Resting or hiding? Why broiler chickens stay near walls and how density affects this

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Abstract

Broiler chickens are reported to be close to walls at higher densities. The reason for this is not clear, since evolutionary theories would suggest that birds should attempt to be in the middle of the flock.

We studied the spatial distribution (during weeks 4–6) of broiler chickens stocked at 2.4, 5.8, 8.8, 12.1, 13.6, 15.5, 18.5 and 21.8 birds/m² (in 3.3 m² pens), to investigate the underlying reasons for the pattern of spatial distribution. Three possible reasons were considered: seeking cover from predators in the centre of the flock, seeking cover from predators near walls, and avoidance of disturbances by conspecifics. Spatial distribution was analysed by comparing the number of birds in four separate parts of the pen (inner, inner middle, outer middle and outer). Apart from effects on spatial distribution, birds were predicted to have their behaviour disturbed more often by other birds in the flock as the overall density in the pen increased, leading to shortened bouts of behaviour and an increase in adjustments of the sitting or lying posture.

We found that higher treatment density led to shorter sitting and preening bouts \( (P = 0.024 \text{ and } P = 0.013) \), and a sharper decrease in walking bout length as weeks progressed \( \text{(density} \times \text{week}, P = 0.025) \). In addition, birds adjusted their sitting or lying posture more often at higher densities \( (P < 0.001) \), indicating an increased number of disturbances.

Preference for the wall area occurred when overall density in the pen peaked (in the last week of rearing, at treatment densities above 12.1 birds/m²). On the other hand, more animals were present in the centre of the pen than at the edges at some of the densities in weeks 4 and 5. Because of its occurrence at peak density, avoidance of disturbance seems the most likely explanation for wall preference. Thus, increased use of the wall area may be an indicator that birds are experiencing crowding.

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1. Introduction

Several studies of spatial behaviour have shown that broiler chickens stay nearer to pen walls than expected by chance, but that they can be drawn to the more central parts of the pen by placing extra partitions in this area (Newberry and Hall, 1990; Newberry and Shackleton, 1997). This effect is apparent throughout the 6-week rear-
The tendency to stay near walls seems to be density dependent, as Arnould and Faure (2004) found more animals in the wall area than in the centre in groups stocked at 15 birds/m², but more in the central area than near the walls in groups stocked at 2 birds/m². Although this effect was significant in the 4th week of life only, it warrants further investigation. These authors also studied the effect of resource allocation on density dependent distribution, and found that animals stocked at the lower density preferred to stay near drinkers and feeders, whilst this effect was not observed at the higher density.

The reason for the preference for areas near walls or partitions remains unclear. It has been proposed to be anti-predator behaviour (Newberry and Shackleton, 1997), with animals using the walls to conceal themselves. Although chickens seldom encounter any predators in commercial indoor settings, they do still display anti-predator behaviour (Newberry et al., 2001; Oden et al., 2005). However, staying near walls means the animal takes up a peripheral position within the group which is not in keeping with established anti-predator theory, since predation risk is lower in the centre of groups (Hamilton, 1971). Furthermore, the relative importance of being in the centre of the group becomes even higher when food is abundant (Morrell and Romey, 2008), as is the case in commercial husbandry.

An alternative to the anti-predator behaviour explanation is that broilers use the walls to decrease crowding. The term crowding is used in this article to imply an aversive experience caused by a too high local density surrounding a chicken. High local densities can lead to disturbances of rest and other behaviour when animals push or climb over other individuals (Hall, 2001). Walls or partitions may decrease such disturbances as they block one possible direction from which the chicken can be approached and jostled. The suggestion that wall preference is a way to avoid disturbances is supported by the observation that the number of disturbances by conspecifics decreases and time spent resting increases when partitions are placed in the pen (Cornetto and Estevez, 2001a; Cornetto et al., 2002; Newberry and Shackleton, 1997). Rest is of great importance to all animals, having an impact on growth, energy conservation, tissue restoration, coping ability and important anabolic processes (Blokhuis, 1984; Malleau et al., 2007). It may be especially important for broiler chickens as these are commonly slaughtered at an age of 6 weeks and it has been suggested that younger animals need more rest (Malleau et al., 2007). If wall preference is the result of avoiding conspecifics, the distribution of birds over their pen could be used as an indicator of the level of crowding the animals experience. That is to say, birds that find their current level of crowding unacceptable can be expected to seek cover near walls, leading to a greater number of animals near the walls than expected when the animals feel crowded, but not when the adequate space is available.

