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Behavioural responses to different floor space allowances in small groups of laying hens

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Abstract 1. Under Council Directive 1999/74/EC, minimum space allowances per laying hen range from 550 cm^2 in unfurnished cages to 1111 cm^2 in alternative housing, and to 40 000 cm^2 outdoors for free-range hens. In official reports on the welfare of laying hens, there is recognition that knowledge of their space requirements is inadequate.

2. This experiment studied expression of behaviour, including spacing, in five groups of six and one group of five ISA Brown hens aged 21–33 weeks in an adjustable test pen providing 600, 2400, 4800, 7200, 9600, and 12 000 cm^2 floor area per hen. Each group was tested with every treatment. Home pens provided 2400 cm^2 per hen. The main aim was to identify a hypothetical point at which mutual repulsion equals mutual attraction (a 'broken stick' response).

3. Sequencing of treatments was according to a Latin square design, daytime tests lasted 2 h and had no feeder or drinker present, and overnight tests were done with 2400, 7200 and 12 000 cm^2 per hen with a feeder and drinker present. Groups were video-recorded from above to allow repeated measurements of spacing and other behaviours.

4. In daytime tests, the relationship between mean distance to nearest neighbour and floor space allowance was asymptotic, rather than a 'broken stick'. The steepest part of the response was between 600 and 4800 cm^2 per hen. Changes in other behaviours were greatest between 600 and 2400 cm^2, and there was no significant change above 7200 cm^2. Spacing behaviour responses at night were the same as by day.

5. It is concluded that any space allowance of less than about 5000 cm^2 per hen imposes at least some constraint on free expression of behaviour, and that hens would benefit from any increase above the current minimum 1111 cm^2 usable area in alternative housing.

INTRODUCTION

Under Council Directive 1999/74/EC ('laying down minimum standards for the protection of laying hens', 1999), minimum space allowances ('usable areas') per hen range from 550 cm^2 in unfurnished battery cages (from 1 January 2003) to 1111 cm^2 in alternative housing systems constructed since 1 January 2002. The outdoor allowance per free-range hen is 40 000 cm^2. In official reports on the welfare of laying hens by both the EC Scientific Veterinary Committee (1996) and the UK Farm Animal Welfare Council (1997), there was recognition that knowledge of hens' space requirements is inadequate. Clearly, a better understanding of such requirements should be fundamental to the structuring of welfare standards.

Space needs of laying hens have been studied in different ways. Faure (1994), for example, used operant conditioning to allow small groups of hens to modify their cage area, and hence demonstrate their preference for space, but this yielded inconsistent results. Other approaches have been to measure the amount of space required for free expression of different behaviour patterns (Dawkins and Hardie, 1989), and to assess the influence of varying space allowance/stocking density on performance of such activities (Nicol, 1987; Appleby *et al.*, 1989; Keeling, 1994). Yet another has been to see how hens distance themselves when provided with different space allowances (Keeling, 1994). Based on this approach, a hypothesis can be constructed which states that as floor area per hen is increased from a low starting point, the mean distance between nearest neighbours should also

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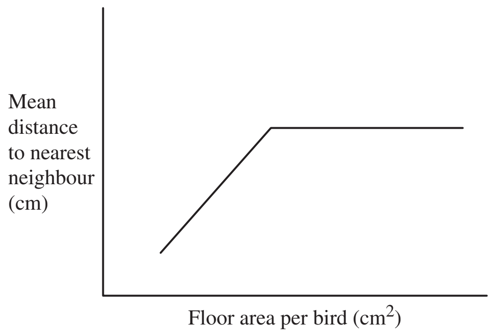

Figure 1. *Hypothetical response of hens to increasing floor space allowance.*

increase due to mutual repulsion. However, because the domestic fowl is a gregarious species (McBride *et al*., 1969), there should come a critical point with increasing area where the mean distance between adjacent birds no longer increases, and where mutual repulsion is equal to mutual attraction. In other words, the response to increasing floor space should be in the form of a 'broken stick' (Figure 1), and knowledge of where the predicted point of inflexion (or equilibrium) is would help in identifying hens' optimal space requirements.

