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Laying hens in large flocks in a perchery system: influence of stocking density on location, use of resources and behaviour

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Abstract 1. ISA Brown laying hens (3000) were housed in a perchery in 10 pens, each with 300 birds. The pens varied in size to produce 4 different stocking densities: 9·9 birds/m^2 (n=3), 13·5/m^2 (n=2), 16·0/m^2 (n=2) and 19·0/m^2 (n=3). Observations began at 20 weeks of age and continued until 69 weeks to establish the spatial distribution of the birds, usage of the different resources and the expression of behaviour.
2. Overall, birds spent most time on the perch frame (47%), litter area (23%), slatted floor (17%) and nestbox area (9%).
3. There was no effect of density on the proportion of birds observed on the slatted floor or on the elevated perches but as density increased the proportion on the littered area decreased.
4. Space usage was determined vertically, horizontally and longitudinally. Individual birds were seen to use about 80% of the pen volume available to them. This value was similar for all densities and showed that individuals did not have separate home ranges.
5. Fewer vertical movements were made within the main perch frame at the upper than at the lower levels but movements between the perches of the main frame and the nestbox rails were relatively frequent. This may help birds move up and down through the main frame.
6. Behaviours which decreased in incidence with crowding included moving, foraging and dust-bathing. Behaviours which increased with crowding included standing. Behaviours which were unaffected included resting, preening, prelaying behaviour, comfort behaviour and the minor behaviours.
7. The proportion of birds engaged in feeding and drinking was unaffected by density, except each time the chain feeders (which operated intermittently) ran more hens were seen feeding at the lower densities. This suggests that food delivery stimulated feeding behaviour; there may have been some restriction at the higher densities on birds feeding when and where they wanted.
8. Stocking density had no effect on the frequency of agonistic interactions: threats, lunges, comb/head pecks, chases and fights.
9. The incidence of damaging pecking was low and not density dependent.
10. Increasing density within the range investigated inhibited the expression of a number of behaviours and limited the use of specific resources: bird welfare at 19 birds/m^2 may have been very slightly impaired.

INTRODUCTION

High stocking densities for poultry are generally considered to restrict behaviour and reduce animal welfare, especially of caged laying hens (evidence reviewed by Hughes, 1975; Adams and Craig, 1985). However, there have been few controlled experimental studies of large groups of pen-housed birds because of the difficulty and cost of adequate replication. Wells (1972) showed that rearing laying pullets in groups of 400 at densities varying from 5·4 to 14·3 birds/m^2 had few effects. Pullets at the higher densities had lower body weights and poorer feather condition but the effect was slight. However, once laying began all birds were stocked at the same density.

Craig and Guhl (1969) compared flocks of 100 and 400 White Leghorns and found few, if any, differences in social behaviour between hens housed at 3·7 or 5·0 birds/m^2. However, no conclusions as to the effect of density *per se* can be drawn because it was confounded with flock size. Gibson *et al.* (1988) compared flocks of 540 to 1200 hens in a straw-yard system at densities varying from 3·3 to 6·0 birds/m^2 and concluded that welfare (judged by mortality and plumage condition) was poorer at the higher densities. Again, however, because sample sizes were small and there was a partial confounding of density with flock size, any conclusions must be treated with caution. Appleby *et al.* (1989) studied the effect of densities varying from 3·4 to 10·7 hens/m^2 in flocks of 370 or 300 in a deep litter/slatted floor house. They concluded that density had little effect on behaviour, except that locomotion was inhibited by high densities which also had detrimental effects (increased mortality and poor plumage) on welfare (Appleby *et al.*, 1988).

All the studies described above were carried out on single level flocks housed at relatively low densities. The aim of our experiment was to determine, at a constant flock size, the effect on behaviour and welfare of systematically varying the

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amount of space per bird at the higher stocking densities typical of commercial conditions in a multi-level perchery system; currently such a density would be 15·5 birds/m^2 of the floor plan of the house available to the hens (Freedom Foods, 1996). We were concerned with the incidence of a broad range of behaviour patterns, with the way birds distributed themselves in space and with the use of resources within the pen. Two complementary observational techniques were used to quantify bird distribution and behaviour: scan sampling of all birds within a clearly delineated sub-section of each pen, and focal sampling of individuals from a sub-set of marked birds.

MATERIALS AND METHODS

ISA Brown hens (3000) were housed at 17 weeks of age as flocks of 300 in 10 pens of a large perchery house. None of the birds was beak-trimmed. There were 4 stocking density treatments (n = number of replicates): A 9·9 birds/m^2 (n = 3), B 13·5 birds/m^2 (n = 2), C 16·0 birds/m^2 (n = 2), D 19·0 birds/m^2 (n = 3). Each pen incorporated a central 3-tier vertical perch assembly with slatted droppings pit below, a 1 m wide littered area each side and 4 tiers of rollaway nestboxes along the sides of the pen (Figure 1). All pens had the same lateral and vertical dimensions; stocking density was varied by altering pen length. Day length at housing was 8 h and, by advancing both dawn and dusk, a maximum photoperiod of 14 h was reached by 35 weeks. Light intensity at bird level was about 10 lux.

Because it was impossible to observe entire pens at one time a clearly defined section (20%) of each pen was delineated using white paint (at all levels and across the full width of the pen including nestboxes). The section lengths were for A 144, B 106, C 92 and D 80 cm. Each contained all the resources on a proportional basis and was thus a representative microcosm of the total pen. The areas within the sections were classified as slatted floor (including feeders at this level), perches (levels 1, 2 and 3 with feeders on 1 and 3), nipple drinkers (level 3) nestboxes and alighting rails, litter areas and girders/water pipes (see Figure 1).

For focal sampling 20 birds from each pen chosen at random were individually marked at 20 weeks using a combination of coloured leg-rings. This was increased by 5 birds before visit 3 and by a further 9 before visit 5. Thus a total of 34 birds (just over 10% of the flock) were identified.

Observations

At 20 weeks and then at intervals of 8 weeks until 69 weeks of age, a series of 7 observations was carried out, each over a 12-d period. They included bird distribution within pen and both instantaneous scan sampling and focal bird sampling of behaviour. All data were collected by the same observer (NLC).

