



**QUEEN'S  
UNIVERSITY  
BELFAST**

## **The influence of providing perches and string on activity levels, fearfulness and leg health in commercial broiler chickens**

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.  
<https://doi.org/10.1017/S1751731114002821>

**Published in:**  
Animal

**Document Version:**  
Peer reviewed version

**Queen's University Belfast - Research Portal:**  
[Link to publication record in Queen's University Belfast Research Portal](#)

**Publisher rights**  
© The Animal Consortium 2014

**General rights**  
Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

**Take down policy**  
The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact [openaccess@qub.ac.uk](mailto:openaccess@qub.ac.uk).

**Open Access**  
This research has been made openly available by Queen's academics and its Open Research team. We would love to hear how access to this research benefits you. – Share your feedback with us: <http://go.qub.ac.uk/oa-feedback>

1 **The influence of providing perches and string on activity levels, fearfulness**  
2 **and leg health in commercial broiler chickens**

3  
4 **C.L. Bailie and N.E. O'Connell**

5 *Institute for Global Food Security, School of Biological Sciences, Queens University*  
6 *Belfast, Belfast, BT9 7BL*

7  
8 Corresponding author: Carley Bailie. E-mail: c.bailie@qub.ac.uk

9 **Running Head**

10 **Influence of perches and string on broiler chicken welfare**

11  
12 **Abstract**

13 The aim of this study was to assess the effect of providing environmental enrichment  
14 in the form of perches and string on the behaviour and welfare of commercial broiler  
15 chickens. Houses containing ~23,000 broiler chickens were assigned to 1 of 4  
16 treatments in a 2 x 2 factorial design. Treatments involved 2 levels of access to  
17 perches (P) (present (24/house) '+P', or absent '-P') and 2 levels of access to string  
18 (S) (present (24/house) '+S', or absent '-S'). All houses contained windows, and 30  
19 straw bales were provided from day 10 of the rearing cycle. Treatments were  
20 applied in 1 of 4 houses on a single farm, and were replicated over 4 production  
21 cycles. Behaviour and leg health was observed in weeks 3-5 of the rearing cycle.  
22 Production performance and environmental parameters were also measured. There  
23 was an interaction between perches and age in the percentage of birds observed  
24 lying, with higher percentages of birds observed lying in the +P treatment than in the  
25 -P treatment during weeks 4 and 5. There was also a significant interaction between

26 string and age in the percentage of birds observed in locomotion, with higher  
27 percentages observed in locomotion in the -S treatment than in the +S treatment  
28 during weeks 4 and 5. There was also an interaction between string and age in  
29 average gait scores, with lower gait scores in the +S treatment than in the -S  
30 treatment during weeks 3 and 5 but not within week 4. Daytime observations  
31 showed that perches and strings were used frequently, with 1 bout of perching  
32 occurring approximately every 80s per perch, and 1 bout of pecking at string  
33 occurring every 78s per string on average. There was a significant effect of age on  
34 use of perches ( $p < 0.001$ ) and string ( $p < 0.001$ ), with perching peaking during week 5  
35 and string pecking peaking during week 3. We conclude that commercial broilers in  
36 windowed houses with access to straw bales display an interest in additional  
37 enrichment stimuli in the form of perches and string, and therefore that these stimuli  
38 have the potential to improve welfare. In addition, provision of string as a pecking  
39 device appeared to positively influence walking ability. However, this effect was  
40 numerically small, was only shown in certain weeks and was not reflected in the  
41 other leg health measure (latency to lie). The results also showed an apparent  
42 negative effect of string and perches on the activity levels of birds (recorded away  
43 from the immediate vicinity of these enrichments) towards the end of the production  
44 cycle. These results emphasise the need for further research into optimum design  
45 and layout of enrichment stimuli for modern broilers in windowed houses to ensure  
46 that their provision leads to clear welfare benefits.

47

48 **Keywords:** *Behaviour, broiler chicken, leg health, perches, string*

49

50

51 **Implications**

52 This study provides novel information on the effect of string and perch provision on  
53 welfare-related parameters in commercial broiler chickens. The results of this study  
54 suggest that these stimuli are used by broiler chickens and that suspended string  
55 has the potential to positively affect the leg health of broilers. However, birds  
56 provided with string and perches (observed outside the direct vicinity of these  
57 enrichment stimuli) showed reduced activity levels in later weeks. This highlights the  
58 need for further research investigating the 'real world' implications of the provision of  
59 different types of environmental enrichment to be carried out on commercial farms.

60

61 **Introduction**

62 Lameness adversely affects economic returns within the poultry industry (Su *et al.*,  
63 1999), particularly through contributing to increased culling rates and mortalities.  
64 Lameness also self-selects more food containing the painkiller carprofen than non-  
65 lame birds, suggesting that the condition is associated with pain and is therefore an  
66 animal welfare issue (Danbury *et al.*, 2000). Artificial selection for increased feed  
67 conversion and rapid growth rate appears to be a salient factor in the development of  
68 lameness in commercial broiler chickens (Kestin *et al.*, 1992; Fanatico *et al.*, 2008).  
69 This may be through direct effects of rapid growth on bone health (see Julian, 1998;  
70 Olkowski *et al.*, 2011), and/or through indirect effects of genetic selection strategies  
71 on behaviour. Research shows that fast growing broilers are extremely inactive and  
72 may spend up to 80% of their time lying down (Weeks *et al.*, 2000). This lack of  
73 activity has been linked with abnormal bone development and leg conformation  
74 (Kestin *et al.*, 1992; Reiter and Bessei, 1998a,b), and may therefore also negatively  
75 impact on the walking ability of birds. In addition, the presence of contact dermatitis

76 lesions has been linked with inactivity and may also adversely affect the movement  
77 of birds (Harms and Simpson, 1975; Hester, 1994).