Keeling (1994) tested small groups of three laying hens in pens with four floor areas ranging from 600 to 5630 cm^2 per hen, and found that as the space allowance increased, so also did the mean minimum distance between adjacent birds. However, as this response was linear over the range of allowances tested, the maximum area per hen (5630 cm^2) was insufficient to confirm the above hypothesis. In the present experiment, therefore, groups of six or five hens in pens were tested with six space allowances over a greater range, from 600 to 12 000 cm^2 per hen. As well as spacing, other behavioural responses were also recorded, and a comparison between daytime and night-time spacing was made with three of the treatments tested.

MATERIALS AND METHODS

Five groups of six and one group of five ISA Brown laying hens were tested between 21 and 33 weeks of age in an adjustable test pen with wood shavings litter floor which provided 600, 2400, 4800, 7200, 9600, and 12 000 cm^2 area per hen. Each group came from a larger group of 10 birds reared together since 1-d-old (only five birds were available in one group), so all birds were familiar with each other within groups. When not being tested, groups were housed in separate home pens in the same room, with litter floors which provided 2400 cm^2 area per hen, and with *ad libitum* access to a layers' mash diet and drinking water. The daily photoperiod in the windowless room was from 07:00 to 21:00 h, and mean ambient temperature varied between 18 and 24°C.

Groups were tested one at a time in a square test pen composed of up to eight moveable vertical wooden panels (each 150 cm long and 55 cm high). Its dimensions were determined by space allowance treatment and number of hens in the group, and it was covered with wire mesh to prevent hens getting out. One test was done on each of 36 d (six groups × six treatments), from 11:00 to 13:30 h and with no feeder or drinker present that could influence hens' spacing. The first half hour was for acclimatisation, and then recording was done over 2 h from 11:30 (by which time most eggs had been laid) to 13:30 h. Treatments were applied to groups in different sequences according to a Latin square design. In addition, overnight tests with infra-red illumination were done whenever the 2400, 7200, and 12 000 cm^2 per hen treatments were applied. Both food and water were present during overnight tests, and test pen sizes were increased accordingly at those times to take account of the combined areas of feeder and drinker.

A video camera was suspended above the centre of the test pen, at a height that allowed the whole pen to be seen on video-recordings when the largest area was being tested (and hence all other areas as well). These recordings were made from 11:30 to 13:30 h during every daytime test, and the recorder was set to run coincidentally with the infra-red light source from 21:00 to 07:00 h during every overnight test.

To measure horizontal distances between birds from the video-recordings, a transparent sheet of acetate was attached to the TV monitor screen with a grid drawn on it which corresponded exactly with 30 × 30 cm squares marked on the bare floor of the largest test pen and recorded at the start of the experiment. Squares in the centre of the grid were largest because that area of the pen was closest to the camera, and measurements in millimetres on the grid could be converted to actual distances in centimetres in the pen.

From the 2 h video-recordings during daytime tests, a measurement was made every 15 min of the distance between the middle of each bird's back and that of its nearest neighbour. The behaviour shown by each subject bird every time this distance was measured was also noted, according to four mutually exclusive categories: stationary (standing still or sitting, which were indistinguishable), walking, preening (while standing or sitting), ground pecking (including scratching). From the video-recordings made during overnight (21:00 to 07:00 h) tests, a measurement of the (back to back) distance between each bird and its nearest neighbour was made at 21:15, 21:30, 21:45, 01:45, 02:00, 02:15, 05:15, 05:30, and 05:45 h. Other behaviour was not measured at night.

For each group (six) and each space allowance treatment (six by day, three at night), an overall mean value was calculated for the back to back distance between nearest neighbours, and the proportion of time spent in each of the above four behaviour categories (daytime only). Four types of analysis were done with these values. First, a one-way ANOVA was carried out with the daytime distance data, to determine whether space allowance treatment had a significant effect. Next, regression analyses were done with the same data to see which model (linear, exponential, quadratic, cubic) best fitted the response. Next, a two-way ANOVA was done with the day- and night-time distance data for the 2400, 7200 and 12 000 cm^2 allowances to see if the response to treatment differed between day and night. Lastly, a one-way ANOVA was done with the percentage time data for each of the four behaviour categories, after they were transformed by angular (arcsine root) transformation to give approximately equal variances between treatments. Significant ($P<0{\cdot}05$) differences between treatment means were determined using the Tukey–Kramer method (Sokal and Rohlf, 1981), and untransformed means are presented in Figure 3. With all ANOVAs, group and week of testing were included as blocking factors.