The three mechanisms mentioned above (seeking protection from predators in the centre of the group, seeking cover from predators near walls, and avoidance of disruptions by conspecifics) would lead to different expectations on the distribution of animals over their pen.

If the observed distribution resulted from attempts to minimize predation risk by attaining a central position within the group, as proposed in the first hypothesis, this would lead to animals avoiding the area near the wall, where they are more likely to be on the periphery of the group. Avoidance of the wall area would be expected to decrease as group size increases because of reduced predation risk. Although there are some reports that predators are more likely to attack larger groups (Ale and Brown, 2007; Ioannou and Krause, 2008), there is a large body of evidence showing a decrease of anti-predator behaviour with increasing group size in both wild birds (Dias, 2006; Fernandez et al., 2003; Harkin et al., 2000; Newey, 2007) and domestic fowl (Newberry et al., 2001). This effect is usually attributed to the increased chance that one of the animals in the flock will detect a predator and warn the others when the group is larger, as well as a decreased chance for each individual bird to be predated when an attack does occur (Beauchamp, 2003).

Conversely, if the observed distribution resulted from seeking cover from predators near walls, as in the second hypothesis, it would be expected that birds would prefer the area along the wall and that this effect would be stronger in smaller groups in which predation risk at the level of the individual is higher. In line with this, Leone et al. (2007) found that the spatial distribution of broilers, as assessed by inter-individual distances, was influenced more strongly by the provision of panels in smaller groups of birds.

If birds used the walls as a protection from disturbances by conspecifics, as outlined in the third hypothesis, it would be expected that they would increasingly prefer the wall area with increasing density, as jostling and behavioural disruption are known to increase with increasing density (Dawkins et al., 2004; Hall, 2001). In addition, the wall preference may become more pronounced in later weeks, even at the same group size, as the pen gets increasingly filled due to the increase in total body mass of the fast growing broilers.

Thus, both avoidance of disturbance by conspecifics and attempting to attain a central position to avoid predation would lead to an increased number of birds in the area along the wall as group size increases. However, at the largest group sizes (highest densities) the expectations would differ under the two hypotheses: disturbance avoidance would be expected to lead to a higher number of animals in the area along the walls than in the centre. Conversely, a decreased motivation to achieve a central position may eventually lead to an equal distribution as birds get increasingly pushed out of the centre when this area becomes too crowded, but the centre area of the pen would always be more densely populated than the wall area, since birds would move into the centre again when it becomes less densely populated than the wall area. Table 1 summarizes the expected distribution under the three hypotheses as group size changes.

To determine if the spatial distribution observed was likely to result from anti-predator behaviour or from avoiding disturbances of rest, we studied spacing and behaviour of broilers stocked at different treatment densities. These densities were achieved by housing different numbers of
animals in equally sized pens, i.e., with the same wall area. To be able to control environmental conditions the study was conducted on an experimental scale. The decision to co-vary group size and density, rather than pen size, was based in part on the work of Leone and Estevez (2008), who found no effect of group size at a consistent density on broiler spatial behaviour (nearest neighbour distances and their deviation from expected values), whilst increasing density at a consistent enclosure size did influence these parameters. Their results suggest that stocking density is a more important factor for spatial distribution of broiler chickens than group size is. Working with smaller group sizes in our study had the added advantage that this increases the wall length available per bird, allowing for a more clear expression of wall preferences. To be relevant to commercial practice, the densities used in the present study include, and exceed, those used commercially.

