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Tree cover and injurious feather-pecking in commercial flocks of free-range laying hens: a follow up

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Abstract

Injurious feather-pecking in non-cage systems is a serious economic and welfare concern for the egg-producing industry. This study presents results from data of over 1,000 flocks from producers who supplied free-range eggs to McDonald's Restaurants Ltd UK between 2008 and 2013. These producers had a minimum 5% of the outdoor range planted in trees. We investigated the correlation between the plumage damage of end-of-lay hens with i) proportion of the total range planted with trees and ii) proportion of canopy cover within tree-planted areas. As tree canopy developed over the study period, we also investigated whether there were any changes in end-of-lay plumage-damage scores within farms, with year over the five years. There was a negative correlation between canopy cover and plumage damage at the end of lay, ie less canopy cover within tree-planted areas resulted in significantly worse plumage damage at the end of lay. There was no correlation between the amount of range planted and plumage damage at the end of lay. These results support the notion that it is the degree of shade and shelter (ie quality of cover) that is important to the hens rather than the absolute area. We did not find any association between year and end-of-lay plumage-damage scores. Due to commercial changes in supply, the proportion of farms providing data for ≥ 3 years was small, thereby limiting the data set with which to compare individual farms' plumage-damage scores. It is hoped the relationship between year and plumage-damage score will be re-examined in a future study.

Keywords: *animal welfare, free range, injurious feather-pecking, laying hens, plumage damage, tree cover*

Introduction

Injurious feather-pecking (IFP hereinafter) is a serious economic and welfare concern for the egg-producing industry (Jones *et al* 2004; Rodenburg *et al* 2004). IFP is an abnormal behaviour that consists of pulling, plucking, and damaging feathers of conspecifics (Savory 1995). IFP can be particularly problematic in non-cage systems (Gentle & Hunter 1990; Gunnarsson *et al* 1999; Huber-Eicher & Sebö 2001) because access to potential IFP victims is unrestricted (Appleby *et al* 1992).

There is a well-established link between outdoor range use and IFP in commercial laying hen flocks; the higher the percentage of flocks using the outdoor range, the lower the prevalence of feather-pecking (Green *et al* 2000; Bestman & Wagenaar 2003; Nicol *et al* 2003; Lambton *et al* 2010). In an experimental study by Mahboub *et al* (2004), a negative correlation was found between percentage of time spent outside and plumage damage.

In 2008, egg producers supplying free-range eggs into the McDonald's Restaurants Ltd UK supply base (via The Lakes Free Range Egg Co Ltd [Lakes hereinafter] and Noble Foods Ltd [Noble hereinafter]) were required to plant, if not present already, at least 5% of the total range area with trees. The species and spacing of trees was largely determined by the producers, however no more than 50% of the trees were to be of *Pinus* genus (ie offering little canopy cover) and the outer branches were to be 20 to 25 m from the house to encourage ranging (Bestman *et al* 2002). Variation in tree cover across farms existed due to the difference in proportion of range on which producers decided to plant trees, the timing of planting prior to flock placements and the presence of existing tree stands.

An initial study by Bright *et al* (2011) demonstrated that there was no correlation between the proportion (5–90%) of range cover and plumage damage at the end of lay, however, plumage damage was negatively correlated with percentage of canopy cover within tree-planted areas. A second study on matched free-range laying flocks with and without tree cover demonstrated that in flocks with tree cover there were less total egg seconds and significantly less ≥ 45-week egg seconds than flocks without tree cover. There was also lower mortality in flocks with tree cover (Bright & Joret 2012).

Here, we present results from data of over 1,000 flocks from producers who supplied free-range eggs to McDonald's Restaurants Ltd UK between 2008 and 2013. We investigated the correlation between the plumage damage of end-

Table 1 Description of scoring system used to evaluate tree cover within tree-planted areas.

Percent	Tree cover description
0	No trees or newly planted trees
10	Trees up to 2 m in height with spacing of no more than 5 m. Branches must cover more than 0.5 m^2 around the base of the tree
25	Trees are between 2 and 3 m in height with spacing of no more than 5 m. Branches must cover more than 1 m^2 around the base of the tree
50	Trees are at least 3 m in height with spacing of no more than 5 m. Branches must cover more than 2 m^2 around the base of the tree
75	Trees are at least 4 m in height with spacing of no more than 5 m. Branches must cover more than 3 m^2 around the base of the tree
100	Mature trees which have overlapping branches

Table 2 Description of scoring system used to evaluate plumage damage of end-of-lay flocks.