78 Environmental enrichment has been posited as a way in which activity levels may be  
79 increased, and lameness reduced, in commercial flocks of fast growing broiler  
80 chickens (eg. Kells *et al.*, 2001; Bailie *et al.*, 2013). Mounting and dismounting  
81 perches, and the act of perching itself, may exercise the broiler musculoskeletal  
82 system in a different way from standing and walking, and may therefore strengthen  
83 legs. Indeed, Bizeray et al. (2002) found a tendency towards improved morphology  
84 of the tibia when broiler chickens were required to traverse barriers to access  
85 feeders. They hypothesized that the physical activity associated with perching on,  
86 and stepping on to and over these barriers contributed to this effect. Perching may  
87 also reduce the amount of time birds spend in contact with wet litter, and may  
88 therefore reduce the incidence or severity of contact dermatitis lesions (Su *et al.*,  
89 2000). Activity levels may also be increased and leg health improved by stimulating  
90 exploratory behaviour through providing pecking devices. McAdie et al. (2005) found  
91 that laying hen chicks showed sustained interest in string when provided as a  
92 pecking device, however the usefulness of string as a source of environmental  
93 enrichment for commercially-housed broiler chickens does not appear to have been  
94 fully evaluated. In addition to potential effects on leg health, environmental  
95 enrichment has also been shown to exert positive effects on the psychological  
96 welfare of farm animals (Newberry, 1995). In particular it has been suggested as a  
97 way to reduce fear in a number of species, including poultry (Jones, 1996).

98 The aim of this study was to investigate the effects of providing enrichment in the  
99 form of perches and string on activity levels, leg health and fearfulness in  
100 commercial broiler chickens. This research was conducted using chickens housed

101 with access to natural light and straw bales. Previous research demonstrated  
102 welfare benefits associated with providing these types of environmental enrichment  
103 (Bailie *et al.*, 2013), and the objective of the current study was to determine if further  
104 benefits could be achieved by additional modifications to the environment. We  
105 hypothesised that both perches and string would independently increase activity  
106 levels, and reduce levels of lameness and fearfulness. We also hypothesised that  
107 there would be a cumulative effect of string and perches on these parameters. The  
108 study also aimed to gain a better understanding of levels of use of perches and  
109 strings by commercially-housed broiler chickens.

110

## 111 **Materials and Methods**

### 112 *Animals, husbandry and housing*

113 A total of 368,000 Ross 308 broiler chickens obtained from 1 breeding company  
114 (Aviagen Ltd, UK) were used in this experiment which took place in Northern Ireland  
115 between February and August 2011. Approximately 23,000 mixed-sex birds were  
116 placed in each experimental house 'as hatched'. The total floor area/house available  
117 to the birds was approximately 1324m<sup>2</sup> resulting in an approximate initial stocking  
118 rate of 17birds/m<sup>2</sup>. Approximately half of the birds were removed for slaughter after  
119 day 30 of the production cycle, and the remaining birds were removed between days  
120 32 and 42. Stocking densities did not exceed 30kg/m<sup>2</sup> at any stage of the production  
121 cycle.

122 Temperature, ventilation, feeding regimes, feed sources and blends were identical  
123 between houses. The ventilation system consisted of ceiling fans and flaps which  
124 could be opened and closed along the 2 long sides of each house in response to the  
125 humidity and temperature (which were recorded by 4 sensors). Fans and flaps

126 operated automatically in the event that humidity fell outside the optimum range of  
127 55-60% and if temperature reached 5 degrees above or below the optimum for each  
128 week. Large gas pan heaters were placed in 2 uniform lines down the length of all  
129 houses and the temperature within all houses was 33°C at day 1, and dropped 2  
130 degrees each week until day 21 of the rearing cycle..

131 All birds had access to natural light from day 4 of the rearing cycle. This was  
132 provided through 46 windows per house (measuring 220cm wide x 60cm high) which  
133 were located at a height of 1.5m along the length of the 2 'long' sides of the house.  
134 Windows comprised double glazed, toughened glass. These windows were  
135 shuttered for the first 4 days of the rearing cycle and during the dark period of the  
136 artificial lighting regime. The hours of darkness supplied for the birds rose by 1 hour  
137 per day from 1 hour at a day old, to 6 hours at 7 days old. This regime was then  
138 maintained from 7 until 28 days old. From 29 days old, hours of darkness were  
139 gradually reduced by 1 hour each day to 1 hour by 33 days old. One hour of  
140 darkness was then maintained until the end of the rearing cycle. The dark period was  
141 between 2300 and 0500 hours. Both lights and shutters were automatically  
142 controlled using timers.

143 Artificial light was provided by 2 rows of 24 horizontally suspended fluorescent strip  
144 lights running parallel to each other along the length of each house. Rows were  
145 placed 8 m from the nearest wall and suspended 12 m from the floor of the house.  
146 Lights comprised 1.2m low frequency T8 tubes emitting 3 thousand lumens each  
147 (F40w/29-530/RS warm white energy rating B, Disano Illuminazione UK Ltd., UK).  
148 Identical light fittings were used in all houses (4ft Disano Hybro 951 IP65 fitting,  
149 Disano Illuminazione UK Ltd., UK) and were suspended from the ceiling by a pulley  
150 system.

151 Thirty straw bales, comprising short chopped straw wrapped in plastic, each  
152 measuring 800 x 400 x 400 mm, were supplied in each house from day 10 of the  
153 rearing cycle. These were dispersed as evenly as possible throughout the house.  
154 Bedding comprised of wood shavings and was placed in the house prior to the birds  
155 arriving. Sixty-six kilos of wood shavings were supplied per thousand birds.  
156 Additional sawdust was added to specific areas of the houses when deemed  
157 necessary by the farmer. Birds were fed on an *ad libitum* basis and received 3  
158 different commercially-available diets across the production cycle. All drinkers were  
159 of the nipple variety and included cups.

160

#### 161 *Treatments and experimental design*

162 The effects of provision of perches (P) and string (S) on the welfare of broiler  
163 chickens was assessed in 2 x 2 factorial design study. Twenty-four perches were  
164 distributed as evenly as possibly throughout the house in the P treatment. Each  
165 perch was manufactured by the commercial supplier of the birds and consisted of a  
166 long horizontal, wooden beam (300 cm x 5 cm x 5cm) with a rounded upper edge  
167 resting on 2 supports at either end (15 cm high) (Supplementary Figure S1). In the  
168 string treatment, 24 pieces of thin white nylon rope (60 cm x 10 mm) were supplied.  
169 One piece of string was tied at its mid-point to the wire above each of the 4 feeder  
170 lines within the house at approximately even intervals. Six pieces of string in total  
171 were tied to each feeder line (Supplementary Figure S2). The wire was positioned  
172 33cms above the litter at the beginning of the rearing cycle and was gradually raised  
173 to a maximum height of approximately 50 cms above the litter (as feeders were  
174 raised to encourage growing birds to feed in a standing position). The ends of the  
175 string may therefore have been situated between 3 and 20 cm above the litter at



176 different points in the rearing cycle depending on the growth rate of the birds. The  
177 number of enrichment items provided was based on the RSPCA Freedom Foods  
178 scheme, which requires a minimum of '1 pecking object and 2 m of perching space  
179 per 1000 birds' in addition to the provision of straw bales and natural light (RSPCA,  
180 2013).