2. Methods and materials

2.1. Animals and housing conditions

Day old broiler chicks (Ross 308) were placed into 1.65 m × 2.00 m pens, in groups of 8, 19, 29, 40, 45, 51, 61 and 72 birds. This resulted in treatment densities of 2.4, 5.8, 8.8, 12.1, 13.6, 15.5, 18.5 and 21.8 birds/m² (i.e., 6, 15, 23, 33, 35, 41, 47 and 56 kg live weight/m² at 39 days of age). The total experiment consisted of four repetitions of these treatments (although the only measure carried out during the first repetition was the continuous sampling of behaviour). Males and females were mixed at a ratio of 1:1 (except in pens with an odd number of birds, where the sex of the last bird differed between rounds). In each pen, eight focal birds were colour marked to allow individual recognition, using non-toxic animal spray cans.

Water cups (10 per pen) and feeders (14 per pen) were placed along each side of the pens. The resources were placed on the outside of the pen walls (but accessible from the inside). By doing this, we assured that the resources would not block the animals’ movements, as would have been the case if we put feeders and water nipples in all four areas. Wood shavings (9 kg per pen) were used as a litter material. These were replaced at the start of weeks 3, 5 and 6, and between repetitions, to keep litter quality good throughout the pen and avoid uneven soiling which could potentially influence spatial distribution. Litter samples were collected in the centre and near the walls in weeks 4, 5 and 6, and analysed for dry matter. Air quality was assessed by NH₃ measurements taken at bird height on the same days. The ambient temperature was 31 °C at the day of arrival, and subsequently lowered by 1 °C daily until a temperature of 21 °C was reached, no lamp brooders were provided. Temperature and relative humidity were measured continuously in each pen, both measures were conducted at bird height. Weekly averages were calculated used for analysis. A 21L:3D light schedule was applied.

2.2. Methods

Pens were filmed 1 day per week using a digital recording system and a camera which could be moved remotely. Recordings were made from the centre of each pen, at a 90° angle to the floor. Each pen was recorded for 5 min at a time, six times per day (twice each morning, afternoon and evening, all three of these time periods fell within the light period).

Spatial distribution was determined in weeks 4–6, by counting the number of animals in four areas of the pen (inner, inner middle, outer middle, outer, see Fig. 1) using the first frame of each recording. A scan sampling of the behaviour in the first frame of each recording was carried out for all eight focal birds in each pen, to link their location to the frequency of adjustments of the sitting or lying position. An adjustment was defined as a change in the sitting or lying posture without fully standing up. Usually animals swayed from side to side and/or crawled a few centimetres. It was most often (but not necessarily) caused by jostling by another bird. When an animal did stand up fully this was not scored as an adjustment, since this would already show as a decrease in the length of sitting or lying bouts, as continuous sampling was also carried out. This continuous sampling was performed in weeks 2–6. The behaviour of one of the eight focal animals per pen was determined during a 5 min observation period. The focal animals used for the continuous sampling were chosen using a fixed order: on the first observation day animals 1–6 were observed, on the 2nd day animals 7, 8 and 1–4, on the 3rd day animals 5–8 and 1–2, etc. The bout length of standing, sitting, lying, walking, eating, drinking, preening and ground pecking and the frequency of adjustments (using the definition given above) were determined from these observations.
Birds were scored as standing when they were not moving and their body did not touch the floor, sitting when the body and both hocks touched the floor underneath or directly on either side of the bird, and as lying when they lay on their side, with both feet on the same side of the bird. Birds were scored as eating when they pecked at the feed and, drinking when they were pecking at the drinkers and subsequently tilted their head back. Preening consisted of moving the beak over the feathers. During ground pecking the birds were pecking at the litter, and this could be done whilst standing as well as during sitting or lying. Bouts were considered to be ended when the animal discontinued performing the behaviour for longer than four seconds, or when a different type of behaviour was started.

The results of the continuous sampling of behaviour were analysed using a linear mixed model. Proc mixed was used for analysis of bout lengths and proc glimmix for frequencies (assuming an underlying poisson distribution), starting from a model including density, week, sex, and their interactions as fixed effects, and time of day (morning, afternoon, or evening) as random effects. Observations on the same pen were treated as repeated measures. Non-significant fixed effects and interactions \((P>0.05)\) were removed one by one.