Use of resources

The number of birds within each resource area of each section was counted on 4 occasions at 08·30, 10·30, 12·30 and 14·30 h, on 3 days during each 12-d period, commencing at 20 weeks of age. The start point (pen) was randomised for each observation, with the subsequent order of pen observations maintained throughout the experiment. Because the entire pen could not be viewed from one position each pen was scanned from both sides and the total number of birds observed in each section was obtained by summing the results from the 2 counts. The sections contained approximately 60 birds, and each scan took about 1 min, the second following immediately after the first. Summed values were divided by the total number of birds within the section (mean±sem = 63·78 ± 0·0.30) to obtain proportional data which were used for statistical analysis. Differences between stocking densities, times of day and flock age were examined using analysis of variance. There were 840 observations across all pens, days and sessions.

Behaviour: scan sampling

The same marked sections were used; the number of birds performing the following behaviours within each section were counted. Moving (including walking and running); standing; resting (sitting with eyes open or closed and including sleeping); foraging (including scratching and ground pecking); dustbathing; preening; feeding; drinking; prelaying behaviours (including nesting); minor behaviours (aggression, bill wiping, investigative pecking)

The scanning procedure, similar to that described above, commenced at 27 weeks (visit 2) and was carried out daily at 09·30 and 13·30 h on 3 days during each 10-d period. There were 348 observations across all pens, days and sessions. The proportions of birds performing each behaviour as a function of the total number of birds observed within each pen were calculated. These data were examined using REML Variance Analysis Components (Genstat, 1993) to determine the effect of density, time of day or flock age.

Movement between perch levels

On one day during 5 of the 7 visits (bird ages: 27–29, 35–37, 43–45, 51–53 and 59–61 weeks), we counted the total number of birds moving: between the different levels of the perch stack; between the perches and the ground; and between the perches and the nestboxes.

All birds on both sides of 4 pens (1 at each density) were observed for 5 min in the morning and in the afternoon. Mean numbers of bird movements during the 5 min were obtained by averaging the results from the 2 pen sides. Data were examined using the General Linear Model (Minitab, 1994) to determine the effects of density, time of day and flock age on number of bird movements.

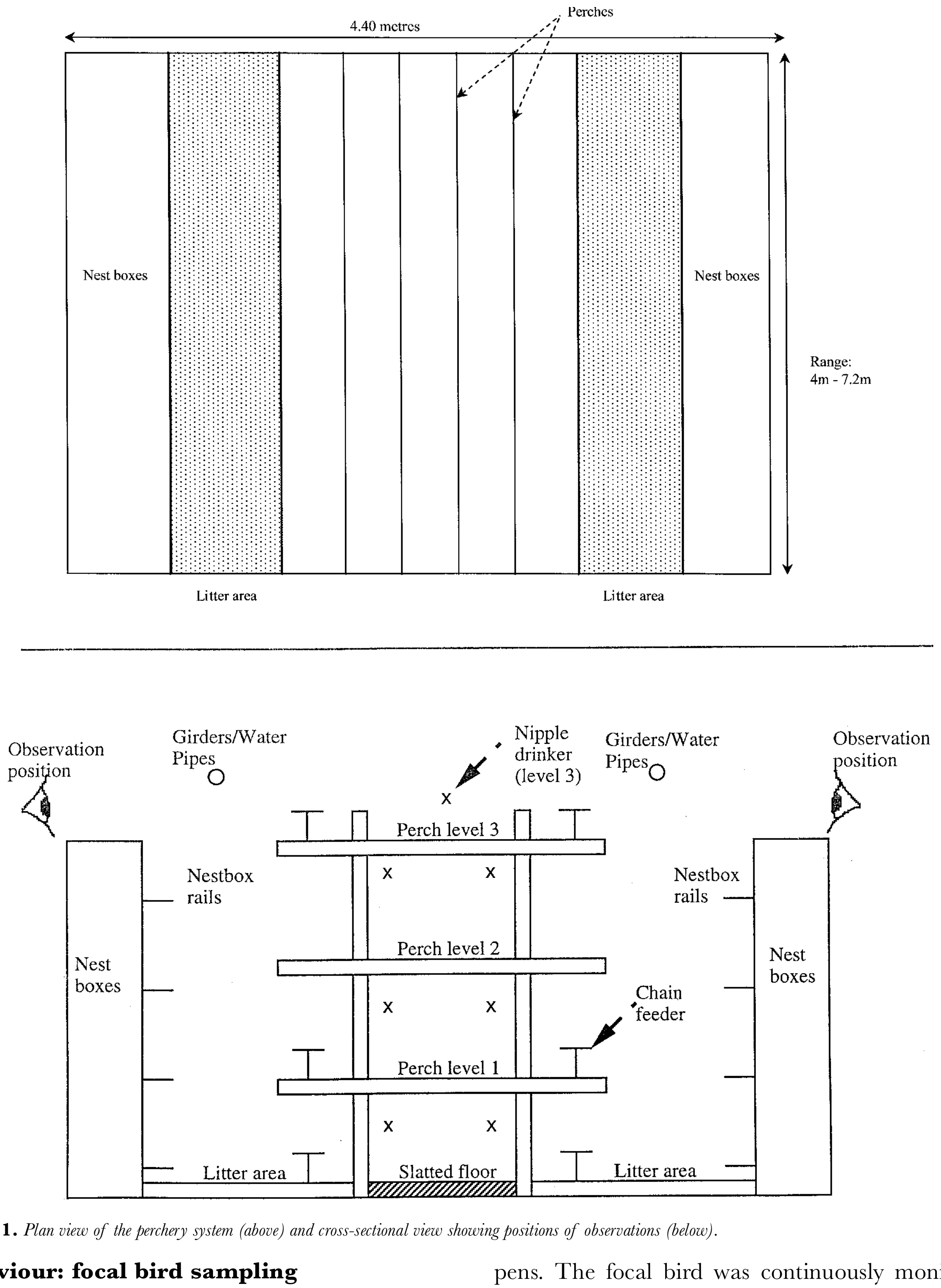

Figure 1. *Plan view of the perchery system (above) and cross-sectional view showing positions of observations (below).*

Behaviour: focal bird sampling

Within each pen (n = 10) 28 birds identified with coloured leg-rings were used for focal observations. Pens were observed in random order and hens were selected by choosing an individual at random before entering the perchery. If that bird could not be located after 15 min, a 2nd marked bird was chosen instead. Individuals were watched on 2 occasions, morning and afternoon, with observations taking place on 5 d in each 12-d period. During periods 1 and 2, data were collected on 5 birds from pens 1,2,3,4,5,8,9 and 10. During period 3 and subsequently data were collected on 4 birds from all 10 pens. The focal bird was continuously monitored for 15 min with behaviour recorded every 5 s on a checklist

Four single-event behaviours were recorded: aggressive behaviour (threats, lunges, comb/head pecks, chases and fights), damaging pecking (feather pecks/pulls aimed at body, tail or chest), comfort behaviours (body shake, wing flap, leg and wing stretch, tail wag) and number of paces (not recorded during period 1). Pecking of other birds, though not space-occupying, may be affected by density because of reduced bird to bird distances at high densities. Pecks delivered and received were both recorded.