181

182 Four houses were selected for this study, giving 2 matched pairs of houses on a  
183 single commercial farm. Pair 1 comprised Houses 1 and 2, and Pair 2 comprised  
184 Houses 3 and 4. All 4 houses were of an identical rectangular design, orientation and  
185 number of windows, with the exception that Houses 1 and 2 had a central doorway  
186 and Houses 3 and 4 had doors that were offset to either the right (House 3) or the  
187 left (House 4). As the birds used were part of the normal commercial enterprises of  
188 the company, the number of replications was limited. However, each treatment was  
189 replicated 4 times (Table 1). All 4 houses were matched exactly for number of chicks  
190 placed and strain of bird. The date when chicks were placed and removed was  
191 matched exactly for all 4 houses, except for Replicate 3. Due to a logistical problem,  
192 Houses 1 and 2 were stocked 1 day earlier than Houses 3 and 4. In order to  
193 counteract any confounding effects, all measures were taken on the same day after  
194 placement (and thus 1 day apart between the 2 pairs of houses) in this replicate.

195

196 *Measurements*

197 *Behavioural observations*

198 Behaviour was assessed during 2 days each week between weeks 3 and 5 of the  
199 rearing cycle. Observations of general activity levels and fearfulness were made on  
200 day 1, and use of enrichment was assessed on day 2. All behavioural observations

201 were taken between the hours of 09.00 and 18.00 and began approximately 4 hours  
202 after the end of the dark period. The house shape was mapped and virtually divided  
203 into thirty-six equal size quadrants. Quadrants in which all behavioral, leg health and  
204 environmental measures were carried out were preselected using a random number  
205 table. A different set was chosen each week.

206

### 207 *Activity levels*

208 Two video cameras on tripods were employed to record behaviours in the 2 pairs of  
209 houses simultaneously. One camera was alternated between the houses within each  
210 pair every 2 observations. Video recordings for scan sampling were taken within 6  
211 quadrants per house per week as detailed in Bailie *et al.* 2013. Quarters that were  
212 selected for recordings did not contain strings, perches or straw bales in order to  
213 ascertain whether or not the presence of enrichment affected general, non-  
214 enrichment-related, activity levels. The first 5 min of film was cut from all videos in  
215 order to ensure a settling period had been imposed after the exit of the researcher  
216 from the house. Instantaneous scan sampling for each 10 minute clip involved  
217 recording both the total number of birds and the numbers of birds lying, standing and  
218 engaging in locomotion (walking or running) within the full frame of the video  
219 recording at 120 second intervals.

220

### 221 *Fearfulness*

222 Fearfulness was assessed by recording the flight distance of birds and their  
223 response to a novel object. Flight distance scoring was performed in ten quadrants,  
224 selected using a random number table, in each house once a week after video  
225 recordings were completed. A square piece of Perspex, measuring 30 x 30 cm, with

226 an 'x' drawn in the middle, was held up at arm's length at the edge of the selected  
227 quadrant. The bird observed closest to the 'x' was tested for flight distance. The  
228 experimenter ensured that selected birds were not tightly packed within a group  
229 before approaching. The approach consisted of slowly walking towards the bird at a  
230 constant speed. At the point when the selected bird retreated, the approximate  
231 distance (in cm) between the experimenter and the bird was recorded using a  
232 standard measure as a guide.

233 A novel object was also presented in 1 randomly-selected quadrant in each house  
234 each week. The experimenter gently placed the novel object upright among the birds  
235 and walked to a distance of approximately 4m away. Observations were taken from  
236 a standing position on top of a straw bale. The latency of the first bird to approach  
237 and contact the object after it had been placed on the ground was measured using a  
238 stop watch. If no bird approached the object within 5 min a maximum latency of 300s  
239 was recorded and the test was terminated. The number of birds that made contact  
240 with the object in the sixty seconds following the first contact with the object was also  
241 recorded, along with the number of birds within 50 cm of the object at 300s. Three  
242 different novel objects were presented within each treatment each week in the  
243 following order; a child's yellow plastic chair (30x30x70cm), a red gardening basket  
244 (or 'trug') (40x60cm diameter) and a blue storage container to keep items cool (or a  
245 'cool box') (30x50x60cm). The same novel object was presented in all houses during  
246 the same week throughout all cycles.

247

#### 248 *Use of enrichment*

249 A video camera placed on a tripod was used to record behaviour directed towards  
250 enrichment. Perch recordings took place during the following time periods: 0900 to

251 1000 hours, 1100 to 1200 hours, 1300 to 1400 hours and 1500 to 1600 hours. String  
252 recordings took place on the same day during the following time periods: 1000 to  
253 1100 hours, 1200 to 1300 hours, 1400 to 1500 hours and 1600 to 1700 hours.  
254 During these times 1 perch or piece of string was filmed for a 30 min period in each  
255 of the 2 houses provided with these enrichments. Two perches or pieces of string  
256 from centre quadrants and 2 from edge quadrants were filmed in each house each  
257 day in order to balance any effects of enrichment location. During later analysis, the  
258 first 5 min of each recording was disregarded in order to allow a settling period for  
259 the birds. The total number of times the perch or string was used by any bird was  
260 recorded, along with the duration of each bout, during the remaining 25 min. Bouts  
261 beginning prior to the 25 min observation window or ending after this period were  
262 disregarded in the analysis of both duration and frequency of perching and pecking  
263 as their duration could not be accurately ascertained. Data comprising the start and  
264 end times of each bout of perching and pecking were also used to deduce the  
265 number of bouts that overlapped (i.e. each bout which had a start time prior to the  
266 end time of a previous bout, resulting in more than 1 animal using the enrichment  
267 simultaneously). The number of overlapping bouts was then calculated as a  
268 percentage of the total number of bouts. Bouts beginning prior to the twenty-five  
269 minute observation window and ending after this period were included in this  
270 analysis.