RESULTS

One-way ANOVA showed that, in the daytime tests, there was a highly significant ($P<0{\cdot}001$) effect of space allowance treatment on the mean (back to back) distance between adjacent hens (to nearest neighbour). Regression analyses with the same data showed that a non-linear regression fitted the observed response better ($P<0{\cdot}001$) than did a linear one ($P=0{\cdot}015$), and that the best non-linear fit was an exponential (asymptotic) regression (Figure 2) described by the following equation:

$$\text{nearest neighbour distance} = 53{\cdot}15 - (40{\cdot}33 \times 0.999655^{\text{floor area/bird}})$$

Hence, the response was not consistent with the hypothetical 'broken stick' (Figure 1), and the steepest part of the response in Figure 2 was between 600 and 4800 cm^2 per hen.

Spacing behaviour responses to the 2400, 7200 and 12 000 cm^2/bird area treatments, by day and at night, are presented in Table 1. The two-way ANOVA with these data showed that the overall effect of treatment was highly significant

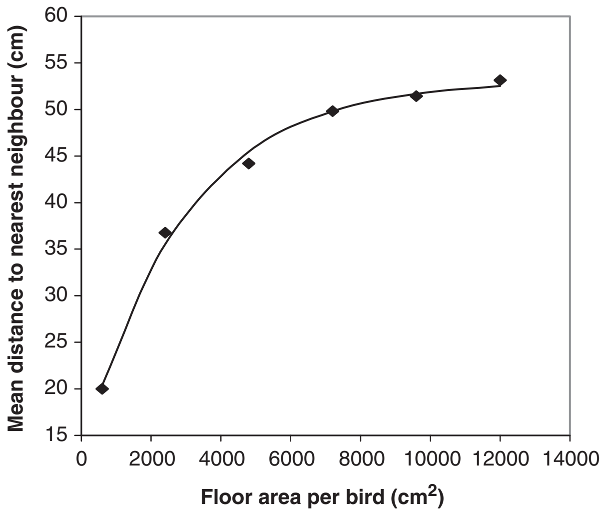

Figure 2. *Asymptotic relationship between spacing behaviour and floor space allowance.*

Table 1. *Mean distance to nearest neighbour (cm) with three floor space allowances, by day and at night*

Space allowance (cm^2/bird)	2400	7200	12 000
Daytime	36·8	49·8	53·1
Night-time	32·7	48·2	58·0

($P<0{\cdot}001$), as before, and that there was no significant effect of either day versus night ($P=0{\cdot}921$) or area × day/night interaction ($P=0{\cdot}367$).

One-way ANOVAs with angular transformed data showed that differences between space allowance treatments in proportions of time spent in the four behaviour categories were all highly significant (preening $P=0{\cdot}001$, others $P<0{\cdot}001$). Using the Tukey–Kramer method to identify significant differences between treatments, more time was spent stationary and less time was spent ground pecking with 600 cm^2/bird than with all greater allowances, less time was spent walking with 600 and 2400 cm^2 than with 7200, 9600, and 12 000 cm^2, and more time was spent preening with 600, 2400, and 4800 cm^2 than with greater allowances. Hence, changes in behaviour were greatest between 600 and 2400 cm^2, and there was no significant change above 7200 cm^2 per hen (Figure 3).

