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Provision of a resource package reduces feather pecking and improves ranging distribution on free-range layer farms.

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Abstract

The effect of a resource package designed to reduce inter-bird pecking and increase range use was tested on fourteen free-range farms in the UK. The package comprised two types of objects intended to attract pecking behaviour: 'pecking pans' containing a particulate pecking block, and wind chimes; plus long, narrow shelters placed just outside the popholes, bridging a barren area 2-10m from the house, with the aim of improving bird distribution on the range. We predicted that if the resource package succeeded in these aims, overall bird welfare would also be improved. Fourteen commercial farms were enrolled for this two-year study. Flocks were assessed for pecking behaviour, range use and general indicators of welfare at 40 weeks in Year 1 without the resource package. The resource package was then added to the same houses at the start of the next flock cycle in Year 2. The new flocks were assessed in the same way at 40 weeks with additional observations taken of their use of the resource package at 25 and 40 weeks. These additional observations showed that most aspects of pecking behaviour directed at the pecking pans remained consistent from 25 to 40 weeks although a reduction in substrate pecking frequency was seen ($p<0.001$) and birds perched on the pan for longer ($p=0.033$) and more often ($p=0.010$) at 40 weeks. Although consistent within houses, wind chime use was very variable between houses, with pecking observed in only 8 of the 14 houses. The number of birds under the shelters increased from 25 to 40 weeks ($p=0.018$), as did the proportion of birds that went under a shelter within 5 minutes of entering the range area ($p=0.021$). Birds were more likely to use a shelter within 5 minutes if they exited the shed via a pophole within 10m of the shelter rather than a pophole more than 10m away at both 25 weeks ($p<0.001$) and 40 weeks ($p=0.001$).

A reduction in gentle feather pecking ($p=0.001$) and severe feather pecking ($p=0.018$) behaviour was seen when the resource package was provided in Year 2. Range distribution also improved, with a greater proportion of birds seen 2-10m from the house ($p=0.023$). Additionally, the proportion of abnormal eggs ($p=0.010$), headshaking behaviour ($p=0.009$) and the percentage of wet/capped litter ($p=0.043$) decreased in Year 2.

Keywords:

Laying hens; Welfare; Behaviour; Range use; Feather pecking; Enrichment

1. Introduction

Consumers perceive that free-range systems provide a higher standard of welfare for laying hens than alternative housing systems (Bennett et al. 2016; Pettersson et al. 2016a). Due in part to this perception, 44% of the national UK flock are now housed in free-range systems (DEFRA, 2016). There are a number of welfare benefits associated with these systems. Access to an outdoor range reduces the risk of feather pecking behaviour (Green et al. 2000; Lambton et al. 2010) and may provide further opportunity to fulfil behavioural needs such as foraging and dustbathing (Weeks and Nicol 2006). However, range use is often low (Pettersson et al. 2016b) and mortality and injurious pecking behaviour are generally at higher levels than recorded in cage systems (Sherwin et al. 2010; Weeks et al. 2016).

There are many drivers encouraging farmers to improve flock welfare such as consumer opinion, assurance schemes and price premiums for producers performing better in audits. Under the RSPCA Assured (RSPCA 2013) or British Lion Quality (BEIC 2013) schemes it is now a requirement for producers to implement strategies to reduce feather pecking, for example by placing safe items throughout the house for birds to peck at. Resources that stimulate foraging behaviour are most successful at redirecting pecks away from conspecifics (Dixon et al. 2010). These have been widely tested in small experimental groups (for example: Dixon et al. 2010; McAdie et al. 2005; Wechsler and Huber-Eicher 1998) but apart from Lambton et al. (2013) there have been few controlled trials on commercial farms. Pecking items for commercial use need to be attractive to the birds (Jones et al. 2000), affordable and with reasonable longevity to reduce the labour associated with replenishing them.

A second focus with potential to improve bird welfare is to encourage greater range use by improving its accessibility and resources. Greater range use is known to be beneficial because it reduces stocking densities in the house, may reduce feather pecking and provides greater opportunity to meet the behavioural needs of the birds (reviewed by Pettersson et al. 2016b). However, in current systems, range use at a given time is often below 10% (Pettersson et al. 2016b) and birds cluster near popholes (Hegelund et al. 2005; Zeltner and Hirt 2003), causing poached ground and increased risk of disease through high stocking densities and faecal contamination in the area. Range cover has been shown to improve range use and to encourage birds away from the house among other benefits (Bright et al. 2011; Hegelund et al. 2005; Rault et al. 2013; Zeltner and Hirt 2003, 2008). However, tree cover and artificial shelters are often sited over 10m from the house, leaving a barren area of 'no-mans-land' between the house and the rest of the range (Chielo et al. 2016).