271

### 272 *Leg health*

273 Leg health was assessed using a latency to lie test (Weeks *et al.*, 2002; Berg and  
274 Sanotra, 2003) and spontaneous gait scoring. Each assessment was performed in  
275 twenty-five randomly selected quadrants following behavioural measures in each

276 house on day 1 of each week. One bird was randomly selected from each quadrant  
277 each week for gait scoring, and one bird for latency to lie testing, which was carried  
278 out as in Bailie *et al.* 2013. Gait was scored on a scale of 0-5 where 0 = normal  
279 movement and 5 = unable to walk (Kestin *et al.*, 1992). Measures of leg health were  
280 carried out within 1 house before moving on to a second house, and the first house  
281 used in observations was alternated weekly. The number of birds culled for leg  
282 problems by day 30 of the rearing cycle was recorded for each cycle in each house  
283 using company records. The incidences of podo dermatitis and hock burn at  
284 slaughter were recorded by slaughterhouse staff as in Bailie *et al.* (2013).

285

#### 286 *Environmental parameters*

287 Light intensity (lux) values and UV wavelengths ( $\mu\text{W}/\text{cm}^2$ ) were recorded  
288 immediately following behavioural observations from the centre of the 6 quadrants  
289 videoed for activity levels and from the area beside filmed perches and strings in  
290 each house each week using a light meter (Digital lux meter LX1010B, Handsun Co.  
291 Ltd, China) and a UV meter (UV-340 meter, Lutron Electronic Enterprise Co. Ltd.  
292 Taiwan) as in Bailie *et al.* (2013). Daily temperature and humidity levels were taken  
293 from farm records.

294

#### 295 *Productivity and mortality*

296 The number of birds culled for reasons other than leg problems and mortalities by  
297 day 30 of the rearing cycle, and the cumulative percentage of dead birds by this  
298 point, were recorded for each cycle in each house using company records. Slaughter  
299 weights were taken from farm records at thinning and clearing. The farmer culled as  
300 normal throughout the study.

301

302 *Statistical analysis*

303 Data were analysed using SPSS (v20). Due to a problem with the video recordings  
304 of perches and string, data for 1 of the 4 observations was missing from cycle 2  
305 week 5 for usage of both types of enrichment. All treatments were balanced across  
306 houses during the 4 replications, and analysis was carried out as for a balanced  
307 Latin square design. A histogram of the residuals was plotted for each variable each  
308 week and was scrutinised for normality. Residuals were also subjected to statistical  
309 testing for normality using the Shapiro-Wilk test. Data for light intensity and UV  
310 recorded in the vicinity of enrichment stimuli, the cumulative percentage of dead  
311 birds at day 30 of the rearing cycle, bout lengths of pecking at string and bout  
312 lengths of perching were subjected to a  $\log_{10}$  transformation in order to achieve a  
313 normal distribution. Data containing zero values had 0.5 added to each value prior to  
314 transformation. The means of normally-distributed transformed and untransformed  
315 data were compared using ANOVA with 'cycle' and 'house' as blocking factors.  
316 Normally distributed data on behaviour and leg health, collected during weeks 3, 4  
317 and 5 of the rearing cycle, were compared using ANOVA with 'string\*perches\*week'  
318 as treatment factors and significant differences between weeks were ascertained  
319 using Tukey HSD post hoc tests. Normally distributed data on the use of string were  
320 analysed using perches\*week as treatment factors, and data on the use of perches  
321 were analysed using 'string\*week' as treatment factors. For each measure, average  
322 values per treatment, week and replicate were used as experimental units, and all  
323 main and interactive effects were determined in analysis. Normally distributed data  
324 collected from farm records were analysed using ANOVA with 'string\*perches' as  
325 treatment factors. Average values per treatment and replicate were used as

326 experimental units, and all main and interactive effects were determined in analysis.  
327 Back transformed means, with 0.5 removed from each value where appropriate, are  
328 presented in the results section. Root mean square error (RMSE) values are  
329 presented for ANOVA data and were calculated by taking the square root of error  
330 mean square values. However, data from a small number of measures remained  
331 non-normally distributed following transformation; therefore a Kruskal-Wallis test was  
332 used to compare ranked means of treatment groups.

333

## 334 **Results**

### 335 *Environmental parameters*

336 There were no significant differences between treatments in light intensity (+S 62.9, -  
337 S 63.9,  $p=0.88$ ; +P 61.0, -P 65.8, R.M.S.E. 23.24 lux,  $p=0.48$ ) or UV wavelengths  
338 (+S 3.4, -S 3.3, ,  $p=0.73$ ; +P 3.3, -P 3.4, R.M.S.E. 1.23  $\mu\text{W}/\text{cm}^2$ ,  $p=0.64$ ). There was  
339 also no significant difference in the light intensity that birds from the +P and -P  
340 treatments were exposed to in the vicinity of string (+P 79.5, -P 69.7, R.M.S.E. 0.31  
341 lux,  $p=0.59$ ) and in the UV content of light near strings (+P 4.3, -P 3.8, R.M.S.E. 0.28  
342  $\mu\text{W}/\text{cm}^2$ ,  $p=0.88$ ). There was no significant difference in the light intensity that birds  
343 from the +S and -S treatments were exposed to in the vicinity of perches (+S 67.3, -  
344 S 54.6, R.M.S.E. 0.28 lux,  $p=0.08$ ) or in the UV content of light near perches (+S 3.3,  
345 -S 2.6, R.M.S.E. 0.28  $\mu\text{W}/\text{cm}^2$ ,  $p=0.12$ ).

346

### 347 *Behaviour*

#### 348 *Group scans*

349 On average there were 83 ( $\pm 25$ ) birds present in each scan observation. Provision of  
350 string had no significant main effect on the percentage of birds observed lying (+S

351 77.4 -S 78.4, R.M.S.E. 3.99%,  $p=0.40$ ) and standing (+S 22.6 -S 21.7, R.M.S.E.  
352 3.99%,  $p=0.40$ ). Provision of perches had no significant main effect on the  
353 percentage of birds observed in locomotion (+P 3.5 -P 3.5, R.M.S.E. 0.77%,  $p=0.82$ ).  
354 However, there was an interaction between perches and age in the percentage of  
355 birds observed lying (week 3 +P 77.0 -P 80.9, week 4 +P 79.5 -P 75.2, week 5 +P  
356 78.4 -P 76.2, R.M.S.E. 3.99%,  $p=0.02$ ) and standing (week 3 +P 23.0 -P 19.1, week  
357 4 +P 20.5 -P 24.8, week 5 +P 21.6 -P 23.8, R.M.S.E. 3.99%,  $p=0.02$ ), with the  
358 presence of perches leading to a decrease in lying behaviour in week 3 and an  
359 increase in weeks 4 and 5. There was an interaction between string and bird age in  
360 the percentage of birds observed in locomotion (week 3 +S 4.9 -S 3.9, week 4 +S  
361 3.3 -S 3.7, week 5 +S 2.6 -S 2.8, R.M.S.E. 0.77%,  $p=0.04$ ); with the presence of  
362 string leading to an increase in locomotion in week 3 but not in weeks 4 and 5.