3. Results

3.1. Environmental variables

Average temperature was lower at a density of \(2.1\) birds/m\(^2\) \((19.9 \pm 0.3 ^\circ \text{C})\) than at densities \(\geq 8.8\) birds/m\(^2\) and lower at a density of \(5.8\) birds/m\(^2\) \((20.4 \pm 0.3 ^\circ \text{C})\) than at densities \(\geq 12.1\) birds/m\(^2\) \((F_{7,13} = 5.8, P=0.003, \text{LSMEANS: 21.2, 21.5, 21.6, 21.8, 21.8 and 21.6 \pm 0.3 ^\circ \text{C}}\) for densities of \(8.8, 12.1, 13.6, 15.5, 18.5 \text{ and 21.8 birds/m}^2, \text{respectively)}\). It was higher in the fourth \((22.0 \pm 0.3 ^\circ \text{C})\) than in the 6th week \((21.2 \pm 0.3 ^\circ \text{C})\), which were both warmer than the 5th week \((20.5 \pm 0.3 ^\circ \text{C}, F_{2,44} = 30.0, P=0.0001)\). No differences were found for NH\(_3\) concentrations \((F_{7,13} = 2.1, P=0.12, \text{mean value 3 ppm} \pm 2 \text{SD})\), relative humidity \((F_{2,13} = 1.37, P=0.3, \text{mean value 69\%} \pm 10 \text{SD})\) or the difference between litter dry matter percentage at the edge and the centre of the pen \((F_{7,12} = 1.57, P=0.2, \text{mean value 5\%} \pm 10 \text{SD})\).

3.2. Spacing

Fig. 2 shows all results on spatial distribution. In the 4th week, groups stocked at \(2.4, 13.6 \text{ and 21.8 birds/m}^2\) had an unequal density in the different parts of the pen \((F_{3,66.7} = 3.62, F_{3,66.8} = 3.22, F_{3,66.4} = 3.76 \text{ and } P=0.018, 0.028, 0.015, \text{respectively})\) but the only difference that was still significant after sequential Bonferroni correction was that more animals were present in the inner than in the outer ring at a density of \(13.6\) birds/m\(^2\). In the 5th week, the density in the respective pen areas differed for treatment densities of \(2.4, 5.8, 12.1 \text{ and 15.5 birds/m}^2\) \((F_{3,67} = 3.85, F_{3,66.2} = 4.32, F_{3,67} = 3.85, F_{3,66.2} = 4.32, F_{3,44.6} = 4.01 \text{ and } P=0.008, 0.013, 0.001, 0.013, \text{respectively})\). The inner part of the pen was more densely populated than in the outer part, but after
correction less pair wise differences remained (see Fig. 2). Treatment groups of 18.5 birds/m² showed an opposite tendency ($F_{3,37.0} = 2.40, P = 0.084$) as density was higher in the outer part. Although the data seems to indicate a similar effect in groups with treatment density 21.8, this effect was not significant ($P = 0.4$). In the last week the preference for the outer part became both more pronounced and more general. All treatments ≥12.1 birds/m² showed differences between the four parts ($F_{3,60.7} = 12.9, F_{3,64.9} = 26.7, F_{3,43.3} = 34.9, F_{3,47.6} = 10.4, F_{3,65.7} = 19.6, P < 0.0001$). Densities were consistently higher in the outer part of the pen than in any of the other three parts, even after sequential Bonferroni correction.

### 3.3. Behaviour

Significant effects of stocking density on behaviour are shown in Table 2. Stocking density had no effect on the bout length of standing, lying, drinking, ground pecking or eating. However, sitting and preening bouts had a shorter duration at higher densities. Walking bout lengths decreased with increasing density, showing a stronger decrease in later weeks. The frequency of adjustments (per animal) increased with increasing stocking density.

### 3.4. Adjustments per pen area

Although the continuous sampling showed that adjustments of the sitting or lying posture occurred quite frequently (two to four times per observation period, depending on the density), these short behavioural elements were only rarely picked up in the scan sampling. In total, 105 out of 3064 scanned animals were observed to adjust their sitting or lying posture. Therefore, data from all densities were pooled to study differences between the pen areas.

