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Effects of cage height and stocking density on the frequency of comfort behaviours performed by laying hens housed in furnished cages

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Abstract

Spatial restriction and low cage height can reduce the rate at which comfort activities, such as wing flaps, stretching, body shakes and tail wags, are carried out by laying hens in conventional wire cages. In this study we investigated the performance of these activities in laying hens housed in furnished cages with perches and nest boxes, similar to those required in EU legislation from 2012. We compared the behaviour of groups of eight hens at a stocking density of 762 cm² per bird with that of pairs of hens housed at a lower stocking density of 3048 cm² per bird at two minimum cage heights of 38 cm and 45 cm. The rates of wing/leg stretches (0.80 stretches per hen per hour), tail wagging (0.76), body shaking (0.48), wing raising (0.19) and feather raising (0.05) were low, whilst full wing flaps were not observed during the study. Hourly rates of performance of wing/leg stretches (0.45 vs 1.06) and tail wags (0.34 vs 1.25) were significantly lower in eight-bird cages than in two-bird cages. We conclude that reducing the number of hens in furnished cages increases opportunities to perform certain comfort activities, but that, even at low stocking densities, comfort activities are rarely observed.

Keywords: *animal welfare, cage height, comfort behaviour, furnished cage, laying hen, stocking density*

Introduction

From 1 January 2012, European Union Council Directive 99/74/EC will prohibit the use of conventional wire cages for laying hens (*Gallus gallus domesticus*), although the use of 'furnished' cages (referred to as 'enriched' cages in legislation) with additional space, nest-sites, perches and scratching areas will be permitted (CEC 1999). Cage systems have some welfare advantages over non-cage systems, including a tendency for lower levels of disease, mortality, cannibalism and aggression (Appleby 1998; Duncan 2001). However, conventional wire cages are also associated with welfare problems, mainly resulting from a lack of space or environmental resources that could allow the expression of motivationally significant activities (Nicol 1990; Baxter 1994; Duncan 2001). Studies such as that of Lindberg and Nicol (1997), Freire *et al* (1999) and Appleby *et al* (2002) have attempted to assess the impact of additional facilities and space in furnished cages on hen welfare. These studies have demonstrated that furnished cages offer hens greater opportunity to perform certain behaviours identified as important to them, such as nesting and perching, and possibly foraging and dust bathing, although other activities such as locomotion and stretching may still be inhibited.

The purpose of this study was to investigate the performance of 'comfort' activities by laying hens housed in furnished cages at different stocking densities and cage heights. Comfort behaviour is a generic term applied to a number of activities that may be involved in feather and body maintenance in hens (Nicol 1990). These include self-directed activities such as those involved in preening, activities that involve interaction with environmental resources such as dust bathing and beak wiping, and body movements such as wing and leg stretching, wing raising, wing flapping, body shaking, feather raising and tail wagging. These body movements have received relatively little attention in poultry welfare research compared with activities such as nesting, perching or foraging (Cooper & Albentosa 2003). This may be because each individual activity is relatively rare within the laying hen's time budget, which can make it difficult to sample efficiently (Nicol 1987a,b). Nevertheless, performance of these infrequent activities, albeit at a low frequency, may still be important to caged hens (Dawkins 1990; Nicol 1990), and their prevention can just as readily cause behavioural deprivation or frustration as can the prevention of more common activities. Furthermore, reduced performance of comfort activities may lead to undesirable physical consequences related to poor body and feather condition (Appleby & Hughes 1991; Baxter 1994).

Previous studies have shown that spatial restriction can reduce the rate at which certain comfort activities are performed by caged hens (Nicol 1987a,b; Appleby *et al* 2002). For example, hens in conventional wire cages with

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heights of 30.0 cm, 42.5 cm and 55.0 cm performed less head scratching, head stretching and body shaking at the lower cage heights. Similarly, when space allowances per bird varied (570 cm^2, 807 cm^2 or 1045 cm^2 per bird), reduced space was associated with lower levels of head scratching, body shaking and feather raising (Nicol 1987a). In trials comparing conventional wire cages with furnished cages at commercial stocking densities, tail wagging, head scratching, beak wiping and balancing wing flaps were generally more common in the more spacious furnished cages, whilst activities such as wing flapping were rarely observed in either system (Appleby *et al* 2002). These findings may be due to the larger physical space required to perform activities such as wing flapping and stretching compared with activities such as standing or feeding (Dawkins & Hardie 1989), or because the hen's perceived spatial restriction of cage housing may inhibit expression of certain activities even when there is sufficient physical space for their performance (Cooper & Albentosa 2004).