This is one of the few replicated, controlled experimental trials to be performed on commercial farms as most similar studies use very few flocks (e.g. Zeltner and Hirt 2003), are observational (e.g. Gilani et al. 2014; Hegelund et al. 2005) or use unmatched control flocks (e.g. Lambton et al. 2013; Zimmerman et al. 2006). Despite the practical difficulties associated with conducting controlled research on working farms, there is a need for relevant research under these conditions. This study aimed to assess, using animal-based measures, the effect of providing a resource package on free-range flock welfare by conducting a pre- and post-intervention experiment using 14 commercial farms. Pecking behaviour and range use were of particular interest, but measures of overall bird welfare were also collected. These included production, mortality and litter quality, as well as behavioural indicators of welfare such as headshaking that have only recently been validated (Nicol et al. 2009). The resources provided included two types of pecking objects, and shelters designed to encourage birds further out onto the range, which were all selected to be practical for commercial use. It was hypothesised that (i) birds would use the new resources (ii) provision of the resource package would specifically reduce inter-bird pecking and improve range use and distribution, and (iii) if these aims were achieved, other measures of bird welfare would also show an improvement.

2. Materials and Methods:

Fourteen commercial free-range laying hen houses were used in this study, across two years. All flocks supplied a 'high welfare' brand in the UK and feed was obtained from the same company. Ten of these houses contained single-tier (also known as flat-deck) systems and four had multi-tier systems. Flock sizes ranged from 6,000-16,000 birds (mean: 13,725) and all flocks were beak-trimmed. Flocks had not had access to the range during rear and were allowed outside for the first time between 19-22 weeks (industry standard). See table 1 for detailed house and flock information. Welfare and behaviour assessments took place during the first flock cycle (year 1) when the birds were at approximately 40 weeks of age (38-42 weeks). A resource package was installed for the next flock cycle (year 2) and welfare and behaviour assessments took place twice at approximately 25 weeks (24-26) and 40 weeks (39-43) of age.

2.1. Welfare assessment and behaviour observations

A detailed welfare assessment of the flock was carried out during the 40 week visit in year 1 and a farmer questionnaire was administered. See table 2 for a description of the methodology and welfare measures recorded. In year 2 the farmer was re-interviewed and the same welfare assessment was performed during the 40 week visit. As commercial flocks are now generally kept for longer than 12 months (due to modern genotypes maintaining production for longer) it was not possible to match the 40 week visits to season in all cases. Precipitation was different in only two flocks across the observations where drizzle was recorded in year 1 but not in year 2. Additional behaviour observations relating to use of the newly provided resources were performed for both the 25 and 40 week visits in year 2 (table 2). All observations were performed between 08.30 and 16.00 with the observations generally matched for time of day across visits.

A variety of scoring systems were used for welfare measures on individual birds. Body condition was scored on a 0-3 scale (where 0 is poor) based on the system by Gregory and Robins (1998). Keel damage was scored using a 0-2 scale (where 0 is no damage) based on the technique described in Wilkins et al. (2004). Plumage damage was scored using a 1-4 scale on 5 body areas (where 4 is perfect plumage), summed to give a total score out of 20. Comb wounds were scored on a 0-2 scale (where 0 is no damage) and both this and the plumage scoring scale were adapted from Tauson et al.

(2004). Any signs of cannibalism or vent pecking were recorded as yes/no but were excluded from the analysis due to low incidences.

2.2. Resource package

Based on observations in year 1, the scientific literature, and discussions with industry stakeholders, three resources were designed and installed in each house and/or range in year 2.

Commercially available pecking pans (Vencomatic, Yorkshire, UK) were installed at 1 per 750 birds in each house. These consisted of a green plastic round feeder pan on a grey plastic base, containing a hard, particulate substrate designed to attract birds to peck (see fig.1a). All pans were distributed throughout the inside of each house, with an additional pan placed on each side of the range. The pan on the range was placed within a couple of meters of the house, in view of the popholes and not within 3m of a shelter (maximum of two outside per house). On 12 farms all of the pans were placed within two weeks of bird placement. Two farms delayed full placement until six weeks because of floor egg laying concerns.

Metal wind chimes (B&Q, UK) were installed at 1 per 4,000 birds in each house. As these were a novel enrichment with potential risk of inducing a flight response, the chimes were installed in lower numbers. Each wind chime consisted of eight chimes hanging by string from a flat circular top (22cm long, 8.5cm wide) (see fig.1b). These were hung above the litter at bird head height and only produced sound if knocked or pecked at by the birds. All chimes were installed by 1 week post-placement for 12 houses (other two houses installed at 4 and 8 weeks due to communication and supply errors). These were chosen as no-one has previously examined whether birds might respond to auditory feedback from their own pecking behaviour.