DISCUSSION

The main aim of this experiment was to identify a hypothetical point at which mutual repulsion between adjacent laying hens equals mutual attraction. However, the observed spacing response to increasing floor area per hen was

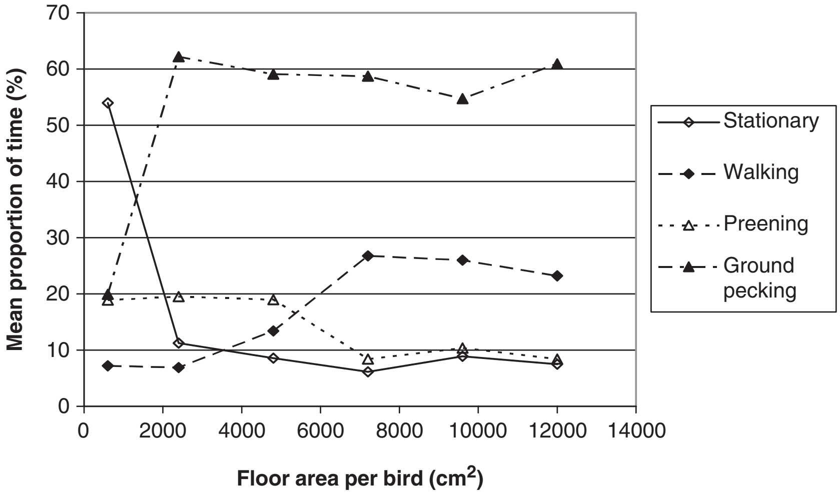

Figure 3. *Mean (untransformed) proportions of time spent in four different behaviour categories in relation to floor space allowance.*

asymptotic (Figure 2), rather than the predicted 'broken stick' (Figure 1). An asymptotic response suggests that, with increasing space allowance, the strength of repulsion between nearest neighbours declines gradually at the same time as the strength of attraction between them grows. Such an interpretation seems just as logical as the idea that there is some precise point where repulsion ceases abruptly and attraction commences. Nevertheless, the observed response indicates that the effect of mutual repulsion between adjacent birds dominated that of mutual attraction with floor space allowances of less than 4800 cm^2 (Figure 2).

It is perhaps surprising that the spacing response to increasing floor area did not differ between daytime and night-time tests (Table 1), when one might expect hens either to be closer together or to space themselves at random after lights off. It seems unlikely that the infra-red illumination used for video-recording at night could have enabled birds to see each other better then, because, in a comparison of their spectral sensitivities, fowls were no more sensitive to infra-red light than are humans (Nuboer, 1993). The fact that there was no difference in hens' spacing between day and night suggests that ambient temperature did not fall much at night, because birds group closer together when they need to conserve heat (Savory and Maros, 1993).

In a comparison of space allowances ranging from 600 to 5630 cm^2 per hen, Keeling (1994) found that, with increasing floor area, times spent walking and ground pecking increased, time spent standing still decreased, and time spent preening did not change. Likewise, in a comparison of laying hen stocking densities ranging from 3·4 to 10·7 per m^2 (2941 to 935 cm^2 per hen), Appleby *et al*. (1989) found that walking declined consistently as density increased. Hughes and Black (1974) also reported less time standing and more pacing with 9791 cm^2 per hen than with 1403 cm^2. Here, time spent stationary decreased and ground pecking increased between 600 and 2400 cm^2 per hen, walking increased between 2400 and 7200 cm^2, and preening decreased between 4800 and 7200 cm^2 (Figure 3). Behaviour patterns did not change with more than 7200 cm^2 per hen.

In conclusion, the combined results of this experiment indicate that any space allowance of less than about 5000 cm^2 per hen imposes at least some constraint on free expression of behaviour. Clearly, it would be uneconomic to provide this amount of space (two hens per m^2) in commercial housing systems. Nevertheless, the results suggest that laying hens would benefit from any increase above the current minimum 1111 cm^2 usable area (nine hens per m^2) in alternative housing (Council Directive 1999/74/EC, 1999), especially as their behaviour appears to change most markedly at around this density (Figure 3). Moreover, if feather pecking represents redirected ground pecking (Blokhuis, 1986), and if ground pecking is suppressed with less than 2400 cm^2 littered floor area per hen (Figure 3), this may mean that the risk of feather pecking damage is increased at densities higher than four hens per m^2. No feather pecking was observed in the present experiment. Further information is needed about effects of stocking densities between four and nine hens per m^2, and about whether space requirements of different commercial strains of laying hen are similar.

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