Score	Description of plumage damage
1	Well feathered body parts with no/very little damage
2	Slight damage to any area of the body with feathers ruffled, body completely/almost completely covered
3	Severe damage to feathers, localised naked area (> 5 cm^2) or localised naked area (< 5 cm^2) in more than one area, and slight damage in any other area
4	Severe damage to feathers with more than two naked areas > 5 cm^2 and/or broken/separated flight feathers; or naked area < 5 cm^2 and any damage to three other areas
5	Severe damage to feathers with broken/damaged skin anywhere; or any three naked areas > 5 cm^2; or flight feathers completely removed

Table 3 Test statistics for the final mixed model; effects of percent canopy cover and covariates on plumage-damage score (associations described when *P* < 0.1).

Variable	χ^2	df	*P*-value	Association with plumage-damage score
Breed	27.79	12	< 0.001	Breed A > B, C*
Egg company	11.89	1	< 0.001	Company A < Company B*
Percent canopy cover	7.05	1	0.008	Negative
Egg per bird production	6.47	1	0.011	Negative
Percent flock mortality	5.46	1	0.019	Positive
Flock size	3.18	3	0.075	Positive
Season at end of lay	3.86	3	0.277	n/a
Farm ownership	0.74	1	0.391	n/a
Year (number of times house included in study)	0.20	1	0.652	n/a
Age at end of lay	0.06	1	0.801	n/a

* Ascribed letters to protect confidentiality.

of-lay hens with i) proportion of the total range planted with trees and ii) proportion of canopy cover within tree-planted areas. Trees that were newly planted in 2008 had grown by 2013 to provide a more mature canopy, potentially influencing birds' outdoor range use. Therefore, we also investigated whether there were any changes in plumage-damage scores within farms, over the five-year time-frame.

Materials and methods

Beginning April 2008, all egg producers were asked to: i) record the percentage of range planted with trees (0–100%); ii) record the average percentage of canopy cover within the tree-planted area (0: no trees or newly planted trees — 100%: mature trees with overlapping branches; Table 1) and; iii) assign an average plumage damage score for each flock at the end of lay (1: best to 5: worst; Table 2). Flock information, productivity and mortality data were collected for every flock from farm records at end of lay. Tree-cover and plumage scores were assessed by the egg producers after training by staff members of the companies. Further details of tree-cover assessment, plumage assessment, data collection and data auditing can be found in Bright *et al* (2011). Whilst every effort was made to ensure the pool of producers remained the same over the five years of study, there were inevitable changes for commercial reasons. The statistical analysis was carried out in January 2014; a complete set of information (see Bright *et al* 2011) was available for 1,113 flocks from 352 farms. Of those, 567 houses had data from one laying cycle; 298 houses, two cycles; 152 houses, three cycles; 71 houses, four cycles; and 25 houses, five cycles.

The statistical software package used for all analyses was 'R' (R Core Team 2014). Data were analysed using a nested, repeated measure, mixed model with the lmer package. Normality and homogeneity of variance were checked by visual examination of residual plots from fitted models.

The analysis was undertaken in three steps; firstly, a base model which included the random variables of farm, house and year (number of times end-of-lay data had been collected from a specific house on a farm, ie a proxy measure for tree growth). Then, the association between percentage of range planted with trees and percentage of canopy cover within the tree-planted area and plumage damage score was assessed. There was a significant association between percentage of canopy cover within the tree-planted area and plumage damage score ($\chi^2 = 8.6$, df = 1; $P < 0.001$). There was no significant association between percentage of range planted with trees and end-of-lay plumage-damage score ($\chi^2 = 0.3$, df = 1; $P = 0.58$). Percentage of range planted with trees and percentage of canopy cover were correlated approximately 4.4% with each other (Pearson's correlation: $r = 0.21$). Percentage of range planted with trees was therefore removed as a term from the model.

Finally, all non-tree related covariates were added: year (overall effect), egg-company, farm ownership (contract or company owned), age at end of lay, season at end of lay, breed, flock size, percentage mortality and egg per bird production.

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Results

In the final model, there was a significant association between percentage canopy cover and plumage-damage score (Table 3); increases in percentage of canopy cover were associated with a decrease in plumage-damage score (parameter estimate –0.003 [± 0.001]).