Specially designed shelters were installed outdoors, before range access was provided in all houses. These consisted of three, 300cm long metal-framed sections (107cm wide at base, 50cm high) placed end to end to create a 900cm long, tunnel-like shelter (see fig.1c). Blue plastic netting was secured to the metal frame over the top and reaching down 22cm on each side thus enabling access from the side. The shelters provided to one house were slightly different in design with netting reaching down to the ground on each side due to a change in design. Two full shelters (three pieces per shelter) were provided per side of house with popholes (maximum of four per house). The shelters were installed within a few metres of the popholes, stretching out onto the range perpendicular to the house. All ranges had little to no grass cover between 2 and 10m and were almost completely barren of overhead cover (apart from the tunnels/shelters provided as part of this study).

2.3. Analysis

All analyses were performed using SPSS version 23.

For comparisons of welfare indicators before and after resource provision, means were calculated for each house for both 40 week visits. Data were checked for assumption criteria and transformed to meet assumptions where possible. Data were analysed using paired t-tests or Wilcoxon paired tests as appropriate. Non-parametric tests were used for ordinal data or where continuous data could not be transformed to normality. Standard deviations of individual weight and body condition score were additionally tested in this way to look for differences in inter-bird variation across the 50 birds studied per house, per visit. Flock 4 was excluded from the analysis of range distribution as zero birds were recorded on the range in year 1 for this flock.

A similar method was used to assess whether resource use in year 2 changed over time. The difference between paired variables was checked for normality and variables transformed where necessary and possible. Normal and transformed normal data were tested for differences between 25 and 40 weeks using paired t-tests or the Wilcoxon test for non-normal data. Owing to lack of interest in the chimes on some farms, we were unable to attain four focal birds for all observations. For pecking behaviour in these cases dummy values of zero were added to the data. For data on birds that left the chime ‘area’ averages were taken from all the focal birds we were able to record. House 5 was excluded from all pophole focal analysis owing to insufficient data through poor range use by this flock. Chi-squared tests were used to look at whether distance of pophole from a shelter (close or far) affected bird behaviour (i.e. either going under a shelter or back into the house within 5 minutes or doing neither and remaining on the range after 5 minutes) for both age points. Whether the average number of birds entering or leaving a pophole per minute was affected by distance from a shelter (close or far) was analysed using independent measures t-tests following transformations to normality. House 2 was excluded from this last analysis due to missing data as a result of technical error.

The difference in value for each welfare measure from year 1 to year 2 was calculated. Decreases were recorded as a negative value and increases as a positive value. These differences were then checked for bivariate correlations with each other and with the actual values of resource use variables at 40 weeks. Pearson correlations were used for normally distributed data (transformed and untransformed). Spearman rank correlations were used for ordinal data and non-normal continuous data that could not be transformed to normality. Due to the large size of the correlation matrix only correlations that were significant at $p<0.01$ and appeared to be biologically relevant were considered.

After the initial analysis of the complete dataset, all statistical tests were repeated with houses 6 and 12 removed as these two houses changed from brown to white bird genotypes in year 2. Brown genotypes are distinctly different both physically and behaviourally from white genotypes (Ali et al. 2016; Fraisse and Cockrem 2006).

3. Results

3.1. Behavioural use of the resources – Pecking pans

Scan observations of pan use showed that the number of birds pecking at and perching on the pan did not change significantly over time but the average number of birds within 1m of the pecking pan significantly decreased from 25 to 40 weeks. Focal observations of pan use showed that substrate pecking bout duration did not change from 25 to 40 weeks but the number of bouts decreased significantly. Pecking behaviour (bout duration and frequency) directed at the plastic pan did not change from 25 to 40 weeks. Perching bout duration and frequency increased from 25 to 40 weeks as did the percentage of birds that left the 1m area around the pan during the 2 minute focal observations. See table 3 for details of these results.

When white bird flocks were removed from the analysis, the age difference in the duration of perching on the pan became insignificant (t(11)=-2.140, p=0.056).

3.2. Behavioural use of the resources – Wind chimes

Chime use was highly variable between houses with no birds observed pecking at the chimes in 6/14 houses at both 25 and 40 weeks (different flocks). No significant differences were found in scan sampled behaviour between 25 and 40 weeks or pecking bout durations and frequencies (see table 3).

3.3. *Behavioural use of the resources – Shelters*

Scan samples of shelter use showed that the number of birds under the shelter increased significantly from 25 to 40 weeks as did the number of birds perching on the shelter and the number of birds within 1m of the shelter (see table 3).