363

#### 364 *Flight distance*

365 Provision of string and perches had no significant effect on the flight distance of  
366 birds. However, there was a significant effect of age on flight distance, with average  
367 flight distance decreasing across weeks (Table 2).

368

#### 369 *Reaction to a novel object*

370 Neither the provision of string or perches had a significant effect on the latency to  
371 touch a novel object or on the number of birds clustered within 50 cm of the object at  
372 300 s (Table 2). There was no significant effect of string or perches on the number of  
373 birds that touched the object within 60s of the first touch occurring (ranked means:  
374 +S 25.4, -S 23.6,  $\chi^2(1, N = 48) 0.25$ ; ranked means: +P 24.6, -P 24.6,  $\chi^2(1, N = 48)$   
375 0.00). Age had a significant effect on the latency to touch a novel object, on the



376 number of birds within 50 cm of the novel object at 300 s (Table 2), and on the  
377 number of birds to touch the object within 60 s of the first touch occurring (ranked  
378 means: week 3 32.4, week 4 20.9, week 5 20.2,  $\chi^2(1, N = 48) 10.26, p=0.01$ ). Birds  
379 gathered near the novel object in smaller numbers as they aged, and fewer birds  
380 approached and touched the object in the 60 s prior to the first bird making contact.

381

### 382 *Use of strings*

383 On average, there were 19.2 ( $\pm 14.08$ ) individual bouts of pecking at string per 25 min  
384 observation, and the average pecking bout lasted 4.2 ( $\pm 2.0$ ) s. The percentage of  
385 bouts of pecking that overlapped with at least 1 other previous bout of pecking  
386 ranged from 0 to 20% across all observations, with an average value of 3.4%.

387 Provision of perches had no significant effect on the average frequency of string  
388 pecking per 25 minute observation (ranked means: +P 46.0, -P 50.1,  $\chi^2(1, N = 95)$   
389 0.52), or on the percentage of bouts of string pecking where more than 1 bird was  
390 involved (ranked means: +P 45.9, -P 50.1,  $\chi^2(1, N = 95) 0.70$ ). Provision of perches  
391 had no significant effect on the average length of pecking bouts (+P 4.3, -P 4.2,  
392 R.M.S.E 0.2 s).

393 There was a significant effect of age on the frequency of string pecking per  
394 observation (week 3 64.7, week 4 48.4, week 5 30.4,  $\chi^2(1, N = 95) 24.36, p < 0.01$ ,  
395 and on the percentage of bouts of pecking that overlapped with at least 1 other bout,  
396 with birds tending to peck less frequently, and exhibiting fewer overlapping bouts of  
397 pecking with age (ranked means: week 3 59.4, week 4 46.3, week 5 38.0,  $\chi^2(1, N$   
398  $= 95) 12.58, p < 0.01$ ). However, age had no significant effect on the average length of  
399 pecking bouts (week 3 4.2, week 4 3.9, week 5 4.6, R.M.S.E 0.2 s).

400

401 *Use of perches*

402 On average, there were 15.1 ( $\pm 13.6$ ) bouts of perching per 25 min observation, with  
403 an average perching bout lasting 117.4 ( $\pm 92.7$ ) s. The percentage of bouts of  
404 perching that overlapped with at least 1 other previous bout of perching ranged from  
405 0 to 100% across all observations, with an average value of 65.4%.

406 Provision of string had no significant effect on the average frequency of perching per  
407 observation (+S 13.8, -S 16.2, R.M.S.E 9.06,  $p=0.20$ ) or on average bout length (+S  
408 110.1, -S 111.3, R.M.S.E. 0.35 s,  $p=0.31$ ). Provision of string also had no significant  
409 effect on the percentage of perching bouts that overlapped with at least 1 other (+S  
410 73.5, -S 70.2, R.M.S.E. 30.87%,  $p=0.61$ ).

411 The frequency of perching per 25 minute observation increased with age and peaked  
412 during week 5 (week 3 4.1, week 4 16.8, week 5 24.2, R.M.S.E. 9.06,  $p<0.01$ ). Age  
413 also affected bout lengths of perching, which increased from weeks 3 to 4 and  
414 decreased slightly from week 4 to 5 (week 3 85.2, week 4 124.9, week 5 123.0,  
415 R.M.S.E. 0.35,  $p=0.43$ ). There was also a significant increase with age in the  
416 percentage of bouts of perching that overlapped with at least 1 other bout (week 3  
417 43.5, week 4 80.7, week 5 91.3, R.M.S.E. 30.87%,  $p<0.01$ ).

418

419 *Leg health*

420 Neither the provision of string or perches had a significant main effect on gait scores  
421 (Table 2). There was however an interaction between age and string on average gait  
422 scores, with +S birds displaying lower gait scores than -S birds during weeks 3 and  
423 5 but not during week 4 (week 3: +S 0.7, -S 0.9, week 4: +S 1.5, -S 1.4, week 5: +S  
424 1.9, -S 2.0, R.M.S.E. 0.13,  $p=0.048$ ). There was no significant effect of string or  
425 perches on latency to lie, however there was a significant effect of age on this

426 parameter (Table 2), with latency to lie decreasing across weeks. Treatment had no  
427 effect on the numbers of leg culls recorded between days 1 and 30 of the rearing  
428 cycle or on the total incidence of hock burn and pododermatitis recorded during  
429 thinning and clearing (Table 3).

430

#### 431 *Culls, mortalities and productivity*

432 Treatment had no significant effect on mortalities and the cumulative percentage of  
433 dead birds recorded between days 1 and 30 of the rearing cycle, or on the average  
434 slaughter weight of birds recorded during thinning and clearing (Table 3). Treatment  
435 also had no significant effect on numbers of culled birds recorded between days 1  
436 and 30 of the rearing cycle (ranked means: +S 8.4, -S, 8.6,  $\chi^2(1, N =16) =0.01$ ,  
437  $p=0.92$ , ranked means: +P = 8.7, -P = 8.3,  $\chi^2(1, N = 16) = 0.03$ ,  $p =0.88$ ).