Mean results for each pen were averages of behavioural data for the birds (n = 4 or 5) watched each period and were examined by analysis of variance to determine effect of density, time of day and bird age.

Spatial distribution: location, movement and home range

Data were collected using 2 methods.

Individual focal bird

Information was collected as part of the behavioural observations on the focal birds. Within each pen the 28 focal birds were used. At the start of each observation and then every 1 min for 15 min, its 3-dimensional position was noted. Each bird's spatial distribution within the pen was estimated by 6 measures which identified the most widely separated positions at which it had been seen during the year. These were: length of pen travelled; number of horizontal perches traversed; number of vertical perches moved through; additional horizontal distance travelled between perches and nesting area; lowest position within an observation; highest position within an observation

Mean results were obtained for each pen for each of the 6 measures; analysis of variance was used to determine the effect of density, time of day and flock age on spatial distribution within the pen.

Scanning focal birds as a group

The focal birds were used to determine individuals' home ranges and were scanned 3 times (08·30, 11·00 and 13·30 h) on one day of each visit. Four pens, 1 of each density, were scanned for 30 min (or until at least 80% of the marked birds had been seen). Each bird's location was marked on a scale drawing of the pen with respect to the 3 axes: vertical, horizontal and longitudinal. Measurements similar to those in the preceding paragraph were recorded. For each bird a summary of all its locations throughout the year was obtained by combining all observations on a single drawing. It was thus possible to determine whether density affected usage of the pen and whether birds limited themselves to particular areas within the pen.

RESULTS

Use of resources

Overall usage is shown in Figure 2: most birds, 47%, were on the main perch frame, 39% were on the ground level (slatted floor and litter areas combined) and 9% were in nest boxes.

Stocking density

The proportion of birds at each resource within the delineated sections over the range of densities is shown in Table 1. Density had no effect on the proportion on the slatted floor (P = 0·990), the perches (P = 0·499) or at the nipple drinkers (level 3) (P = 0·362). Though not significant, there was a suggestion that the proportion of birds using the nestboxes (P = 0·054) and girders/water pipes (P = 0·063) increased with density. There was an effect on the proportion in the litter area (P = 0·019): regression analysis revealed a linear relationship (P = 0·007) with the proportion of birds on litter decreasing as density increased.

Time of day

The proportion of birds at each resource during the 4 time periods (Table 2) changed over the day. Numbers on the lower levels increased for both the

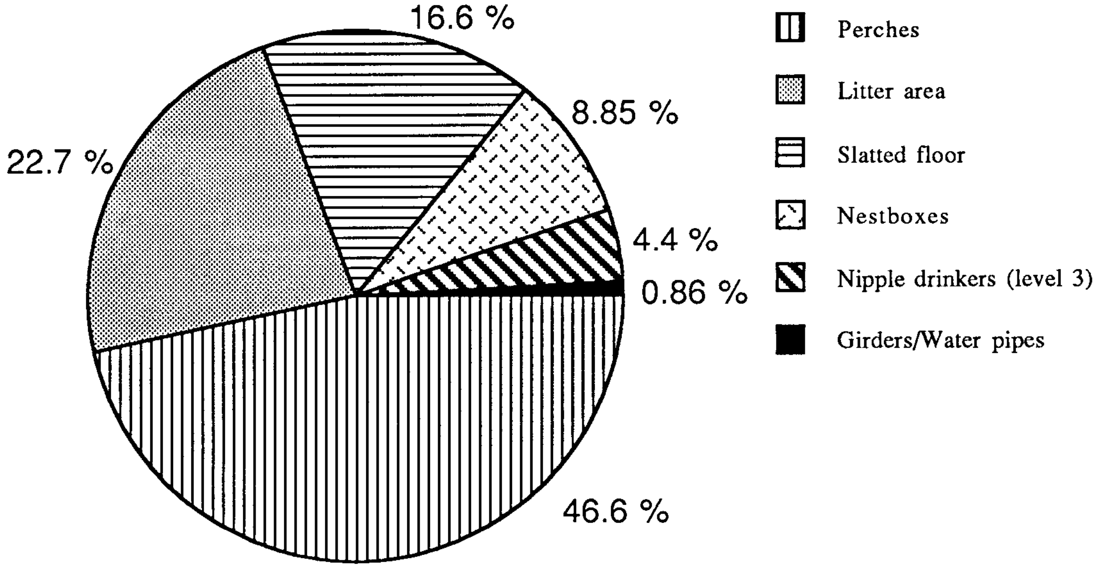

Figure 2. *Mean percentage usage of available resources within each observation section of each pen of the perchery.*

Table 1. *Use of resources at 4 stocking densities: mean proportion (SED) of birds counted within each of 6 delineated areas*

Area	Stocking density (birds/m^2)				SED
	9·9 (n=252)	13·5 (n=168)	16·0 (n=168)	19 (n=252)	
Slatted floor	0·165	0·162	0·168	0·167	0·02
Perches	0·452	0·476	0·477	0·467	0·02
Nipple drinkers (level 3)	0·046	0·047	0·043	0·040	0·004
Nestboxes	0·075	0·08	0·095	0·10	0·009
Litter area	0·258	0·221	0·206	0·214	0·014
Girders/water pipes	0·004	0·010	0·011	0·010	0·003

Table 2. *Mean proportions (SED) of birds* (n*=210) observed during 4 distinct time periods within each of 6 delineated areas*

Area	Time of day (h)				SED
	8·30	10·30	12·30	14·30	
Slatted floor	0·151	0·165	0·172	0·175	0·004
Perches	0·461	0·475	0·464	0·466	0·006
Nipple drinkers (level 3)	0·047	0·044	0·043	0·041	0·002
Nestboxes	0·119	0·085	0·076	0·0737	0·003
Litter area	0·213	0·221	0·238	0·235	0·005
Girders/water pipes	0·008	0·010	0·007	0·009	0·001

slatted floor (P < 0·001) and the litter area (P < 0·001) as the day went on. There were no changes in the proportion on the perches (P = 0·080) or girders and water pipes (P = 0·194) but there were decreases at the nipple drinkers (level 3) (P = 0·005) and at the nestboxes (P < 0·001) as the day progressed. Regression analysis revealed linear trends for slatted floor, litter area, nipple drinkers (level 3) and nestboxes (all P < 0·001), showing that birds moved from higher levels down to the ground during the day. Other observations (unpublished) showed that just before 'lights off' birds moved back to the upper levels to roost over night.