There were significant breed and egg company correlations with plumage-damage score (Table 3). An increase in egg per bird production was associated with a decrease in plumage-damage score (parameter estimate –0.002 [± 0.001]) and an increase in flock mortality resulted in an increase in plumage-damage score (parameter estimate 0.015 [± 0.004]) (Table 3). There was no association between year, age at end of lay, season at end of lay, flock size or egg per bird production and plumage-damage score (Table 3).

Discussion

When tree cover or artificial structures are present on the range, more birds are observed ranging, and ranging further than when no cover is available (Horton 2006; Gilani *et al* 2014). Commercial studies have identified ranging behaviour as a key factor in the development of IFP within laying-hen flocks; a higher proportion of the flock ranging reduces the risks of IFP (Green *et al* 2000; Bestman & Wagenaar 2003; Nicol *et al* 2003; Mahboub *et al* 2004; Lambton *et al* 2010). Similar to Bright *et al* (2011), this study found a negative correlation between canopy cover and plumage damage at the end of lay, ie less canopy cover within tree-planted areas resulted in significantly ($P < 0.001$) worse plumage damage at the end of lay. This study did not find any correlation between the percentage of range planted and plumage damage at the end of lay, supporting the notion that it is the degree of shade and shelter (ie quality of cover) which is encouraging the hens outdoors to range and thereby reducing IFP, rather than the absolute area of cover (provided the distance between the house and the nearest cover is close [< 20 m: Bestman *et al* 2002; Zeltner & Hirt 2008]). The composition of tree stands and the benefits that different species provide to the hens is yet to be investigated, but may also be important in ranging behaviour and/or IFP.

As the trees on the majority of farm ranges were planted at the beginning of the study, it was expected that an individual farm's end-of-lay plumage-damage scores would decrease over time, as the trees grew and provided more canopy cover. However, we did not find any effect of time on plumage-damage scores (Table 3). It is possible that farm management changes during the study confounded any effect of time. Furthermore, due to commercial changes in supply, the proportion of farms providing data for ≥ 3 years was small, thereby limiting the data set with which to compare individual farms' end-of-lay plumage-damage scores. It is hoped to re-examine the relationship between the effects of increasing tree cover and end-of-lay plumage-damage score in a future study.

The finding that mortality was positively correlated with end-of-lay plumage damage is also a similar finding to Bright *et al* (2011) and other commercial studies. For example, Nicol and Sherwin (2009) surveyed producers from a variety of laying-hen production systems; the second highest reason given for mortality (after disease) was injurious pecking (includes aggressive pecking, cannibalism and feather-pecking). IFP is also associated with disease (Green *et al* 2000; Pötzsch *et al* 2001; Nicol *et al* 2003).

Both experimental and commercial studies have found variation between laying hen breeds and IFP (eg Savory & Mann 1997; Hocking *et al* 2004; Bright *et al* 2011). In this study, 13 different breeds were reared by producers, and it was therefore not surprising to find an association between breed and end-of-lay plumage-damage scores. However, breed was not a particular focus of this study and, due to commercial sensitivities, the differences between breeds are not further discussed. It was also unsurprising to find an association between egg company and the end-of-lay plumage-damage score; management, husbandry, staff training, feed sourcing, pullet rearers (for example) all differ between egg companies, and the effects of these factors on IFP have been well-documented by other researchers (Lambton *et al* 2013; Nicol *et al* 2013; Rodenburg *et al* 2013). What is encouraging, is that canopy cover had an influence on end-of-lay plumage-damage score *in addition to* the effects of breed and egg company.

Egg per bird production was not investigated in the earlier Bright *et al* (2011), however, the negative correlation between production and end-of-lay plumage cover in this study is also not an unexpected finding (Hagger *et al* 1989; Glatz 1998; Yngvesson *et al* 2004; Su *et al* 2006). IFP can result in poor quality plumage, feather loss and damage to the skin (Savory 1995). Birds with feather loss have poor thermoregulation and consequently greater energy demands than unaffected birds (Leeson & Morrison 1978; Tauson & Svensson 1980; Tullett *et al* 1980; Peguri & Coon 1993) all of which can affect egg production. However, the relationship between ranging behaviour and production was not investigated in this study, a possible alternative explanation is that more hens were ranging, resulting in more eggs being laid outside (ie lower egg per bird count).