The average number of birds moving in and out of the focal popholes was not significantly affected by pophole position (close or far) relative to the shelters.

Focal observations of birds leaving popholes showed that there was a significant increase in the percentage of birds going under a shelter within 5 minutes from 25 to 40 weeks (48.56% vs 62.26%, t(12)=-2.656, p=0.021). There was a significant decrease with age in the percentage of birds returning to the house within 5 minutes (26.68% vs 15.87%, t(12)=-3.035, p=0.01). The percentage of hens that neither went under a shelter or back into the house within 5 minutes did not change significantly with age.

A significantly higher proportion of birds went under a shelter within 5 minutes if it was ‘close’ (within 10m) to their exit pophole rather than ‘far’ (over 10m) away at both 25 weeks (62.7% vs 37.3%, $\chi^2(1)=21.013$, $p<0.001$) and 40 weeks (57.4% vs 42.6%, $\chi^2(1)=12.083$, p=0.001). The percentage of birds that went back into the house (without using a shelter) within 5 minutes was significantly higher for birds exiting via ‘far’ popholes at 25 weeks (35.8% vs 64.2%, $\chi^2(1)=8.744$, p=0.005). The proportion that remained on the range without using a shelter within 5 minutes was significantly higher for birds exiting via ‘far’ popholes at both 25 weeks (38.5% vs 61.5%,

$\chi^2(1)$=5.493, p=0.026) and 40 weeks (34.3% vs 65.7%, $\chi^2(1)$=8.850, p=0.004).When white bird houses were removed from the analysis this result became insignificant at both 25 weeks ($\chi^2(1)$=1.337, p=0.312) and 40 weeks (($\chi^2(1)$=4.078, p=0.062).

At 25 weeks most (72.5%) of the birds that went under a shelter within 5 minutes entered the first section of the shelter (closest to the house), 17.4% entered via the second section and 9.9% via the third section (furthest from the house). At 40 weeks 61.9% entered via the first section, 23.3% via the second section and 14.8% via the third section.

3.4. Effect of resource provision on general flock welfare

Following the addition of the resource package, the number of headshakes observed at 40 weeks decreased significantly from 1.32 per bird/min to 0.86 per bird/min. A threefold reduction in gentle feather pecks from 0.33 per bird/min to 0.10 per bird/min was seen in year 2 and observed rates of severe feather pecking also decreased significantly from a low level of 0.04 per bird/min to none (0.00 per bird/min). The percentage of abnormal eggs reduced by approximately 5% after the resource package was added. The proportion of wet/capped litter also decreased in year 2 from 29.32% to 21.43%. See table 4 for further details. When the two houses that changed to white bird production were removed from the analysis the difference in the proportion of wet/capped litter became insignificant (Z=-1.646, p=0.100). Arousal levels were also found to be significantly decreased in year 2 when white bird houses were removed from the analysis (2.33 vs 1.67, Z=-2.530, p=0.011). However, with these flocks removed, mortality became significantly higher in year 2 (1.50% vs 2.34%, t=-2.606, p=0.024). Flock 11 had a disease outbreak in year 2 (mortality increase of 5.73%) so this flock was then also removed from the mortality analysis (n=11) but the result remained significant (1.45% vs 1.85%, t=-2.661, p=0.024)

Total range use did not change significantly but the distribution of the birds between the three recording areas altered in Year 2. Specifically, we found a significant increase in the proportion of birds counted in the 2-10m area after the resource package was added (see table 4).

Bird health and body condition were similar in both years with no significant differences in comparisons of any of the individual measures. However, there was significantly lower variation in body weight at 40 weeks as measured by standard deviation in year 2 (0.16 vs 0.14, $t(13)=2.602$, $p=0.022$) probably due to the two white flocks, as this became insignificant with these flocks removed ($t=1.932$, $p=0.070$). For the brown bird flocks mean total plumage score was found to be significantly better in year 2 than year 1 (19.38 v 18.79, $Z=-2.120$, $p=0.034$).

No significant difference was found between the two flock cycles in general preening behaviour (see table 2 for variables analysed). However, when the white bird houses were removed from the analysis there was a significant difference in the average number of 'preens' observed per bout (5.56 vs 4.09, $t=2.528$, $p=0.028$). The resource package did not affect dustbathing behaviour.

3.5. Correlations

Only two correlations met the criteria for further consideration. The difference in plumage score was negatively correlated with the difference in gentle feather pecking behaviour (spearman correlation coefficient=-0.811, $p<0.001$), meaning that a greater decrease in gentle feather pecking was associated with a greater improvement in plumage score. The difference in weekly production was also found to be positively correlated with the difference in arousal score – so birds with increasing levels of arousal had a greater improvement in production (spearman correlation coefficient=0.771, $p=0.001$).