438

#### 439 **Discussion**

440 Although layer chicks have been shown to be interested in, and peck at, bunches of  
441 string (Jones *et al.*, 2000), this did not appear to be the case in previous research  
442 conducted under experimental conditions with broiler chickens (Arnould *et al.*, 2004).  
443 However, results of the current study suggest that the chickens were interested in  
444 string, with a bout of pecking occurring approximately every 78s at each piece of  
445 string. The fact that strings were presented close to feeders possibly increased the  
446 number of birds in the vicinity of them and may have increased usage. Unfortunately  
447 the methodology employed did not allow for the identification of individual birds.  
448 Therefore it is possible that the use of string by certain individuals remained low; as  
449 in previous studies (Arnould *et al.*, 2004).

450 The frequency of string pecking declined with age, while bout lengths remained  
451 consistent throughout the rearing cycle. This may have been due to the increased  
452 difficulty in standing experienced with age; this was also reflected in reduced latency  
453 to lie times across weeks. Only approximately 4% of pecking bouts involved 2 or  
454 more birds, which may suggest a lack of social facilitation in the elicitation of this  
455 behaviour. However, this may simply reflect the short bout lengths of string pecking,  
456 at approximately 4s on average, or difficulty in large numbers of birds accessing  
457 lengths of string simultaneously.

458 Previous research has assessed levels of usage of perches through instantaneous  
459 scan sampling (i.e. Le Van *et al.*, 2000; Martrenchar *et al.*, 2000; Pettit-Riley and  
460 Estevez, 2001), which leads to difficulties in making comparisons with this study.  
461 However, perches appeared to be used frequently in the current study, with a bout of  
462 perching occurring approximately every 99s on each perch. The design of the  
463 perches within this study, in particular the low height at which the horizontal perching  
464 bar was placed above the ground (Davies and Weeks, 1995), may have facilitated  
465 easy access. The increase in the frequency of perching with age agrees with the  
466 results of previous research (Le Van *et al.*, 2000) and was probably due to the  
467 increase in ease with which birds could access perches as they grew.

468 The average bout length of perching was short at just under 2 min. Genetic selection  
469 for rapid weight gain and increased breast size (Corr *et al.*, 2003) may change the  
470 centre of gravity of birds and negatively affect the birds' ability to balance on a perch  
471 and thus lead to short perching bouts. In addition to this, skeletal abnormalities of the  
472 legs and feet and associated lameness among commercial flocks (Kestin *et al.*,  
473 1992) may negatively affect the ability of broiler chickens to remain on perches. This  
474 may be due to either mechanical reasons, such as structural deformities of the feet

475 inhibiting birds' ability to grip the perch, or the pain this may cause in chronically  
476 lame birds (Danbury *et al.*, 2000). Over 65% of the bouts of perching involved 2 or  
477 more birds on the perch. This may reflect a high level of social facilitation or  
478 motivation to perch within commercial broiler flocks, along with a perch design that  
479 enabled access by a number of birds at the same time.

480 The provision of string and perches had no significant main effect on activity levels  
481 recorded out of the vicinity of these enrichments. However, there was an interaction  
482 between perches and age in the percentage of birds observed lying. The percentage  
483 of +P birds observed lying was higher compared to -P birds during weeks 4 and 5.  
484 This finding supports the suggestion that birds supplied with ramps and barriers  
485 spend more time sitting than control birds (Bessei, 1992b). Past research has  
486 suggested that birds approaching feeders and drinkers disturb other individuals in  
487 the vicinity, which leads to increased activity levels in those areas (Arnould and  
488 Faure, 2004). A similar effect may have taken place in areas furnished with perches.  
489 This may have led to a potential decrease in local stocking density and in bird  
490 'jostling' or disturbances in other areas (Hall, 2001), increasing opportunities for  
491 undisturbed resting. The increased activity involved in mounting and dismounting  
492 perches may have also made birds tired and more prone to resting. There was also  
493 an interaction between string and age in the percentage of birds observed in  
494 locomotion, with a greater percentage of -S birds than +S birds observed in  
495 locomotion during weeks 4 and 5 of the rearing cycle. As with the provision of  
496 perches, the reduced activity observed in +S birds in areas of the house away from  
497 enrichment stimuli may have been due to increased activity taking place in the  
498 vicinity of strings.

499 Light intensity and UV content have both been shown to influence the activity levels  
500 of broiler chickens (Newberry *et al.*, 1988; Maddocks *et al.*, 2001). This study was  
501 performed in windowed houses, resulting in possible variation in light intensity and  
502 UV wavelengths within houses. However, all houses were supplied with identical  
503 artificial lighting in addition to windows, treatments were randomised among houses  
504 during each cycle, and no significant differences in light intensity or UV wavelengths  
505 were recorded between treatment groups. Therefore it is unlikely that minor  
506 variations in these factors were sufficient to affect activity levels.

507 Provision of string and perches had no significant effect on measures of fearfulness.  
508 This may have been due to individual differences in access to enrichment stimuli  
509 within houses. A greater degree of interaction with enrichment stimuli may have  
510 resulted in less fearful birds, whereas limited or no interaction may have produced  
511 more fearful birds (Jones and Waddington, 1992). Birds appeared to display a  
512 reduced flight distance with age but conversely took longer to approach and make  
513 contact with a novel object. The results of these tests may perhaps reflect limitations  
514 in bird mobility with age (eg. Kestin *et al.*, 1992) rather than an increase or decrease  
515 in fearfulness. This is supported by the fact that latency to lie times significantly  
516 decreased across weeks. The propensity of younger birds to gather in greater  
517 numbers around objects than older birds echoes the results of past research (Kells  
518 *et al.*, 2001; Bailie *et al.*, 2013).

519 Previous studies have shown mixed effects of perches and barriers on leg health,  
520 with several studies reporting no effect of perches on gait score (eg. Bessei, 1992b;  
521 Su *et al.*, 2000). The provision of perches had no effect on any measures of leg  
522 health recorded within this study. Due to constraints on time and labour, gait and  
523 latency to lie were scored in only 0.1% of the population of birds studied. However,

524 this sample size highlighted significant age effects in both gait score and latency to  
525 lie measures in this study, and significant environmental enrichment effects in these  
526 measures in previous research (Bailie *et al.*, 2013). Although string exerted no main  
527 effects on leg health, there was an interaction between string and age on average  
528 gait scores. Birds provided with string displayed slightly improved walking ability  
529 during weeks 3 and 5 of the rearing cycle. The increase in walking ability may have  
530 been linked to the increase in locomotion observed in birds provided with string  
531 during week 3 of the rearing cycle. The activity levels of broilers at early and later  
532 ages have been shown to be positively correlated. Therefore, it has been suggested  
533 that selection for more mobile chicks may therefore have the potential to reduce the  
534 occurrence of leg abnormalities later in the rearing cycle (Bizeray *et al.*, 2000).  
535 However, although statistically significant, the difference in locomotion score  
536 between treatments was numerically small. This, coupled with a lack of effect on  
537 latency to lie behaviour, suggests that the effects of string provision on leg health  
538 were not strong. In line with the results of previous studies (eg Simsek *et al.*, 2009),  
539 culls performed for reasons other than leg problems, mortality and slaughter weights  
540 were unaffected by the provision of string and perches, indicating that the provision  
541 of these types of enrichments in these amounts had no negative effects on  
542 productivity.