Finally, unlike Bright *et al* (2011), this study did not find any relationship between season at end of lay and plumage damage. A five-year period will have a greater range in temperatures between and within the seasons than a single year (eg Bright *et al* 2011); it is possible that this temperature range displaced any seasonal effect on IFP. Since ranging behaviour in laying hens is known to be temperature dependent (Nicol *et al* 2003; Lambton *et al* 2010), it might be useful in future studies to specify actual temperature rather than seasons. It is also possible that the increased canopy cover over the five-year period reduced temperature fluctuations (and/or light-level fluctuations) at hen level thereby masking the previously found seasonal effect.

Animal welfare implications

Tree-cover provision on laying-hen ranges is a feasible and *practical* method on a commercial scale which can improve feather cover at the end of lay. It is the degree of shade and shelter (ie quality of cover) that appears to be important to the hens rather than the absolute area of range covered.

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References

Appleby M, Hughes B and Arnold Elson H 1992 *Poultry Production Systems. Behaviour, Management and Welfare*. CAB International: Oxford, UK

Bestman MWP and Wagenaar JP 2003 Farm level factors associated with feather pecking in organic laying hens. *Livestock Production Science 80*: 133-140. http://dx.doi.org/10.1016/S0301-6226(02)00314-7

Bestman MWP, Wagenaar JP and Nauta W 2002 Shelter in poultry outdoor runs. *Proceedings of the 14th IFOAM Organic World Congress*. 21-24 August 2002, Victoria Conference Centre, Canada

Bright A, Brass D, Clachan J, Drake KA and Joret AD 2011 Canopy cover is correlated with reduced injurious feather pecking in commercial flocks of free range laying hens. *Animal Welfare 20*: 329-338

Bright A and Joret A 2012 Laying hens go undercover to improve production. *Veterinary Record 170*: 228. http://dx.doi.org/10.1136/vr.100503

Gentle M and Hunter LN 1990 Physiological and behavioural responses associated with feather removal in *Gallus gallus* var domesticus. *Research in Veterinary Science 50*: 95-101. http://dx.doi.org/10.1016/0034-5288(91)90060-2

Gilani AM, Knowles TG and Nicol CJ 2014 Factors affecting ranging behaviour in young and adult laying hens. *British Poultry Science 55*: 127-135. http://dx.doi.org/10.1080/00071668.2014.889279

Glatz PC 1998 Productivity and profitability of caged layers with poor feather cover. *A report for the Rural Industries Research and Development Corporation*. RIRDC Publication: Australia

Green LE, Lewis K, Kimpton A and Nicol CJ 2000 Cross-sectional study of the prevalence of feather pecking in laying hens in alternative systems and its associations with management and disease. *Veterinary Record 147*: 233-238. http://dx.doi.org/10.1136/vr.147.9.233

Gunnarsson S, Keeling LJ and Svedberg J 1999 Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. *British Poultry Science 40*: 12-18. http://dx.doi.org/10.1080/00071669987773

Hagger C, Marguerat C, Steiger-Stafl D and Strangizer G 1989 Plumage condition, feed consumption, and egg production relationships in laying hens. *Poultry Science 68*: 221-225. http://dx.doi.org/10.3382/ps.0680221

Hocking P, Channing C, Robertson G, Edmond A and Jones RB 2004 Between breed genetic variation for welfare-related behavioural traits in domestic fowl. *Applied Animal Behaviour Science 89*: 85-105. http://dx.doi.org/10.1016/j.applanim.2004.03.014

Horton L 2006 *A study into the effect of tree cover on the range on the welfare of free-range layer hens by observing animal behaviour*. Unpublished report EMS G84. Royal Veterinary College, University of London, UK

Huber-Eicher B and Sebö F 2001 The prevalence of feather pecking and development in commercial flocks of laying hens. *Applied Animal Behaviour Science 74*: 223-231. http://dx.doi.org/10.1016/S0168-1591(01)00173-3

Jones R, Blokhuis H, de Jong I, Keeling LJ, McAdie T and Preisinger R 2004 Feather pecking in poultry: the application of science in a search for practical solutions. *Animal Welfare 13(S)*: S215-S219

Lambton SL, Knowles TG, Yorke C and Nicol CJ 2010 The risk factors affecting the development of gentle and severe feather pecking in loose housed laying hens. *Applied Animal Behaviour Science 123*: 32-42. http://dx.doi.org/10.1016/j.applanim.2009.12.010