In this experiment we investigated the effects of increasing the vertical and horizontal space available to birds in furnished cages on the frequency of performance of comfort activities. Two minimum cage heights were investigated: 38 cm, which was consistent with the requirements for all cages up to January 2003 (CEC 1988), and 45 cm, which is the requirement for all cages from January 2012 (CEC 1999). The stocking densities investigated included 762 cm^2 per bird, which is slightly more space than the minimum of 750 cm^2 per bird recommended by the Directive (CEC 1999), and much lower stocking densities of 1016, 1524 and 3048 cm^2 per bird. Stocking density was compounded with group size as space per bird was increased by reducing the number of hens per cage. Consequently, it was not possible to distinguish between the effects of space per bird and group size. However, in commercial laying systems, where cages are built with fixed dimensions, any changes in stocking density that are required by legislation are conventionally achieved by reducing the number of birds per cage, so our approach bore some similarity to the commercial situation.

Methods

Birds and housing

Eighty beak-trimmed ISA Brown pullets were obtained at 16 weeks of age from a commercial rearer. Information on the type of housing used during rearing was not available. The birds were housed in groups of ten birds in eight pairs of furnished cages (width × depth × height = 120 × 50.8 × 38 or 45 cm) at a space allowance of 1219.2 cm^2 per bird. Half of the cages had a minimum cage height of 38 cm and half had a minimum cage height of 45 cm. All cages had a sloping floor at an angle of 8º. Each group of 10 hens housed within a pair of cages could access both cages of the pair through a pophole (width × height = 21 × 24 cm) in the dividing wall. The popholes between adjacent cages of a pair could be closed using a shutter so that hens were confined to single cages. Based on a group size of eight hens per cage, a cage provided 15 cm of trough space per hen. Each cage had a long perch running the width of the cage and two shorter perches between the long perch and the back of the cage to provide 18 cm of perch per bird. Each cage had an enclosed nest site (width × depth = 24 × 50.8 cm) which was lined with Astroturf as a nesting material. The cages did not have a dedicated pecking/scratching area as this was being developed in a separate study, although an abrasive claw shortener was attached to the cage side of the feed trough in order to maintain good claw condition. Layers' mash was available in the trough at the front and water was supplied via three nipple drinkers at the back of each cage. Food and water were provided *ad libitum*.

Overhead incandescent lighting produced a light intensity at trough height of at least 15 lux. Day length was maintained at 8 h until 19 weeks of age, and then increased in a stepwise manner to a maximum of 16 h at 28 weeks. The target room temperature was 21°C and the room was naturally ventilated. The under-cage belts were cleaned weekly. Housing treatments and management of the hens complied with the Welfare of Farmed Animals (England) Regulations 2000 throughout both experiments (Anon 2000). Following the study, all hens were re-homed to non-commercial, free-range housing systems at one year of age.

Data collection

A pilot study was conducted at 19–20 weeks of age in order to develop a method of sampling rare activities in groups of hens in furnished cages and to estimate an appropriate total observation period for the main study. For the pilot study, the pophole in the adjoining wall of each pair of cages was closed and hens from each ten-bird group were distributed between the same two cages of the pair in which they were previously housed, either as group sizes of 2 and 8, or as group sizes of 4 and 6. This method of allocating hens to treatments ensured that hens remained with familiar conspecifics and that unfamiliar hens were not mixed. We then recorded the total number of distinct episodes of each of the following activities (see Nicol 1987a for descriptions) using behavioural sampling for 5 min periods, starting 90 h after hens had been assigned to treatments: wing/leg stretch, wing raise, wing flap, preen, body shake, feather raise, tail wag, yawn, beak wipe, head scratch, head shake, head stretch and dust bathe. The hens within a cage pair were then randomly redistributed as the alternative combination of group sizes (2 and 8, or 4 and 6) and, after a further 90 h period, comfort activities were recorded as before. There were eight replicates of each group size (space allowances of 3048 cm^2, 1524 cm^2, 1016 cm^2 and 762 cm^2 per hen including nest box for groups of 2, 4, 6 and 8 hens) balanced for minimum cage height (low = 38 cm and high = 45 cm).