Flock age

The proportion of birds at each resource from 20 to 69 weeks (Figure 3) changed little with age, shown by the relatively flat gradients of the lines.

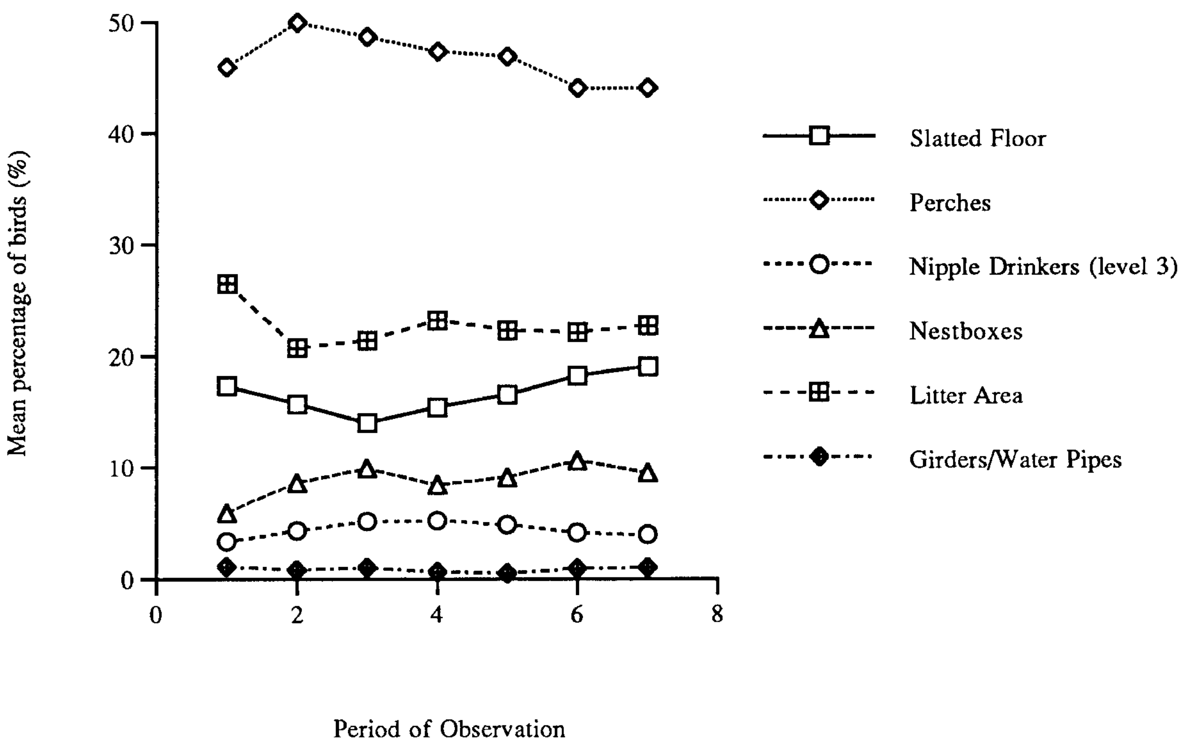

Figure 3. *Mean percentage of birds observed in the delineated resource areas as the year progressed.*

Perches. There was an increase on the perches from week 21 to 28 followed by a linear decrease ($P <$ 0·001).

Litter area. There was a decrease in the proportion on litter between weeks 21 and 28, a small increase until 44 weeks and stable values thereafter.

Slatted floor. Over the year the number of birds first decreased and then increased ($P <$ 0·001).

Nestboxes. Nestbox usage increased linearly over the year ($P <$ 0·001). This is surprising because after peaking at about 30 weeks egg production fell; it suggests that birds used the nestboxes for reasons other than nesting.

Nipple drinkers (level 3). The proportion on the nipple drinkers increased over the 1st half of the experiment and then decreased after week 52 ($P <$ 0·001).

Girders/water pipes. There was a linear decrease (P < 0·001) in the proportion on the girders and water pipes.

Spatial distribution and movement

Movement within perch frame (focal observations)

The mean number of perches that the focal birds moved through vertically, horizontally and longitudinally were calculated. There were few density effects. The average number of perches moved through vertically in 15 min was less than 1 (mean = 0·56), showing that over this length of time birds generally stayed on the same level. During a single observation period the lowest occupied position on average was level 1, while level 2 was the highest. Over the year as a whole, however, home range observations showed that birds used almost 85% of the vertical space available to them.

There were more horizontal movements, birds on average moved 1 or 2 perches across the frame (mean = 1·6), which corresponded to birds being seen on just less than half of the horizontal perching area over the 15 min. More horizontal perches were traversed in the afternoon than in the morning ($P <$ 0·001). On average 16% of the additional horizontal space (litter area) was used during the 15 min.

The birds moved longitudinally over about 35% of the length of the pen during the 15 min. There was a slight reduction with crowding, from 37·5% at the lowest density to 34·2% at the highest. The analysis only took extreme positions into account, there being no indication of how much birds moved back and forth within this distance.

Table 3. *Mean (±SEM) number of bird movements/5 min between different levels of the perchery*

Perchery level	Movements/ 5 min	±SEM
Litter to perch 1	5·625	0·512
Perch 1 to perch 2	2·063	0·225
Perch 2 to perch 3	0·243	0·048
Perch 3 to nipple drinkers	0·222	0·049
Litter to perches 2 and 3	0·931	0·124
Perch to nestbox rails	5·931	0·504

Movement between resources (scanning observations)

The counts of movements within the perch frame, between ground and perches and between perches and nestbox rails show many more between the litter area and the 1st perch than at any of the higher levels (Table 3). There were also many between the main perch frame and the nestbox rails, perhaps to facilitate movement up and down through the perchery frame. These differences were significant ($P <$ 0·001).

