful attempts at perching over each half hour observation period (N=227), within each week of the cycle. Different letters denote significance within weeks.

Figure 4. Average failed attempts at perching over each half hour observation period (N=227), within each week of the cycle. Different letters denote significance between weeks.

Figure 5. Withdrawal distances for broilers in each treatment (N=799). Shorter withdrawal distances indicate that an observer was able to get significantly closer to a bird before it withdrew, and thus that the bird was less fearful. Different letters denote significance at $p < 0.05$.

Figure 6. Withdrawal distances for broilers by week (N=799). Shorter withdrawal distances indicate that an observer was able to get significantly closer to a bird before it withdrew, and thus that the bird was less fearful. Different letters denote significance at $p < 0.05$.