Lambton SL, Nicol CJ, Friel M, Main DCJ, McKinstry JL, Sherwin CM, Walton J and Weeks CA 2013 A bespoke management package can reduce levels of injurious pecking in loose-housed laying hen flocks. *The Veterinary Record 172*: 423. http://dx.doi.org/10.1136/vr.101067

Leeson S and Morrison W 1978 Effect of feather cover on feed efficiency in laying birds. *Poultry Science 57*: 1094-1096. http://dx.doi.org/10.3382/ps.0571094

Mahboub H, Muller J and von Borrell E 2004 Outdoor use, tonic immobility, heterophil/lymphocyte ratio and feather condition in free-range laying hens of different genotypes. *British Poultry Science 45*: 738-744. http://dx.doi.org/10.1080/00071660400014267

Nicol CJ, Bestman M, Gilani AM, De Haas E, De Jong IC, Lambton S, Wagenaar JP, Weeks CA and Rodenburg TB 2013 The prevention and control of feather pecking: application to commercial systems. *Worlds Poultry Science Journal 69*: 775-788. http://dx.doi.org/10.1017/S0043933913000809

Nicol CJ, Pötzsch C, Lewis K and Green LE 2003 Matched concurrent case-control study of risk factors for feather pecking in hens on free-range commercial farms in the UK. *British Poultry Science 44*: 515-523. http://dx.doi.org/10.1080/00071660310001616255

Nicol CJ and Sherwin CM 2009 A comparative study to assess the welfare of laying hens in current housing systems. *Injurious Feather Pecking Workshop*. 8 July 2009, FAI Farms Ltd, Oxford, UK

Peguri A and Coon C 1993 Effect of feather coverage and temperature on layer performance. *Poultry Science 72*: 1318-1329. http://dx.doi.org/10.3382/ps.0721318

Pötzsch CJ, Lewis K, Nicol CJ and Green LE 2001 A cross-sectional study of the prevalence of vent pecking in laying hens in alternative systems and its associations with feather pecking, management and disease. *Applied Animal Behaviour Science 74*: 259-272. http://dx.doi.org/10.1016/S0168-1591(01)00167-8

R Core Team 2014 *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing: Vienna, Austria. http://www.R-project.org/

Rodenburg TB, van Hierden YM, Buitenhuis A, Riedstra B, Koene P, Korte SM, van der Poel J, Groothuis T and Blokhuis H 2004 Feather pecking in laying hens: new insights and directions for research. *Applied Animal Behaviour Science 86*: 291-298. http://dx.doi.org/10.1016/j.applanim.2004.02.007

https://doi.org/10.7120/09627286.25.1.001 Published online by Cambridge University Press

Rodenburg TB, Van Krimpen MM, De Jong IC, De Hass EN, Kops MS, Riedstra BJ, Nordquist RE, Wagenaar JP, Bestman M and Nicol CJ 2013 The prevention and control of feather pecking in laying hens: identifying the underlying principles. *World's Poultry Science Journal 69*: 361-374. http://dx.doi.org/10.1017/S0043933913000354

Savory C 1995 Feather pecking and cannibalism. *World's Poultry Science Journal 51*: 215-219. http://dx.doi.org/10.1079/WPS19950016

Su G, Kjaer JB and Sørensen P 2006 Divergent selection on feather pecking behavior in laying hens has caused differences between lines in egg production, egg quality and feed efficiency. *Poultry Science 85*: 191-197. http://dx.doi.org/10.1093/ps/85.2.191

Tauson R and Svensson SA 1980 Influence of plumage condition on the hen's feed requirement. *Swedish Journal of Agricultural Research 10*: 35-39

Tullett S, Macleod M and Jewitt T 1980 The effects of partial defeathering on energy metabolism in the laying fowl. *British Poultry Science 21*: 241-245. http://dx.doi.org/10.1080/00071668008416662

Yngvesson J, Keeling LJ and Newberry RC 2004 Individual production differences do not explain cannibalistic behaviour in laying hens. *British Poultry Science 45*: 453-462. http://dx.doi.org/10.1080/00071660412331286163

Zeltner E and Hirt H 2008 Factors involved in the improvement of the use of hen runs. *Applied Animal Behavioural Science 114*: 395-408. http://dx.doi.org/10.1016/j.applanim.2008.04.007