4. Discussion

The first aim of this research was to see whether the birds used the resources provided and whether this changed over time. From this we could infer whether usage was sufficient to have had a plausible effect on flock level welfare indicators. The extent to which birds engaged with the resources was also relevant to inform future decisions about resource provision in the commercial setting.

Few studies have looked at whether pecking devices actually sustain bird interest over time and those that have, assert that a pecking device sustained interest when used over a relatively short period of time such as 10 days (Jones and Carmichael 1999; Jones et al. 2000). As a typical commercial laying hen lifespan is 72 weeks, pecking devices in the commercial setting must sustain interest for considerably longer. That the use of the pecking pans observed in this study did not show much decrease over a 15 week period is therefore very positive. However, the percentage of focal birds that left the pan area within 2 minutes was high at both time points (over 45%) and increased with age. This may be due to reducing interest in the pan or, as pecking duration and frequency mostly remained unchanged (with only substrate pecking frequency decreasing), perhaps more efficient use of the pan where birds peck and move on rapidly. Interestingly, focal observations showed increased pecking aimed at the green plastic casing rather than the substrate within, perhaps because the plastic was easier to access than the substrate (fig. 1a). However, the plastic itself may be attractive as a pecking material. According to scan observations very few birds (average of 0.2 birds) perched on the pan and this did not change over time. Yet, focal observations showed a significant increase with age in the duration and frequency of perching bouts on the pecking pan. Perching birds may block access for conspecifics and soil the pecking material, potentially reducing pecking behaviour directed at the pan. It is possible that substrate pecking bout frequency decreased when plastic pan pecking bout frequency did not because of increased soiling of the substrate. It may therefore be important to prevent perching on the pan when installing on farm or to refine the way in which the pecking material is presented to the birds.

Wind chime interactions varied considerably. In six houses no wind chime use was seen at all. However, in other houses chimes were used at a high frequency and use did not decrease over time. The chimes may therefore be appropriate as a pecking device for some flocks but not others. Location of the chimes may have affected their attractiveness. All chimes were placed over the litter but the exact location varied between houses. Additionally, the chimes themselves provided a small surface area for pecking and could have attracted more attention if, for example, they were connected to an object with a large surface area that moved the chimes when pecked. Further work into pecking enrichment providing auditory feedback would be valuable.

Shelter use was assessed in two main ways during this study. First, the scan observations showed an increase in use with age and revealed that many birds were found within 1m of the shelter but not underneath it (average of 14 at 40 weeks). The shelters may therefore have provided the birds with a perception of greater security from potential predators without requiring them to be actually underneath, thus increasing the number of birds that could benefit from each shelter. Similarly, birds have been seen in the vicinity of vertical shelters despite their lack of overhead protection (Rault et al. 2013). Second, the focal observations established whether birds sought out the shelters upon entering the range area. A high proportion of birds moved under a shelter within 5 minutes of entering the range area and this increased with time. As this observation was not affected by overall numbers of birds ranging (unlike the scan observations that could be influenced by total birds outside) we conclude that the shelters became more attractive over time. Birds that exited from a pophole near a shelter used the shelter more, most likely due to its proximity. However, at 40 weeks over 40% of birds exiting from popholes more than 10m from a shelter, still used a shelter within 5 minutes. This suggests that birds actively seek shelter and are willing to travel to access it. The percentage of birds that went back into the house within 5 minutes decreased with age and was lower for birds that had exited close to a shelter. This suggests that increased shelter use may encourage birds to stay out for longer. Since observations ceased once a bird used a shelter it is unclear if there was simply an increase in birds using the shelter before returning to the house in the same time frame.

The pecking pans and shelters were used consistently over time and across flocks whilst the wind-chimes were used more variably between flocks. We next evaluated whether this level of usage had led to reductions in inter-bird pecking and increased range use. Both gentle and severe feather pecking decreased following provision of the resource package, although very few incidences of severe feather pecking were observed. All birds in this study were beak-trimmed which may explain why more gentle feather pecking was observed (Lambton et al. 2010). Although gentle feather pecking does not cause plumage damage and economic losses to the same extent as severe feather pecking (Rodenburg et al. 2013), it has been associated with limited behavioural opportunities (Lambton et al. 2010, Nicol et al. 2013) and is widely believed to be redirected foraging (Rodenburg et al. 2013). Addition of the resource package, specifically the well-used pecking pans, may therefore have provided further foraging opportunities, reducing the need to redirect onto conspecifics. As gentle feather pecking does not usually cause plumage damage (Lambton et al. 2010; Rodenburg et al. 2013) it is interesting that a decrease in gentle feather pecking was correlated with an increase in plumage score. As plumage score was generally very good in all houses, gentle feather pecking may have resulted in perceptible albeit minor plumage damage that has not previously been noticed in other studies. This may also be the result of severe feather pecking that occurred outside of observation periods.