The main study began at the end of week 23. The hens within each ten-bird group were allocated to either an eight-bird cage with a stocking density of 762 cm^2 per bird (including nest box) or a two-bird cage with a stocking density of 3048 cm^2 per bird. Consequently there were eight replicates of each stocking density, which were balanced for cage height (38 cm and 45 cm). The frequency of each activity was recorded by direct observation for 10 min per cage per day on six non-consecutive days (a total of 60 min of sampled behaviour per cage) over a two-week period, starting 90 h after hens had been assigned to treatments. Hens in each cage were given 3 min to habituate to the presence of the observer prior to the start of each data-collection period.

We used the same behavioural categories as in the pilot study, but with the following changes. Unlike Nicol (1987a), we recorded 'wing raise' and 'wing flap' separately, as the pilot study suggested that wing flapping might be more affected by spatial restriction. We also found from pilot observations that 'beak wipe', 'head stretch' and 'preen' were too difficult to record accurately in cages containing more than two birds, so these activities were not recorded in the main study. Finally, the incidence of wing movements used by perching birds to balance themselves (balancing wing flaps) was recorded separately from stretching wing movements (wing flaps, wing stretch, wing raise), as they were clearly distinguishable from each other by context. 'Balancing wing movements' occurred when a bird was moving along the perch and became temporarily unstable, whereas 'stretching wing movements' tended to occur when a bird was in a stationary, secure position on or off the perch. The number of birds dust bathing per 10 min observation period was also recorded using one–zero sampling. Observations of cages at each stocking density were balanced for time of day (0900h–1230h and 1300h–1630h) and order of observation.

Statistical analysis

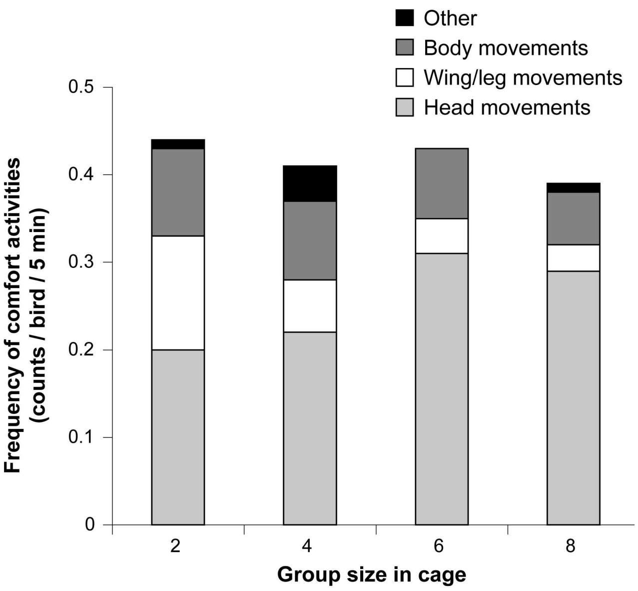
All data were analysed using Minitab 13. For the pilot study, the incidence of each activity was converted to mean count per bird per 5 min. As preen, beak wipe and head stretch could not be recorded accurately these were excluded from the analysis. The remaining data were analysed using a Friedmann non-parametric ANOVA, with group size as treatment, blocked by original group. For the main study, data were converted to mean frequency per bird per hour. Data for all activities except for wing flapping were normalised following square root transformation, so we analysed the effects of stocking density and cage height using a two-way balanced ANOVA with data again blocked by original group. Untransformed means (± standard error [SE]) of frequency of activities per hen per hour are presented unless stated otherwise. As multiple comparisons were made, a confidence level of 99% (ie significance level of $P < 0.01$) was adopted for identifying significant effects.

Results

Pilot study

The incidence of all sampled activities was low, at only 0.41 ± 0.05 acts per bird per 5 min observation period (Figure 1). The majority of recorded activities were head movements such as yawns, head scratches and head shakes at 0.23 ± 0.03 acts per bird per observation. There were only 0.06 ± 0.03 wing movements (mainly wing stretches and wing raises) and only 0.06 ± 0.02 body movements (mainly body shakes or tail wags) per bird per observation period. Full wing flaps and feather raising were not observed in the pilot study. There was no effect of stocking density on the frequency of any activity per bird ($S < 5$; n = 8; $df = 3$; $P > 0.05$ for all activities [Figure 1]).

Figure 1



Frequencies of comfort activities per bird per 5 min observation period during the pilot study. Although the number of head movements appeared to increase and the number of wing/leg movements appeared to decrease with increasing group size, neither effect was statistically significant (Friedmann: $S = 3.13$; n = 8; $df = 3$; $P = 0.37$ for head movements; $S = 0.47$; n = 8; $df = 3$; $P = 0.925$ for body movements).