Density had no effect on movement between the litter and perch 1, between perches 1 and 2, between perch 3 and the nipple drinkers (level 3), between litter and perches 2 or 3, or across the pen between the frame and the nestbox rails. However, there were fewer moves ($P <$ 0·001) between perches 2 and 3 at both minimum and maximum densities than at the intermediate ones.

Time of day had a significant effect on the number of movements between the litter and perch 1 and perhaps between perch 1 and 2, with more movements in the afternoon for both of these variables (Table 4). This is consistent with the scan sampling observations that more birds were on litter during the afternoon.

Bird location (home range)

Overall, 66·2% of the marked birds used most (about 85%) of the vertical space available to them. Most birds were observed at both the lowest level

Table 4. *Mean (SEM) number of bird movements between the different levels of the perchery stack in the morning and afternoon*

Perchery level	Morning		Afternoon		P
	Mean	±SEM	Mean	±SEM	
Litter-Perch 1	4·50	0·287	6·750	0·920	= 0·026
Perch 1-Perch 2	1·625	0·180	2·50	0·393	= 0·051
Perch 2-Perch 3	0·208	0·06	0·278	0·078	> 0·05
Perch 3-Nipple drinker	0·236	0·06	0·208	0·076	> 0·05
Litter-Perch 2,3	0·833	0·12	1·03	0·219	> 0·05
Perch-Nestbox Rail	6·36	0·677	5·50	0·751	> 0·05

(litter) and at the highest level (3rd perch and above) (Table 5*a*). Above the 3rd perch there were only adventitious locations such as supporting girders and nipple drinker lines (level 3). Density had no effect on either the lowest or the highest point at which marked birds were observed throughout the year (Table 5*b*) nor on the proportion that moved through 3 or more levels (Table 5*c*). A similar assessment of the mean number of horizontal perches that the birds had traversed over the year (Table 5*d*) showed no density effect.

The mean length of pen travelled (Table 5*e*) shows that each individual was seen in about 80% of the pen length in all 4 densities. Although REML analysis revealed a density effect ($P < 0{\cdot}05$), the effect was not linear and there was less than 1% difference between the 2 extremes, Of course, because pen size is proportional to density, the actual distance spanned is only half as much at the highest density as at the lowest.

Finally, the amount of litter area used was considered and no significant effect of density was found. About 70% of birds were seen on the litter but each individual used only about 50% of the space available to it (Table 5*f*).

Bird distribution before and after intermittent feeding

A comparison of the proportion of birds on perching level 2 and on litter after the chain feeders operated, divided by the number of birds before chain operation began, showed that density had an effect ($P < 0{\cdot}001$) (Table 6). The percentage of birds remaining at these non-feeding locations was greater at the higher densities (68%) than at the lower ones (42·3%) (Figure 4). At the highest density about 25% fewer of the flock moved to a feeder than at the lowest, perhaps because at the higher densities the feeders were already accommodating the maximum numbers possible; if so, it implies that feeder space was limiting.

Behaviour recorded by scan sampling

The number of birds (pooled data) engaged in each behaviour pattern (Figure 5) shows that feeding was the most common behaviour, with about 35% of the flock feeding at any one time. This was followed by standing (20%), with between 2% to 10% of birds engaged in each of the remaining behaviours.

Stocking density

Density had a marked effect on activity (Table 7). At the minimum density the proportion of birds moving (running and walking) was largest (10·4%), whilst the proportion standing was lowest (16·5%). The reverse was true for the maximum density, where the proportion moving was lower (7·3%) and the proportion standing (24·7%) much higher. These results were both highly significant. Resting was not density dependent. The proportion foraging in litter increased as density decreased (from 7·4% to 8·4%); there were no density effects on feeding or drinking.

Dust-bathing and preening are maintenance behaviours. As density increased, there was a progressive decrease in birds dust-bathing (from 3·9% to 2·3%) but no significant difference in the percentage preening. There were no significant effects of density on nesting nor on other behaviours.

Table 5. *Effect of density on the position and movement of birds and on the space used*

Measures		Stocking density (birds/m^2)				SED
		9·9 (n = 42)	13·5 (n = 28)	16 (n = 28)	19 (n = 42)	
(a)	Percentage of birds seen at both the lowest and highest levels, expressed as the total number of birds observed					
	Lowest position (litter)	94·1	91·2	85·3	94·1	
	Highest position (Level 3 and above)	67·7	76·5	67·7	73·5	
(b)	Mean (SED) lowest (litter) and highest (level 3 and above) positions for the birds					
	Lowest position (litter)	0·15	0·15	0·06	0·09	0·11
	Highest position (Level 3 and above)	2·74	3·06	2·74	2·85	0·24
(c)	Mean number (SED) of vertical perches through which birds travelled and percentage of birds that travelled through 3 or more levels					
	Mean vertical perches	2·588	3·059	2·588	2·765	0·252
	Percentage vertical perches	64·7	70·5	61·8	67·6	
(d)	Mean number (SED) of horizontal perches over which birds travelled and percentage of birds that moved over all perches					
	Mean horizontal perches	4·706	4·382	4·471	4·324	0·271
	Percentage moved	67·6	73·5	88·2	76·5	
(e)	Mean percentage (SED) length of the pen used in each of the densities					
	Percentage length	79·26	84·23	72·89	80·88	0·041
(f)	Mean (SED) additional space used in each density and the corresponding percentage usage					
	Mean additional space (cm)	112·5	109·9	87·0	108·8	15·98
	Percentage additional space	56·2	54·9	43·5	54·4	

Table 6. *Mean percentage (SEM) of birds housed at a range of densities expressed as a proportion of birds that remained at either of 2 locations immediately after food delivery*

Area	Stocking density (birds/m^2)			
	9·9 (n=23)	13·5 (n=14)	16 (n=14)	19 (n=24)
Litter	43·4 ± 2·65	59·6 ± 5·5	66·8 ± 3·4	65·7 ± 2·5
Perch 2	42·5 ± 3·56	62·5 ± 5·19	59·8 ± 4·6	68·5 ± 5·0