Although no overall change in range use was observed, significantly more birds ranged in the 2-10m area in year 2. Chickens are prey animals that find security from shelter (as discussed in Pettersson et al. 2016b) so may be fearful of traversing such an open area. Only 20% of all birds on the range were found in this open area during year 1. This proportion increased to 32% after shelter provision and, as no other alterations were made to the range area between flock cycles and the shelters were well-used, it is reasonable to attribute this change to the shelters. Shelters have previously been found to change bird distribution (Rault et al. 2013; Zeltner and Hirt 2003, 2008) but have not been formally tested commercially in the typically barren 2-10m area prior to this study.

The final aim was to see whether the resource package influenced other general measures of bird welfare and productivity. Headshaking and the proportion of abnormal eggs decreased following provision of the resource package. Headshaking has been deemed an alerting response (Hughes, 1983) and it has been validated as an indicator of negative valence (Nicol et al. 2009). Stress can delay oviposition, resulting in egg abnormalities such as calcification spots and deformities (Hughes et al. 1986; Reynard and Savory 1999). The decrease in abnormal eggs seen in this study in year 2 suggests that the flocks had reduced stress responses. However these findings should be interpreted with some caution. Although the resource package is the most likely cause of these changes, it is also possible that other uncontrollable factors such as weather and bird genotype operated across all farms between Year 1 and Year 2.

Levels of arousal decreased in year 2 when white genotype houses were removed from the analysis. The two white bird flocks had much higher levels of arousal which likely prevented a significant result in the first analysis. This concurs with existing literature showing that white genotypes exhibit greater fear responses compared with brown birds (Fraisse and Cockrem ~~(~~2006).

Although there was no significant difference in mortality between year 1 and year 2 in the original analysis, a significant increase in mortality was found when the two white genotype flocks were removed. The mortality of both white genotype flocks was low in Year 2, so this was likely responsible for masking an underlying increase in the other flocks. The producers likely changed to white genotypes because of high mortality in Year 1 (both flocks over 4% in year 1) so it is appropriate to exclude these two flocks when considering this variable. A disease outbreak occurred in flock 11 during year 2 but a significant increase in mortality remained after exclusion. It is not clear why an increase in mortality occurred during this study although the mean difference was not particularly great with flock 11 removed (<0.5%).

It should be noted that repeating the analysis with white genotype houses removed also reduced the sample size and so it is possible that this may also have affected the significance level, particularly where results narrowly became insignificant with the reduced sample size.

As all flocks were provided with the resource package in the second flock cycle, year has a potentially confounding effect on the results. This was unavoidable in this study. Different flock cycles can vary in their behaviour even within the same shed and it is possible that this may have influenced the results. Changes in bird genotype may have exacerbated this issue although again, this was unavoidable. Weather remained similar during the 40 week observation points for both years and where genotype was likely to affect the results this was controlled for in the analysis (white flocks). Despite these potential confounding factors there was no systematic change in any variable except the one of interest – resource provision.

5. Conclusions

This is one of the very few replicated intervention trials to examine hen behaviour on commercial farms and to our knowledge, is the first to use a pre and post-intervention methodology on multiple farms.

Provision of a resource package designed to provide foraging opportunity and encourage birds out onto the range had encouraging results with reductions in feather pecking, improved distribution of birds on the range and some indications of improved overall welfare. Additionally, this study has provided new information on continued bird use of resources designed to encourage pecking behaviour in a commercial setting and their potential welfare benefits, as well as measuring the benefits of a new shelter design to overcome a problem faced by most free-range hens, which are fearful of being outside without overhead cover.

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Table 1: Flock information and resource provision for the fourteen houses studied.