Main study

As in the pilot study, head movements were the most commonly recorded activities. Head shakes were recorded at a rate of 5.24 ± 0.68, head scratches at 2.48 ± 0.30 and yawns at 1.32 ± 0.62 per hen per hour. The next most common activity was balancing wing flaps, which occurred at a frequency of 1.23 ± 0.19 flaps per hen per hour. Tail wagging and wing/leg stretching were recorded at frequencies of 0.80 ± 0.19 wags and 0.76 ± 0.16 stretches per bird per hour, and body shaking was observed at a rate of 0.48 ± 0.09 shakes per hen per hour. Finally, wing raising, which occurred at a frequency of 0.19 ± 0.05 per hen per hour, and feather raising, at 0.05 ± 0.03 per hen per hour, were rarely observed. There was one recorded attempt at a full wing flap by one hen in a high eight-bird cage, although this did not proceed to a complete act of flapping.

Both tail wags (1.25 ± 0.30) and wing/leg stretches (1.06 ± 0.27) were more common in two-bird cages than in eight-bird cages (0.34 ± 0.08 wags and 0.45 ± 0.09 stretches

Table 1 Hourly frequencies of comfort activities per hen (mean [SE]) in furnished cages at two stocking densities (3048 cm² per bird in two-bird cages and 762 cm² per bird in eight-bird cages) and at two minimum cage heights (38 cm in low cages and 45 cm in high cages) (n = 4 cages per treatment, n = 8 for comparisons of stocking density and cage height effects).

Behaviour	2-bird cages		8-bird cages		Stocking density	Cage height	Interaction
	Low	High	Low	High	$F_{1,12}$	$F_{1,12}$	$F_{1,12}$
Wing/leg stretch	0.50 (0)	1.63 (0.38)	0.44 (0.11)	0.47 (0.16)	10.18**	7.03	6.83
Wing raise	0.13 (0.13)	0.25 (0.14)	0.28 (0.11)	0.06 (0.04)	0.09	0.08	1.91
Wing flap	0	0	0	0.03	n/a	n/a	n/a
Balancing wing flap	0.88 (0.38)	1.25 (0.60)	1.56 (0.32)	1.25 (0.25)	0.72	0.01	0.72
Body shake	0.38 (0.24)	0.25 (0.14)	0.75 (0.05)	0.56 (0.19)	5.32	0.39	0.04
Feather raise	0.13 (0.13)	0	0.09 (0.03)	0	0.20	5.00	0.20
Tail wag	1.38 (0.52)	1.13 (0.38)	0.38 (0.18)	0.31 (0.04)	9.34**	0.09	0.06
Yawn	3.00 (2.50)	0.75 (0.43)	0.56 (0.12)	0.97 (0.13)	0.22	0.31	1.54
Head scratch	2.50 (0.89)	3.13 (0.88)	2.00 (0.21)	2.31 (0.04)	0.54	0.62	0.06
Head shake	6.13 (2.81)	5.13 (0.59)	4.47 (0.46)	5.25 (0.63)	0.11	0.04	0.18

** $P < 0.01$

per hen per hour [Table 1]). No other significant stocking density, cage height or interaction effect was found.

Discussion

Overall, the frequency of comfort movements was low in both the pilot study and the main study. These findings are consistent with observations of behaviour in both conventional and furnished cages at commercial stocking densities (eg Nicol 1987a,b; Appleby *et al* 2002). Reducing stocking density affected behaviour, as tail wagging and wing/leg stretching occurred at a higher frequency in the two-bird cages than in the eight-bird cages in our main study. The reduced individual space available in eight-bird cages might have inhibited these behaviours, either physically or behaviourally. Single hens have been recorded as using between 660 cm² and 1476 cm² of space when performing wing stretching (Dawkins & Hardie 1989), an area which would rarely have been unoccupied in the eight-bird cages in our study, so individual hens may not have had the opportunity to perform wing stretching at their preferred rate (Nicol 1987a).

As in our study, Nicol (1987a,b) recorded very low rates of wing flapping in cages, so it seems likely that wing flapping is strongly inhibited by commercial designs of cage, even at relatively low stocking densities. Wing flapping was the most space-consuming activity reported by Dawkins and Hardie (1989), using 1085–2606 cm² per bird, so it is likely to be an activity that is strongly influenced by available space. As wing flapping was virtually absent from our cage treatments and rarely observed in other studies of caged hens (Nicol 1987a; Albentosa & Cooper 2002; Appleby *et al* 2002) it is worthwhile discussing the implications of low frequencies of performance.