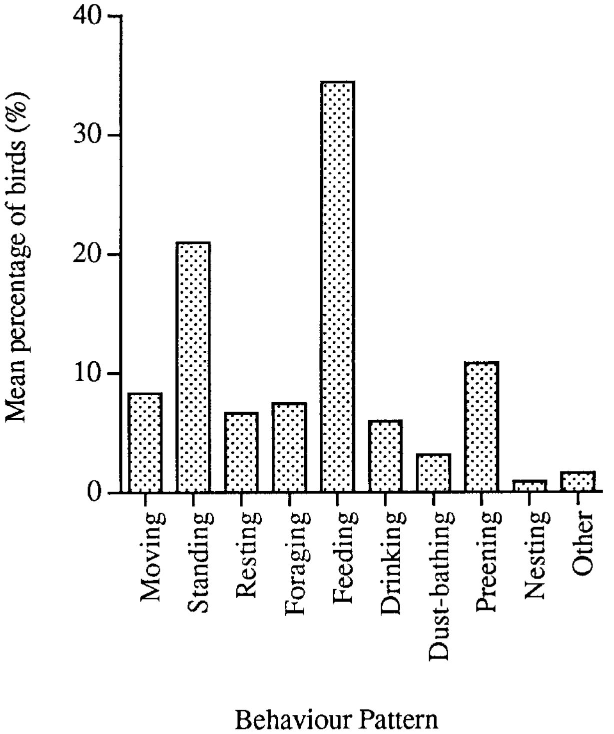

Figure 4. *Mean proportion of birds housed at a range of stocking densities, expressed as a percentage that remained at 1 of 2 levels after the chain feeders had ceased.*

Time of day

There were a number of significant behavioural differences attributable to time of day. Although the proportion standing was similar in the morning (21·5%) and afternoon (20·4%), the percentage moving decreased significantly from 8·6% to 8·0% in the afternoon. The proportion resting also decreased (from 8·1% to 5·1%). This was compensated for by afternoon increases in foraging (from 5·8% to 9·1%) and feeding (from 32·5% to 36·3%). There was no change in drinking.

There was a decrease in dust-bathing during the afternoon (from 4·0% to 2·2%), while the proportion preening was unaffected by time of day. Nesting decreased (from 1·1% to 0·2%), while the proportion engaged in other behaviours was unaffected.

Flock age

Though there were significant between-age differences (Figure 5) in the mean proportions of birds engaged in moving, standing, resting, foraging, feeding, drinking, dust-bathing and preening there were few clear linear trends.

Behaviour: focal bird sampling

Agonistic interactions

Aggressive behaviour was similar in all pens, unaffected by density and overall very low. The 167 interactions observed was equivalent to 0·76/bird/h. Flock age had an effect: aggression increased towards the end of the year, with more birds becoming involved in agonistic interactions.

Damaging pecking

Overall the incidence was low. Throughout the study 466 feather pecks/pulls were observed (equivalent to 2·1/bird/h): none of the treatments had a significant effect (density P = 0·680; time of day P = 0·588; flock age P = 0·131).

Comfort behaviour

The incidence of comfort behaviours was low; less than one per observation, so the data from the 4 individual behaviours were pooled and analysed. Neither density (P = 0·457), nor time of day (P = 0·843) affected the incidence of comfort behaviour. However, there was an effect of age (P < 0·001): an initial sharp increase, a steady rise over the middle part of the year and a final decrease (Table 8).

Number of paces

The mean number per focal bird during the 15 min was calculated for each pen. More paces were taken at the lowest density (40 compared with 29 per bird) but the difference was not significant (P = 0·194), nor was there any diurnal effect (P = 0·245). However, number of paces increased (P < 0·001) markedly with flock age (Table 8).

DISCUSSION

This study shows the value of using the complementary methodologies of scan and focal bird sampling. Scan sampling, with its larger sample sizes, revealed general effects on resource use and the expression of behaviour, while focal sampling was more sensitive for detecting effects on spatial distribution and individual bird activity. Overall, few differences were observed between the 4 densities for use of resources and spatial distribution but there was evidence that increased density limited some behaviours.

Table 7. *Mean percentages (SED) of total number of birds observed performing 10 behaviour patterns*

Behaviour	Stocking density				SED			*P*
	9·9 m² (*n* = 90)	13·5 m² (*n* = 84)	16·0 m² (*n* = 84)	19·9 m² (*n* = 90)				
Moving	10·4	7·3	8·2	7·3	0·58	0·63	0·54	< 0·001
Standing	16·5	20·8	21·8	24·7	0·89	0·95	0·82	< 0·001
Resting	7·0	6·9	6·4	6·1	0·68	0·74	0·63	NS
Foraging	8·4	6·4	7·5	7·4	0·54	0·59	0·50	< 0·02
Feeding	35·3	34·0	34·9	33·4	2·3	2·4	2·1	NS
Drinking	6·0	5·5	6·2	5·8	0·52	0·56	0·47	NS
Dust-bathing	3·9	3·8	2·5	2·3	0·44	0·47	0·40	< 0·001
Preening	9·8	12·6	10·5	10·3	1·1	1·2	1·0	NS
Nesting	0·89	0·68	1·0	0·95	0·31	0·34	0·28	NS
Other	1·78	1·46	1·47	1·63	0·65	0·7	0·58	NS

The 3 SEDs are, respectively, between the 2 smaller sample sizes, between the larger and smaller samples and between the 2 larger samples.

Table 8. *Mean (SED) number of comfort behaviours and paces per pen as the year progressed*

Number	Flock age (weeks)							SED
	20	28	36	44	52	60	68	
Comfort behav	0·050	0·497	0·625	0·713	0·850	0·738	0·650	0·167
Steps	22·0	23·9	29·7	35·0	31·7	46·3	49·3	5·91

Use of resources and space

Most birds (about 50%) were found on the 3 perch levels, consistent with a FAWC (1991) report that up to 55% of perchery flocks will be found on overhead areas. This is in line with a study of aviary-housed hens by Hansen (1994), who reported that they spent most time on the feeding floors, followed by resting levels and then litter areas. These results (pie chart Figure 2) also mirror findings (Bubier, 1994) in a similar perchery housing 265 birds at 16·5 birds/m², where 49% of birds were on the main frame and 33% on the ground (slats or wire and litter areas). Thus separate studies have all yielded a consistent pattern of resource usage.