In the 4th week, animals in the inner part of the pen adjusted their posture about twice as often as would be expected, whereas birds in the other parts adjusted their posture less frequently than expected (Chi squared, 3 df, $P = 0.00002$, see Fig. 3). In weeks 5 and 6 no significant difference in the number of adjustments occurred ($P = 0.15$ and 0.90, respectively).

### 4. Discussion

In this study a preference for certain pen areas was found, which differed with age and treatment density. More animals were present at the edges than in the centre of the pen at treatment densities ≥12.1 birds/m² during the last week. In contrast, in the 4th and 5th weeks, more animals were present in the centre of the pen than in the other areas, for some of the treatment densities. The observed spatial distribution may best be described as an attempt by the birds to achieve a central position at low treatment densities and to minimize disturbances by conspecifics at high densities.

A predominant influence of environmental factors on distribution seems unlikely, since temperature, humidity and NH₃ were within the normal range for all density treatments, and the highest temperatures occurred in week 4, where the least effects on spatial distribution were observed. Humidity did not increase with stocking density, and NH₃ values were low overall and did not differ with treatment. Furthermore, an effect of air characteristics on area preference seems unlikely because of the small width of the areas (20 cm). The difference in litter dry matter between the wall area and the centre area did not chance with density and can thus not explain why birds would prefer the wall area at higher densities either.

In accordance with the first hypothesis (seeking protection in the centre of the group), birds in smaller groups were more often located in the centre of the pen, leading to a more densely populated inner than outer area for several treatment densities in weeks 4 and 5. Similar results were found by Arnould and Faure (2004) using a treatment density of 2 birds/m² in the 4th week of rearing. But the finding that the birds in more densely stocked groups (larger group sizes) preferred the wall area over the centre area in week 6, is not in accordance with this hypothesis. Although some decrease in motivation to gain a central position might be expected in larger groups, where predation risk at the individual level is lower, it would not be expected to be reversed. Our findings do not support the second hypothesis that the preference for the area along walls is an effect of

**Table 2**

Effects of treatment density (and its interactions) on behaviour.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Density</th>
<th>Density × week</th>
<th>Equation for bout length (sec) or frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting bout length</td>
<td>$P_{1,26.7} = 5.7, P = 0.024$</td>
<td>ns</td>
<td>$-147 - 0.52 \times (\text{animals/pen}) + 10.8 \times \text{week}$</td>
</tr>
<tr>
<td>Walking bout length</td>
<td>ns</td>
<td>$P_{5,410} = 5.1, P = 0.025$</td>
<td>$-1.86 + 0.007 \times (\text{animals/pen}) + 0.33 \times \text{week} - 0.006 \times (\text{animals/pen}) \times \text{week}$</td>
</tr>
<tr>
<td>Preening bout length</td>
<td>$P_{1,26.7} = 7.1, P = 0.013$</td>
<td>ns</td>
<td>$-0.9 - 0.07 \times (\text{animals/pen}) + 1.43 \times \text{week}$</td>
</tr>
<tr>
<td>Adjusting frequency</td>
<td>$P_{2,29.7} = 30.8, P &lt; 0.001$</td>
<td>ns</td>
<td>$\exp(1.64 + 0.01 \times (\text{animals/pen}) - 0.20 \times \text{week})$</td>
</tr>
</tbody>
</table>