It has been argued that increasing stocking density imposes a greater cost on activities that require more personal space for their performance (Dawkins & Hardie 1989; Keeling 1994; Cooper & Albentosa 2003). Removing hens from an enclosure of fixed dimensions will both increase the space available to each hen and the likelihood of transient, larger areas of space becoming free as a result of stochastic movement of hens within the cage. If hens use this temporary access to extra free space to perform more space-demanding activities then a rise in space allowance from 450 cm² per hen in the UK (prior to January 2003) to 600 cm² (excluding nest box) for all caged hens in the European Union from 2012 could result in some performance of activities requiring more than 600 cm² of space. However, the data from our cages with a space allowance of 3048 cm² per hen suggest that even when adequate space is available in the cage for the physical performance of space-demanding activities such as wing flapping, hens do not perform this activity. Also, other activities such as wing and leg stretching, body shaking and tail wags continue to be infrequent. This leads to two possible, alternative conclusions. Firstly, these activities may still be inhibited or thwarted by cage housing, either psychologically if the hens do not perceive the enclosure to be large enough for adequate expression, or physically if they experience aversive contact with cage walls or pen-mates when they attempt the activities. Alternatively, the hens may have little inclination to perform these naturally low-frequency activities in cages. This could be because the hens become habituated to their restricted conditions, or because the additional space and cage furniture provided in furnished cages allows sufficient opportunity to express body maintenance activities, for example by increased locomotion or use of the perch (Appleby *et al* 2002). In order to determine whether hens have been deprived of the opportunity to express highly motivated, space-expensive activities, additional work would be required. No single approach in isolation could demonstrate a need for additional space or the activities that it could

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promote, but two experimental approaches in combination would provide strong evidence.

The first approach would be to investigate the effect of a temporary increase in enclosure size for hens experiencing different degrees of spatial restriction, by measuring any differences in the frequency, latency, intensity or duration of activities such as wing flapping or tail wagging possibly thwarted by high stocking densities. A study of this type was carried out for hens at different stocking densities in conventional cages by Nicol (1987b). She found that tail wagging, wing flapping and wing stretching were more frequent in hens that had previously experienced greater spatial restriction, and we have found similar results in our own hens (Albentosa & Cooper 2003). In isolation, however, 'rebound' experiments cannot conclusively demonstrate deprivation, as it is difficult to discriminate between an increase in behavioural expression due to the release of a thwarted motivational state or simply the novelty of additional space (Dawkins 1988).

A second approach would be to find out how hard space-deprived hens are willing to work to access environments perceived by them to be appropriate for the performance of comfort activities (Dawkins 1990; Cooper & Albentosa 2003). We know that space is important to hens, as they prefer large spaces to small spaces (Hughes 1975; Lindberg & Nicol 1996) and will work hard to gain access to extra space in an operant task (Lagadic & Faure 1987). The main methodological difficulty with this approach in isolation would be discriminating between hens' motivation to obtain extra space to perform comfort activities and their interest for other reasons, such as exploration or locomotion (Nicol & Guilford 1991; Cooper & Appleby 1997). Providing opportunities to express these activities for free could, however, control for these motives, eg by using a treadmill or peep-holes (Freire *et al* 1996).

To summarise, comfort activities are extremely time consuming to record in commercial cage environments as they tend to occur infrequently for very short time periods, and even quite large differences in performance rates have little impact on overall time budgets. The two cage heights used in the present study were not sufficiently varied to allow us to detect behavioural differences between treatments within such limited time periods. Horizontal spatial restriction significantly affected the rates of performance of some comfort activities in furnished cages, although rates at all stocking densities remained low. Full wing flaps were not recorded.

Animal welfare implications

At this stage we cannot be certain of the implications of restricted performance of comfort activities on the laying hens' physical (eg bone breaks) or psychological (eg frustration) well-being. We did not, for example, attempt to measure the motivational state of the hens during the deprivation period or investigate bone strength post mortem. Not all behaviours may be necessary to ensure good welfare in laying hens (Nicol 1994), and we can only speculate that hens in furnished cages at stocking densities of up to 3048 cm^2 per bird may experience some discomfort or frustration if motivation to perform certain comfort activities is cumulative over time. Further studies should try to determine whether hens' inability to perform wing flaps or other comfort activities as a result of spatial restriction is an aversive experience, and if so, how aversive it is.

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