At high stocking densities one might expect fewer birds in areas where demand for resources exceeded supply. Only litter usage was affected by density, with fewer birds on the litter areas at the higher densities. There were no density effects on

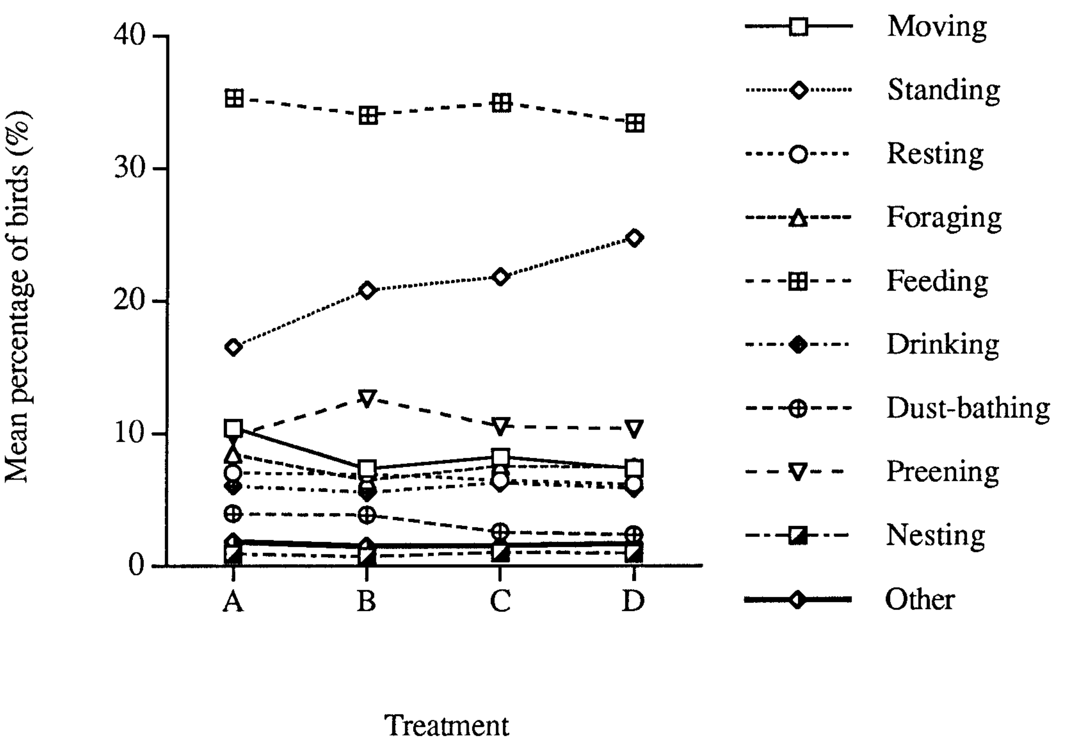

Figure 5. *Mean percentage of birds engaged in 10 behaviour patterns as the year progressed.*

the numbers on the slatted floor, perches, nipple drinkers (level 3), nestboxes and girders/water pipes, except for a suggestion that the proportion using nestboxes and girders/water pipes increased with density. However, numbers using elevated areas were still quite low; this is important because Gibson *et al.* (1988) suggested that such birds were subordinates attempting to escape attack. The findings suggest that welfare was not severely compromised by the highest densities in this study.

Time of day had little effect except that later in the day the numbers of birds on the litter areas and the slatted floor increased, perhaps reflecting a switch away from prelaying and nesting behaviours in the morning towards foraging, maintenance and comfort behaviours.

As far as flock age was concerned, the present results were compared with data for 2 half-year periods from a previous Gleadthorpe study (Bubier 1994). In the earlier study changes in resource usage were more pronounced. The proportion of birds on the perches declined by 11·5% (3·2% in the present study comparing visits 1 to 3 with visits 4 to 7) while the proportion on the ground declined by 4·5% (0·5% in the present study).

Location and spatial distribution

It is widely accepted that under semi-natural conditions galliform birds have home ranges (Wood-Gush *et al.*, 1978) spending disproportionate amounts of time in particular areas (McBride and Foenander, 1962). Indeed, a previous study of birds in a similar perchery (Bubier, 1994) reported 'hens on top perches do not come down very often' and 'the same hens are often found in the same places'. However, there is also evidence that in many intensively housed flocks, individual home ranges are a myth and birds move around sufficiently to encounter all other individuals in the flock (Hughes *et al.*, 1974; Gibson *et al.*, 1988: Appleby *et al.*, 1989). In a study of broiler breeders on litter (Appleby *et al.*, 1985), individuals used approximately 73% of the house.

In the present study, two-thirds of the marked individuals were recorded over the year using around 85% of the vertical space, 80% of the pen length and 75% of the horizontal perching space available to them. Combining results from all 3 axes, individual birds used about 80% of the pen volume available and did not limit their movements to small areas.

Increased congestion at higher densities did not greatly restrict birds' movements. The proportion of the pen length traversed in 15 min was almost identical at all densities, though, of course, this represented a shorter absolute distance in the smaller, high-density pens. Because pen-mates sitting on perches form an obstacle to movement along the pen, birds at higher densities may be obliged to make more horizontal movements across the pen, in order to progress diagonally along its length. Though not significant, the number of horizontal movements *was* greater for birds at the higher densities.

Movement within the perchery

Focal birds, during 15-min observations, utilised more horizontal perches (1·56) than vertical ones (0·55). Horizontal separation between perches was 30 to 41 cm, whilst vertical separation was 43 to 56 cm. Ascending and descending through the frame may be more difficult than moving across at the same level. This is consistent with findings (Scott and Parker, 1994) that birds' ability to negotiate perches successfully at a given distance increased with experience, with an apparent limit for horizontal perches of 1 m. The authors emphasised that the design of alternative housing systems must be carefully related to the bird's abilities in order to reduce frustration, prevent broken limbs and improve welfare. It may be necessary to alter the way perches are arranged to make movement easier.

Observing movements between levels supports these ideas. Higher in the perchery, there were few movements between levels but many between the perch frame and the nestbox rails. Because there were few birds on the nestbox rails at any one time (about 10% of the flock), we postulate that they used the rails as a transit point to move up and down through the higher levels of the main frame. Though the difference was not significant, as the year progressed there were increases both in the proportion of birds on the rails and in movements between the frame and the rails.

Behaviour

Activity-related behaviour (moving, standing) was affected by crowding: as density increased, there was a decrease in the number of birds moving and an increase in the number standing. The number of paces at the lower densities was greater (though not significantly so) than at the higher ones. No stereotypic back-and-forth pacing, comparable to that seen in caged hens, was observed. In a previous comparison (McLean *et al.*, 1986) between a perchery and cages, birds actually spent the same amount of time in motion but the birds in percheries moved a greater distance than the caged birds. Appleby *et al.* (1989) reported that time spent in locomotion decreased from 16% at 3 birds/m^2 to about 9% at 11 bird/m^2; our scanning results extend their finding in showing that as density is increased further the decline continues, from 10% at 9·9 birds/m^2 to 7% at 19/m^2.

