The Effect of a Single or Repeated Period of High Stocking Density on the Behavior and Response to Stimuli in Broiler Chickens

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ABSTRACT Broiler chickens are normally housed at a fixed number per unit area throughout their life, which reduces their opportunity for movement during the later stages of rearing. An experiment is described that exposed broilers to a high stocking density either once or twice in the rearing period, and investigated the effects on the birds' behavior, and the response to other birds and humans after the second exposure to high or low stocking density. The stocking density was increased from a low level (1.7 kg/m^2) to a high level (14 kg/m^2) for the 2nd and/or 4th wk of rearing, or left unchanged at the low level. When stocked at the low rate, the birds spent more time walking and sitting and less time dozing and sleeping. They pecked more at inanimate objects and interacted more with other birds, but this did not include aggressive interaction. The effects of stocking density on behavior were greater in Week 4 than in Week 2, but there was no evidence that exposure to a high stocking density in Week 2 influenced the birds' behavioral response to a high stocking density in Week 4. Where stocking density did affect behavior in both Weeks 2 and 4, there was evidence of the response being cumulative. The activity of birds in the presence of another bird restrained in an open field arena was greatest when they had been stocked at the low density throughout the experiment. When a familiar person was in the arena, the birds that had been stocked at the high density in Week 2 were most active, but these birds showed the longest tonic immobility when inverted in a cradle. It is concluded that a high stocking density reduces activity in broiler chickens, and that birds stocked at a high density early in the rearing period are most active in the presence of people and show the longest tonic immobility in response to a fearful stimulus.

(*Key words*: stocking density, broiler, behavior, open field test, tonic immobility)

1997 Poultry Science 76:1655–1660

INTRODUCTION

Stocking density of broilers can be either defined by the number or the weight of birds in a given area. The UK Ministry of Agriculture (1990) recommends a maximum stocking density of 40 kg/m^2 for broilers, without specifying the stage of growth of the birds. At a young age, such a high stocking density cannot be achieved unless the birds are vertically stacked on top of each other. It is therefore assumed that this recommendation must only apply to birds approaching maturity, and is not relevant to young birds. In enclosed commercial broiler houses, fixed stocking densities of up to 20 birds per square meter are typical (Elson, 1993). Twenty birds per square meter represents approximately 5 and 8 kg/m^2 in Weeks 2 and 4, respectively, and should present little discomfort in the early weeks of a bird's life, but may reduce welfare in later life by restricting locomotion and preening (Newberry and Hall, 1988; Lewis and Hurnik, 1990). At this density, there will also be increased contact with soiled litter, which can cause contact dermatitis (Proudfoot *et al*., 1979; Greene *et al*., 1985; McIlroy *et al*., 1987). Conflicting results have been obtained on the effect of stocking density on locomotion. Bessei (1992) found no effect of stocking density on activity between 10 and 30 birds per square meter, but Bessei and Reiter (1992) reported that activity was greater at 5 than at 15 birds per square meter. Broilers make effective use of their floor space, but in the last weeks of growth movement may be reduced by the development of aggressive behavior (Newberry and Hall, 1988). Other authors, however, have not recorded any agonistic behavior up to 7 wk of age (Murphy and Preston, 1988; Preston and Murphy, 1989). Lying bouts can be disrupted by a high stocking density, particularly if it causes heat stress, and results in birds standing periodically to increase heat loss (Murphy and Preston, 1988; Lewis and Hurnik, 1990).

The objectives of the present study were 1) to investigate the effects of stocking density, imposed in the first or second half of life, on the behavior of broiler

Received for publication February 18, 1997.
Accepted for publication July 30, 1997.

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chickens, and 2) to examine whether there were any permanent effects on the response of the birds to novel stimuli.

MATERIALS AND METHODS

Male (n = 32) and female (n = 32) Ross broiler chicks were purchased at 1 d of age and kept together under a brooder lamp for 1 wk. At the start of the 2nd wk, the birds were divided into four male and four female groups, each of eight birds. This group size was chosen so that at the lowest stocking rate employed the whole pen could be recorded by video recorder. Individual pens were constructed for each group. These were in the shape of equilateral triangles, constructed out of 1.2 m high hardboard sheets so that they could be enlarged without changing shape by moving just one side. Each pen was equipped with a 40 W tungsten filament lamp connected to a dimmer switch, and the light intensity was equated for each pen using a light meter[3] connected to an integrator. Lights were automatically switched off for 1 h each day from 1400 to 1500 h. The room temperature was decreased with time as recommended by MAFF (1990). All groups consumed grower pellets and water *ad libitum* throughout the trial, these being provided in conical automatic dispensers of 40 cm diameter at the base. Sawdust bedding was provided throughout the trial.

From Day 8, when the birds transferred into the pens in groups, four of the groups (two male and two female) were allocated to be kept at a high stocking density (14 kg/m^2) and the other four groups were kept at a low stocking density (1.7 kg/m^2) for 1 wk. For the 3rd wk, all birds were kept at 1.7 kg/m^2. For the 4th wk, two of the groups (one male and one female) from each of the low and high stocking density treatments in Week 2 were kept at the high stocking density (14 kg/m^2) and the remaining four groups were kept at the low stocking density (1.7 kg/m^2). The area occupied by the feeder and drinker were accounted for in calculating pen area requirements.