House	**Size**	**Genotype (Year 1)**	**Genotype (Year 2)**	**System**	**Shelters (2 per side)**	**Pecking Pans (1 per 750)**	**Chimes (1 per 4000)**
1	16000	Novogen Brown	Novogen Brown	Multi-tier	2	21	4
2	11700	Novogen Brown	Novogen Brown	Single-tier	2	16	3
3	6950	Lohmann Brown	Novogen Brown	Single-tier	2	9	2
4	16000	Lohmann Brown	Lohmann Brown	Multi-tier	2	21	4
5	16000	Novogen Brown	Novogen Brown	Single-tier	4	21	4
6	6000	Hyline	LSL Lohmann White	Single-tier	4	8	2
7	16000	ISA Warren	Bovan Brown	Single-tier	4	21	4
8	15000	Lohmann Brown	Novogen Brown	Single-tier	4	20	4
9	12500	Lohmann Brown	Lohmann Brown	Single-tier	4	17	3
10	16000	Lohmann Brown	ISA Brown/Hyline	Single-tier	4	21	4
11	16000	Shaver	Shaver	Multi-tier	2	21	4
12	12000	Novogen Brown	Novogen White	Single-tier	4	16	3
13	16000	Hyline	Lohmann Brown	Multi-tier	4	21	4
14	16000	Lohmann Brown	Lohmann Brown	Single-tier	4	21	4

Table 2: Description of the methods used to assess general welfare and behavioural use of the resources.

Variable	Method
Welfare assessment (40 weeks in years 1 and 2)	
Production (%)	[Obtained by farmer questionnaire] Weekly based on all hens placed, as recorded by the farmer for the last full week
Mortality (%)	[Obtained by farmer questionnaire] Cumulative, as recorded by the farmer at the end of the last full week
Litter quality (% capped)	Proportion of capped/wet litter recorded in 3-8 areas of the house (dependent on house setup). Mean of all areas used in analyses.
Abnormal eggs (%)	150 ungraded eggs observed to identify 6 types of egg: white banded, calcium spotted, rough, misshapen, blood marked and normal.
Range use (%)	3 times on each assessment throughout the day. Number of birds on the range counted and calculated as a percentage of live birds. Additionally, proportions of birds (summing 100%) in three areas of the range calculated: within 2m of the popholes, 2-10m from popholes and 10m plus from popholes. These three areas were estimated visually during the counts.
Arousal	Arousal levels of the flock, recorded using a 1-4 point scale, where 4 is most flighty.
Behavioural indicators (per bird per min)	6 areas of 1m^2 selected randomly to include slats, litter and range. All incidences of the following behaviours recorded for 5mins per area: headshakes, gentle feather pecking, severe feather pecking, aggressive pecking, bill wipes, tail wags, stretching and scratching. Only three behaviours (headshakes, gentle feather pecking and severe feather pecking) were seen sufficiently frequently to analyse.
Dustbathing	Full dustbathing bouts recorded for one hour per 40 week visit. Duration of bouts and behavioural elements recorded. Interruptions to bouts recorded. A dustbathing bout began with a vertical wing shake and ended with a body shake or after a minute had passed and no further behavioural elements seen.
Preening	10 preening bouts recorded per 40 week visit. Duration and number of 'preens' recorded. A preening bout was recorded from when the beak first touched the feathers until the beak was removed for longer than 10s. A new 'preen' begins when a new body area is focused on or if the beak is removed for 5-9s and then the hen preens the same area. Interruptions to bouts recorded.
Individual measures	50 birds caught from all areas of the house and the following information recorded: weight (g), body condition, keel fractures, keel deformation, plumage damage, cannibalism, vent pecking, comb wounds. See text for full description of scoring criteria.
Behavioural use of resources (25 and 40 weeks in year 2)	
Pecking pan use - scans	1/3 of the total pans provided observed. Two scan samples performed approximately 10 mins apart. Number of birds in the area, pecking at and on the pan recorded. The two scans were then averaged.

Pecking pan use - focals	1/3 of the total pans provided observed. 4 individual birds interacting with the pan observed for 2 mins and all behaviours recorded as bouts. A bout was deemed to be over when a bird started another behaviour or stopped the previous behaviour for over 5s. If the bird left an area of 2m around the pan, the observation ended. Whether birds pecked at the substrate of plastic pan was recorded. Averages were taken from these 4 birds.
Chime use - scans	2 chimes observed for all houses. Two scan samples performed approximately 10 mins apart. Number of birds in the area and pecking at the chimes recorded. The two scans were then averaged.
Chime use - focals	2 chimes observed for all houses. 4 individual birds interacting with the chimes observed for 2 mins and all behaviours recorded as bouts A bout was deemed to be over when a bird started another behaviour or stopped the previous behaviour for over 5s. If the bird left an area of 2m around the pan, the observation ended. Averages were taken from these 4 birds. In some cases, there were not enough birds interacting to perform 4 focal observations, in which case dummy values with zeroes for all behaviours and durations were included.
Shelter use	Each shelter was observed. The number of birds within 1m of the shelter, under the shelter, and on the shelter were counted every minute for 5 minutes (6 scans total) and averaged.
Pophole observations	Two popholes were observed per shelter – a close pophole (within 10m of shelter) and a far pophole (over 10m from shelter). The number of birds moving in and out of the house via each of these popholes was first recorded for 3 mins and averages for close and far popholes calculated for each flock. Four focal birds were then observed per pophole for 5 minutes or until they went under a shelter or back into the house.