At all densities, individual focal birds used approximately the same proportion of pen length (30%) during one 15-min period, which means that birds at the lowest density moved about twice as far as those at the highest and, in doing so, spent more time moving and took more paces than birds at the higher densities. The results from the various observation methods all support the same conclusion, that crowding reduced movement.

Resting behaviour was not density dependent but the number of birds resting decreased between the morning and afternoon.

Foraging is regarded as an important behaviour: 'hens are strongly motivated to perform scratching' (FAWC, 1991) and in semi-natural conditions birds spend much of their day foraging even if supplied with food (Dawkins, 1989). However, in contrast to birds in a deep-litter system which showed a foraging rate of about 25% (Appleby *et al.*, 1989), there was rather little foraging in the present study. Only around 7% of birds were seen to be foraging at any one time, a result consistent with that of Gibson *et al.* (1986), who reported that hens in a covered strawyard engaged in foraging for 7% of their day.

Feeding occupied about 35% of the observation period, again similar to the covered strawyard (Gibson *et al.*, 1986). Density had no effect on number of birds feeding. Feeding behaviour generally has a diurnal rhythm, with a feeding peak in the morning after laying, a decrease in the middle of the day and an increase towards evening (Savory, 1979). In the present study there was an increase in the numbers seen feeding towards the end of the day, Hens receiving mash, as here, show a less pronounced diurnal feeding rhythm than birds receiving pellets (Fujita, 1973).

It has been suggested that by dividing flocks into smaller groups, laying fowl remain evenly spaced in relation to fixed equipment. When chain feeders begin to operate, it can cause a crush at one end of the house as birds try to reach fresh food (FAWC, 1991). We attempted to measure the crowding induced by chain feeders, by counting the number of birds at 2 levels where there were no feeding facilities, both as feeding began and then once the feeders had stopped. At the higher densities, more birds remained at these levels, suggesting that fewer were able to move to preferred feeding areas.

Drinking is also an ingestive behaviour and is associated with feeding. Birds were engaged in drinking for 5·9% of the time, which compares with about 6% in the strawyard (Gibson *et al.*, 1986). Water intake decreases as number of birds per drinker increases (Hearn, 1976). In the present study, an ample number of drinkers was provided (1 for every 5 birds in all pens) and there was no difference in drinker usage or time spent drinking between densities. There was a marginal (but not significant) increase in drinking during the afternoon, in conjunction with the increase in feeding.

Dust-bathing occurs on average once every 48 h (Vestergaard, 1982). The numbers dust-bathing during scanning observations decreased with crowding, from 4% at the lowest density to 2% at the highest. In contrast to previous studies (Vestergaard, 1982; Gibson *et al.*, 1986; Appleby *et al.*, 1992) there was less dust-bathing in the afternoon.

Preening is necessary to keep feathers in good condition. Although in caged hens it is affected by available space (Nicol, 1987), the number of birds preening in our study was influenced neither by density nor time of day.

Pre-laying behaviour, nesting and egg-laying are closely associated with photoperiod: hens generally lay within 6 h of lights-on. As expected, the numbers nesting decreased during the day, Density did not affect nesting behaviour: as with feeding and drinking, adequate provision had been made for all birds housed at all densities to nest.

Other minor behaviours showed a suggestion of a decrease in expression as density increased; for example, bill wiping declined. Time of day did not affect their incidence.

Comfort behaviours help to keep the plumage in good condition (Appleby *et al.*, 1992). Because their expression requires a relatively large amount of space (Dawkins and Hardie, 1989), it was predicted that their occurrence would be reduced by an increase in density. However, no effect of either density or time of day was observed. Although overall occurrences were few, their incidence increased towards the end of the study.

One of the most unexpected findings was the low incidence both of aggression and damaging pecking. Further experiments were performed (Hughes *et al.*, 1997) once the trial had finished. These suggested that birds in large flocks (n=300), such as in the present experiment, do not recognise one another. The consequential lack of social hierarchies is probably a factor in producing these low incidences of aggression, which were apparently unaffected by density. In contrast, Appleby *et al.* (1992) suggested that crowding cage-housed birds may decrease aggression as birds become restricted in their movements. The incidence of damaging pecking was low throughout; no effect was observed of density, time of day or flock age. However, the occurrence of feather pecking and cannibalism is notoriously variable and it would be unwise to draw general conclusions from the findings of a single study.

Flock age

Annual trends were seen in both the frequency and duration of behaviours. These rarely followed linear trends either upwards or downwards and were more likely to be expressed by either cubic or quadratic relationships. In most cases it is doubtful if they mean very much.

In general terms, activity-related behaviours decreased after period 1 and then increased towards the end of the study. Because the birds were first observed soon after housing, it is not surprising that more movement was seen at this time as the birds were exploring their new environment, as they would in natural conditions trying to identify the best food sources. As the year progressed, there was an increase in the number of steps taken by the focal birds. Although not significant, there was also a suggestion that birds moved over a greater distance in all 3 axes (vertically, horizontally and longitudinally) as time passed.

As the year progressed the numbers of birds engaged in foraging decreased, numbers on litter decreased slightly but the number dust-bathing increased. The annual trends for litter usage and foraging were similar, suggesting that litter was used more for foraging than for dust-bathing. Towards the end of the year the number of birds preening decreased, whereas feeding and drinking rose.

Nestbox and landing rails usage increased throughout the year. The proportion of birds nesting did not change dramatically during the year, so it must have been landing rails usage that increased. This links with observations that the number of movements between the main frame and the nestbox rails increased with age; the birds appeared to use the rails as a 'staging post' to gain access to the upper parts of the main frame, even though they had to cross a gap of about 1·2 m (Figure 1). Other behaviours remained fairly constant throughout the year, with a decrease in their expression during the final visit.

In conclusion, the behaviour and movement of hens in this large flock perchery system was slightly, though measurably, restricted by doubling the stocking density from 9·9 to 19 birds/m^2. Overall, it seems possible that, even though perching space was ample, their welfare was very slightly impaired at 19 birds/m^2, a judgement supported by the findings of a separate study concerned with the parallel changes in performance and physical variables in the same flocks (Walker, 1997). These findings suggest that the current UK statutory requirement that stocking rate in perchery systems should not exceed 25 birds/m^2 (MAFF, 1987) is at the top end of the scale: 20 birds/m^2 might be a more defensible figure.

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