543 In conclusion, the results of this study confirm that broiler chickens housed in  
544 commercial windowed houses use perches and string when they are provided. The  
545 level of usage observed suggested that they were attractive to birds and thus had  
546 welfare benefits. However further investigation of the nature of usage by individual  
547 birds is needed. The provision of string and perches exerted no significant main  
548 effects on the measures of bird activity, leg health or fearfulness employed within this

549 study. An interaction between string and week suggested a beneficial effect of string  
550 provision on gait score in certain weeks of the cycle. However, this effect was  
551 numerically small and was not accompanied by a reduction in latency to lie times. It  
552 strongly suggests though that further research into the leg health effects of providing  
553 different types and levels of pecking devices to commercial broiler chickens is  
554 warranted. Interactions between week and both types of enrichment suggested a  
555 reduction in activity levels (recorded away from the enrichment) during later weeks of  
556 the cycle when enrichment was provided. The reason for this is not clear and an  
557 assessment of the effects of enrichment on overall levels of activity (including activity  
558 in the vicinity of and away from enrichment items) would be useful in future studies.  
559 The provision of perches did not appear to be an effective tool to improve leg health  
560 under the 'real world' conditions used in this study. It is clear that careful  
561 consideration needs to be given to their design and layout if this is the key goal in  
562 their provision within windowed houses.

563

## 564 **Acknowledgements**

565 This research project was funded by the Department of Agriculture and Rural  
566 Development in Northern Ireland. The authors also wish to thank Moy Park Ltd. for  
567 allowing access to their farms and for their support and advice throughout the  
568 project.

569

## 570 **References**

571 Arnould C, Bizeray D, Faure JM and Leterrier C 2004. Effects of the addition of sand and  
572 string to pens on use of space, activity, tarsal angulations and bone composition in broiler  
573 chickens. *Animal Welfare* 13, 87-94.



574 Arnould C and Faure JM 2004. Use of pen space and activity of broiler chickens reared at  
575 two different densities. *Applied Animal Behaviour Science* 87, 155–170.

576 Bailie CL, Ball MEE and O’Connell NE 2013. Influence of the provision of natural light and  
577 straw bales on activity levels and leg health in commercial broiler chickens. *Animal* 7, 618-  
578 626.

579 Bessei W 1992b. The behaviour of broilers under intensive management conditions. *Archiv*  
580 *fur Geflugelkunde*. 56, 1-7.

581 Bizeray D, Estevez I, Leterrier C, and Faure JM 2002. Effects of increasing environmental  
582 complexity on the physical activity of broiler chickens. *Applied Animal Behaviour Science* 79,  
583 27–41.

584 Bizeray D, Leterrier C, Constantin P, Picard M and Faure JM 2000. Early locomotor  
585 behaviour in genetic stocks of chickens with different growth rates. *Applied Animal*  
586 *Behaviour Science* 68, 231-242.

587 Corr SA, Gentle MJ, McCorquodale CC and Bennett D 2003. The effect of morphology on  
588 the musculoskeletal system of the modern broiler. *Animal Welfare* 12, 145-157.

589 Danbury TC, Weeks CA, Chambers JP, Waterman-Pearson AE and Kestin SC 2000.  
590 Preferential selection of the analgesic drug carprofen by lame broiler chickens. *Veterinary*  
591 *Record* 146, 307-311.

592 Davies HC and Weeks CA 1995. Effect of age and leg weakness on perching behaviour of  
593 broilers. *British Poultry Science* 36, 838.

594 Fanatico AC, Pillai PB, Hestor PY, Falcone C, Mench JA, Owens CM and Emmert JL 2008.  
595 Performance, livability, and carcass yield of slow- and fast-growing chicken genotypes fed  
596 low-nutrient or standard diets and raised indoors or with outdoor access. *Poultry Science*  
597 87, 1012-1021.

598 Hall AL 2001. The effect of stocking density on the welfare and behaviour of broiler chickens  
599 reared commercially. *Animal Welfare* 10, 23–40.

600 Jones RB 1996. Fear and adaptability in poultry. *World’s Poultry Science Journal* 52, 131-  
601 174.

602 Jones RB and Waddington D 1992. Modification of fear in domestic chicks, *Gallus gallus*  
603 *domesticus*, via regular handling and early environmental enrichment. *Animal Behaviour* 43,  
604 1021-1033.

605 Jones RB, Carmichael NL and Rayner E 2000. Pecking preferences and predispositions in  
606 domestic chicks: implications for the development of environmental enrichment devices.  
607 *Applied Animal Behaviour Science* 69, 291-392.

608 Julian RJ 1998. Rapid growth problems: ascites and skeletal deformities in broilers. *Poultry*  
609 *Science* 77: 1773-1780.

610 Kells A, Dawkins MS and Borja MC 2001. The effect of a 'freedom food' enrichment on the  
611 behaviour of broilers on commercial farms. *Animal Welfare* 10, 347-356.

612 Kestin SC, Knowles TG, Tinch AE and Gregory NG 1992. Prevalence of leg weakness in  
613 broiler chickens and its relationship with genotype. *Veterinary Record* 131, 190– 194.

614 Le Van NF, Estevez I and Stricklin WR 2000. Use of horizontal and angled perches by  
615 broiler chickens. *Applied Animal Behaviour Science* 65, 349–365.

616 Maddocks SA, Cuthill IC, Goldsmith AR and Sherwin CM 2001. Behavioural and  
617 physiological effects of absence of ultraviolet wavelengths for domestic chicks. *Animal*  
618 *Behaviour* 62, 1013-1019.