Table 3: A comparison of behavioural use of the resources between 25 weeks of age and 40 weeks of age (summary statistics and tests, including white flocks) *=significant at <0.05

	Mean (SD)		Test result (degrees of freedom) and significance level
	25 weeks	40 weeks	
Pecking pans			
Number within 1m	8.30 (±4.84)	5.45 (±1.36)	t(13)=2.665, p=0.019*
Number pecking	2.17 (±2.22)	1.57 (±0.91)	t(13)=1.138, p=0.275
Number perching	0.20 (±0.27)	0.21 (±0.23)	t(13)=-0.212, p=0.836
Substrate pecking bout duration (s)	3.95 (±2.16)	3.78 (±3.47)	t(13)=1.386, p=0.189
Substrate pecking bout frequency	1.18 (±0.52)	0.64 (±0.31)	t(13)=4.859, p<0.001*
Plastic pecking bout duration (s)	5.90 (±4.19)	5.77 (±3.71)	t(13)=-0.490, p=0.632
Plastic pecking bout frequency	1.45 (±0.72)	1.17 (±0.48)	t(13)=1.001, p=0.335
Perching duration (s)	4.51 (±5.40)	7.21 (±7.45)	Z(13)=-2.134, p=0.033*
Perching frequency	0.10 (±0.12)	0.14 (±0.14)	t(13)=-3.012, p=0.010*
Percentage left $1m^2$ area within 2 minutes (%)	47.82 (±21.73)	65.27 (±13.89)	t(13)=-3.532, p=0.004*
Wind chimes			
Number within 1m	3.95 (±3.45)	3.00 (±2.06)	t(13)=1.657, p=0.122
Number pecking	0.61 (±0.84)	0.54 (±0.63)	t(13)=0.744, p=0.470
Pecking bout duration (s)	3.87 (±4.99)	5.14 (±7.90)	t(13)=-0.472, p=0.645
Pecking bout frequency	1.34 (±1.30)	1.09 (±1.04)	t(13)=1.630, p=0.127
Percentage left $1m^2$ area within 2 minutes (%)	65.00 (±36.23)	58.04 (±37.08)	t(13)=0.404, p=0.695
Shelters			
Number within 1m	9.05 (±11.61)	13.56 (±13.20)	Z(13)=-1.977, p=0.048*
Number underneath	8.86 (±8.73)	18.13 (±12.56)	t(13)=-2.708, p=0.018*
Number perching	0.27 (±0.64)	2.04 (±2.67)	Z(13)=-2.936, p=0.003*

Table 4: A comparison between baseline flocks (year 1) and flocks given the resource package (year 2) of general measures of welfare at 40 weeks of age (summary statistics and tests, including white flocks). *=significant at <0.05

Welfare measure	Mean (SD)		Test result (degrees of freedom) and significance level
	Year 1	Year 2	
Production (%)	86.14(±8.87)	87.39(±11.39)	Z(13)=-0.909, p=0.363
Mortality (%)	1.93(±1.17)	2.34(±1.70)	t(13)=-1.601, p=0.308
Capped/wet litter (%)	29.32(±15.91)	21.43(±15.65)	Z(13)=2.028, p=0.043*
Abnormal eggs (%)	12.96 (±5.01)	7.98 (±4.76)	t(12)=3.060, p=0.010*
Arousal	2.21(±1.05)	2.00(±1.18)	Z(13)=-0.734, p=0.463
Total range use (%)	9.74(±10.56)	9.98(±6.90)	t(13)=-0.113, p=0.912
Within 2m of popholes (%)	37.23(±22.71)	24.65(±10.15)	t(12)=1.771, p=0.102
2-10m (%)	19.88(±14.11)	32.04(±12.04)	Z(12)=-2.271, p=0.023*
10m+ (%)	42.88(±23.00)	43.31(±14.58)	t(12)=-0.830, p=0.935
Headshakes (per bird per min)	1.32(±0.52)	0.86(±0.49)	t(13)=3.064, p=0.009*
Gentle feather pecking (per bird per min)	0.33(±0.19)	0.10(±0.06)	t(13)=4.328, p=0.001*
Severe feather pecking (per bird per min)	0.04(±0.07)	0.00(±0.00)	Z(13)=-2.371, p=0.018*

Figure 1. Photographs of the three resources provided in year 2 of the study: a) pecking pan, b) wind chime, c) shelter.