**Fig. 3.** Adjustments as a percentage of total birds present.
seeking cover from predators, since we found an increase in the number of birds along the walls with increasing group size, i.e., when the risk of predation would be expected to be lower. The observed spatial distribution seems in keeping with an attempt by birds to minimize disturbances by conspecifics at high densities, as predicted under hypothesis three. Local densities were higher in the outer ring than in the other areas when more space was taken up by the physical presence of the animals (i.e. in later weeks at higher treatment densities). Thus, staying near the walls can be seen as an adaptation to crowding. The lack of a preference to stay near the walls when the birds were younger contrasts with previous studies reporting a preference for the area along the wall throughout the rearing period (Cornetto and Estevez, 2001b; Newberry and Hall, 1990). A contributing factor to this lack of wall preference in early weeks may be that the feeders and drinkers were placed along the walls. This may have increased activity (thus, risk of disturbance) in this area. Avoidance of the wall area to avoid the increased disturbance due to feeding or drinking birds seems unlikely however, as Arnould and Faure (2004) report that a low treatment density (2 birds/m²) led to a preference to stay near feeders and drinkers, whilst this effect was not observed in groups stocked more densely (15 birds/m²). An increased tendency to stay near the feeder when density is low would have meant that animals stocked less densely would more often be located along the walls in our experiment, which is the opposite of what was observed. Increased presence in the centre of the pen at the lowest densities/group sizes may therefore be an anti-predatory behavioural response, occurring when jostling risk is low. The chance of being disturbed (number of disturbances/bird) during the last week was equal for each of the four parts of the pen. This seems to contradict the hypothesis that animals used the wall to minimize disturbances. However, if density would have been as high in the inner parts of the pens as it was in the outer, this would probably have led to an increase in disturbances in these inner parts (as seen in week 4 when it was four times higher than in other parts of the pen). By increasingly placing themselves near the walls, the birds alleviated the negative effects of crowding as much as possible. The density at which groups show a significant relocation to the wall area at higher treatment densities is more likely to result from avoiding disturbance by conspecifics than from seeking cover from predators. The changes in spatial distribution can be seen as an indicator of the level of crowding perceived by the birds. In this study, this change started at treatment densities of 12.1 birds/m². Although this adaptation may have decreased disturbances, it could not fully compensate for the increase in disturbance of resting and other behaviours as treatment density increased.

5. Conclusion

Full grown birds stocked at medium to high density showed a preference for the area along the walls, but this effect was not observed at low densities. The preference for the wall area at higher treatment densities is more likely to result from avoiding disturbance by conspecifics than from seeking cover from predators. The changes in spatial distribution seem in keeping with an attempt by birds to minimize disturbances. However, if density would have been as high in the inner parts of the pens as it was in the outer, this would probably have led to an increase in disturbances in these inner parts (as seen in week 4 when it was four times higher than in other parts of the pen). By increasingly placing themselves near the walls, the birds alleviated the negative effects of crowding as much as possible. The density at which groups show a significant relocation to the walls may therefore be used to indicate the density at which the birds themselves perceive stocking density as high. Thus, it is potentially an animal-based (outcome) measure of broiler welfare.

Nevertheless, despite the birds’ attempts to compensate for crowding by using the protection of the walls, the frequency of adjustments increased with treatment density. Birds stocked at the highest treatment density adjusted their posture 1.5–2 times as often as those at the lowest treatment density. Bouts of sitting decreased 20–16% in length between these two treatments. Both effects may reflect an increased level of disturbances, with animals that were only slightly disturbed adjusting their posture, and severely jostled animals standing up and ending their sitting bout. At high treatment densities, bouts of walking and preening also had shorter durations. Similar effects of density on bout length have been reported for large flocks housed under commercial conditions (Febre et al., 2006; Hall, 2001) and for the amount of jostling (Dawkins et al., 2004) (which causes adjustment of the sitting or lying posture). Preening bout length increased with age, thus, it seems unlikely that the decreased length at higher densities was the result of physical pain, which is reported as a cause of decreased dustbathing (Vestergaard and Sanotra, 1999). More likely, preening bouts were shortened as a result of disturbance of this behaviour by nearby conspecifics, or short preening bouts may have been caused by jostling (Febre et al., 2006). The decrease in walking bout length with age may have been caused by increased leg weakness, but it could also indicate that it was harder for animals to reach their target without stopping because they had to avoid other birds. Since broilers kept under commercial circumstances receive only few (if any) hours of darkness, they have to rest and sleep during the light period as well. Rest is of great importance, especially for young animals (Blokhuis, 1984; Malleau et al., 2007), and disturbances of these day-time resting periods may have severe implications for broiler welfare.

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