619 Martrenchar A, Huonnic D, Cotte JP, Boilletot E and Morisse JP 2000. Influence of stocking  
620 density, artificial dusk and group size on the perching behaviour of broilers. *British Poultry*  
621 *Science* 41, 125–130.

622 McAdie TM, Keeling LJ, Blokhuis HJ and Jones RB 2005. Reduction in feather pecking and  
623 improvement of feather condition with the presentation of a string device to chickens.  
624 *Applied Animal Behaviour Science* 93, 67-80.

625 Newberry RC 1995. Environmental enrichment: increasing the biological relevance of  
626 captive environments. *Applied Animal Behavioural Science* 44, 229–243.

627 Newberry RC, Hunt JR, Gardiner EE 1988. The influence of light intensity on behaviour and  
628 performance of broiler chickens. *Poultry Science* 67, 1020-1025.

629 Olkowski AA, Laarveld B, Wojnarowicz C, Chirino-Trejo M, Chapman D, Wysokinski TW and  
630 Quaroni L 2011. Biochemical and physiological weaknesses associated with the  
631 pathogenesis of femoral bone degeneration in broiler chickens. *Avian Pathology* 40, 639-  
632 650.

633 Pettit-Riley R and Estevez I 2001. Effects of density on perching behavior of broiler  
634 chickens. *Applied Animal Behaviour Science* 71, 127–140.

635 Reiter K and Bessei W 1998a. Effect of locomotor activity on bone development and leg  
636 disorders in broilers. *Archiv Fur Geflugelkunde* 62, 247–253. (Abstr.)

637 Reiter K and Bessei W 1998b. Possibilities to reduce leg disorders in broilers and turkeys.  
638 *Archiv Fur Geflugelkunde* 62, 145–149. (Abstr.)

639 RSPCA, 2013. RSPCA Welfare Standards for Chickens, November 2013. Available at  
640 <http://www.freedomfood.co.uk/industry/rspca-welfare-standards> [Accessed 17/09/14]

641 Simsek UG, Dalkilic B, Ciftci M, Cerci IH and Bahsi M 2009. Effects of enriched housing  
642 design on broiler performance, welfare, chicken meat composition and serum cholesterol.  
643 *Acta Veterinaria Brno* 78, 67-74.

644 Su G, Sorensen P and Kestin SC 1999. Meal feeding is more effective than early feed  
645 restriction at reducing the prevalence of leg weakness in broiler chickens. *Poultry Science*  
646 78, 949-955.

647 Su G, Sorensen P and Kestin SC 2000. A note on the effects of perches and litter substrate  
648 on leg weakness in broiler chickens. *Poultry Science* 79, 1259–1263.

649 Weeks CA, Danbury TD, Davies HC, Hunt P and Kestin SC 2000. The behaviour of broiler  
650 chickens and its modification by lameness. *Applied Animal Behaviour Science*. 67, 111-125.

651 Weeks CA, Knowles TG, Gordon RG, Kerr AE, Peyton ST and Tillbrook NT 2002. New  
652 method for objectively assessing lameness in broiler chickens. *Veterinary Record* 151, 762–  
653 764.

**Table 1** *Replication of treatments across cycles and houses*

Cycle	House 1	House 2	House 3	House 4
1	+S+P	+S-P	-S+P	-S-P
2	-S-P	-S+P	+S-P	+S+P
3	-S+P	-S-P	+S+P	+S-P
4	+S-P	+S+P	-S-P	-S+P

+S = provided with S, -S = no access to string, +P = provided with perches, -P = no access to perches

**Table 2** Main effects of string, perches and bird age on normally distributed measures of fearfulness and leg health recorded during weeks 3, 4 and 5 of the rearing cycle

	String		Perches		Age			R.M.S.E	p(S)	p(P)	p(Wk)
	+S	-S	+P	-P	Wk3	Wk4	Wk5				
Flight distance (cm)	62.1	67.6	63.9	65.8	71.1 <sup>a</sup>	70.1 <sup>a</sup>	53.4 <sup>b</sup>	14.3	0.2	0.7	<0.01
Latency to touch novel object (s)	231.8	222.9	229.0	225.7	167.9 <sup>a</sup>	231.1 <sup>ab</sup>	283.0 <sup>b</sup>	83.0	0.7	0.9	<0.01
Birds within 50cm of novel object <sup>1</sup>	8.1	9.6	8.8	8.9	14.6 <sup>a</sup>	7.3 <sup>b</sup>	4.7 <sup>b</sup>	6.7	0.5	1.0	<0.01
Gait score			1.4	1.4				0.1		0.4	
Latency to lie (s)	19.5	18.8	18.7	19.6	22.5 <sup>a</sup>	20.1 <sup>a</sup>	14.9 <sup>b</sup>	4.1	0.5	0.5	<0.01

<sup>1</sup>No. of birds within 50cm of novel object at 300s. +/-S = presence or absence of string, +/-P= presence or absence of perches for all behaviours (df 1, 47). Means are presented for each treatment. Data not represented here are subject to an interaction effect. Data analysed by ANOVA with 'String\*Perches\*Week' as a treatment factor and 'Cycle' and 'House' as blocking factors. All measures recorded during weeks 3, 4 and 5 of the rearing cycle. <sup>a,b</sup> means in the same row with a different superscript differ significantly

**Table 3** Main effects of string and perches on normally distributed measures of leg health, productivity and mortality taken from farm records

	String		Perches		R.M.S.E	p(S)	p(P)
	+S	-S	+P	-P			
Hock burn incidence (%) <sup>1</sup>	12.8	9.3	10.0	12.1	3.9	0.1	0.3
Podo dermatitis incidence (%) <sup>1</sup>	88.2	89.5	87.8	89.9	8.0	0.8	0.6
Slaughter weight (g) <sup>1</sup>	2196	2151	2188	2159	46.8	0.1	0.3
Leg culls <sup>2</sup>	92.0	95.6	95.1	92.5	27.9	0.8	0.9
Mortalities <sup>2</sup>	94.8	96.9	94.3	97.4	17.9	0.8	0.7
Cumulative dead birds (%) <sup>2</sup>	2.3	2.3	2.4	2.3	0.0	0.9	0.7

+/-S = presence or absence of string, +/-P= presence or absence of perches for all behaviours (df 1, 15). Means are presented for each treatment. Data analysed by ANOVA with 'String\*Perches' as a treatment factor and 'Cycle' and 'House' as blocking factors.

<sup>1</sup>Recorded at thinning and slaughter. <sup>2</sup>Recorded at day 30 of the rearing cycle.