The behavior of individual birds in each group was recorded by a time-lapse videorecorder[4] for four 3-h periods (1100 to 1400 h) for each of Weeks 2, 3, and 4. Cameras[5] were suspended at a height of 1.3 m above the floor of each pen. During replay of the tapes the dominant behavior of each bird was recorded at two minute intervals in one of the following categories: feeding, standing, walking, sitting (eyes fully open), dozing (eyes half open or closed with flickering), or sleeping (eyes closed for at least 30 s). Sitting, dozing, and sleeping were also aggregated for statistical analysis into resting behavior. Within 2-min intervals it was observed whether or not birds performed the following behavioral events: pecking inanimate objects (with subclassifications of pecking feed, water, floor, or wall), interaction with other birds (with subclassifications of body, head or vent pecks, chasing, and display), stretching, and preening.

To compensate for the growth of the birds, at the beginning of Weeks 3 and 4 the triangular pen area was changed to form a larger pen of exactly the same shape, the new triangles being mathematically similar to the old. This enabled the stocking densities described above to be maintained without the pen shape changing.

In Week 5, all birds were individually removed from their pens to a 1.5 m^2 enclosed, solid-sided test area where the response to a number of stimuli was monitored. A camera was installed 2.4 m above the floor of the pen and connected to a videodigitizing modem (Sallinen and Hatunen, 1993) installed in a Matmos 486 computer. This modem recorded the number of times that 4% or more of the pixels on the video screen changed brightness due to movement of the bird (birds were white on a dark floor). Measurements were made every 5 s over a 5-min period, and the order of testing was randomized between birds within treatments. In the first test the bird was placed in the center of the pen and the response to the enclosed area monitored. The second test was identical to the first test except that the bird demonstrating the most dominant behavior in the treatment group (as determined by the records of aggressive behavior or priority of access to space in the pen) was restrained behind a perspex barrier in the corner of the pen. This test was omitted for the restrained bird. In the third test, the restrained bird was replaced by a person, who stood motionless in the corner of the pen. This person had been the birds' keeper for the first 4 wk and, therefore, may have been recognized by the birds.

Finally, the birds were subjected to a tonic immobility test for fear response as described by Scott and Moran (1993). Each bird was manually inverted and restrained in a cradle for 10 s. The time taken for the bird to right itself was recorded (up to a maximum of 6 min).

Results were analyzed for the treatment differences in the major behaviors, the open field test, and the tonic immobility test by ANOVA, with all of these variables being normally distributed. Behavioral events were not normally distributed and were analyzed by the Kruskal Wallis test using the Minitab statistical package.

RESULTS

Behavior results are presented as the means for the 3 wk recorded. There was no effect of stocking density on the time spent feeding or standing (Table 1). Walking was increased in birds stocked at the low density, particularly in Week 4. Total time spent lying was not affected by treatment, but birds stocked at the low rate in Week 4 spent more time sitting and less time dozing

[3]Quantum Sensor, Delta-T Devices Ltd., Burwell, Cambridge, CB5 OEJ, UK.

[4]Hitachi model VT-L30OED, Hayes, Middlesex, UB3 4DR, UK.

[5]Panasonic model WV-1450/B, Matsushita Electric Co. Ltd., Uxbridge, Middlesex, UB11 1DD, UK.

TABLE 1. Time spent in major behaviors by broilers in treatments HH, HL, LH, and LL[1] from 8 to 26 d of age[2]

	Stocking density				SED[3]		Probabilities		
Behavior	HH	HL	LH	LL	2/4[4]	Interaction[5]	Week 2	Week 4	Interaction[5]
	(min/100 min)								
Feeding	15.5	14.6	15.2	17.6	1.84	2.63	0.21	0.54	0.14
Standing	13.8	13.6	14.8	14.8	2.26	3.20	0.18	0.71	0.53
Walking	4.6	5.5	5.1	7.2	1.25	1.77	0.05	0.02	0.25
Lying	66.1	66.4	64.9	61.8	13.40	18.90	0.13	0.18	0.43
Sitting	29.4	40.6	28.6	38.5	5.47	7.73	0.92	0.00	0.73
Dozing	18.9	15.6	16.9	12.7	1.87	2.64	0.10	0.00	0.90
Sleeping	17.8	10.2	19.4	10.6	1.68	2.37	0.12	0.00	0.91

[1]H = high stocking density, L = low stocking density, the first letter indicates the stocking density in Week 2 and the second letter indicates the stocking density in Week 4 (e.g., HL = high stocking density Week 2, low stocking density Week 4).

[2]Two pens of four birds each per mean.

[3]Standard error of the difference between two means.

[4]Week 2 or 4.

[5]Interaction between Weeks 2 and 4.

and sleeping. Stocking density in Week 2 did not affect the ratio of sitting to dozing and sleeping.

Birds in the low stocking density in Week 4 pecked more at inanimate objects, particularly when they had already been stocked at the high rate in Week 2 (Table 2). In Week 2 the low stocking density increased the incidence of wall pecking but reduced the incidence of feed and water pecking.

Birds in the low stocking density in Week 4 interacted more with other birds than those in the high stocking density, and this effect was greater when they had previously been stocked at the low rate in Week 2. These effects were evident in body pecking, chasing, and display. They were not evident in pecking the head or vent, which were uncommon forms of interaction in all treatments. The high stocking density in Week 4 decreased the amount of preening, particularly in the birds that had been stocked at the low rate in Week 2.

Male birds stood and walked for longer than female birds and slept less (Table 3). There was no difference in the time males and females spent feeding (Table 3) or pecking at inanimate objects, but male birds interacted more with other birds than female birds (Table 4).

In the tests of movement in a pen with different stimuli, the birds' movement was considerably greater in the empty pen test (the first one) than subsequent tests (Table 5). There were no treatment effects in the empty pen test, but when the bird was restrained in the corner of the pen the greatest activity was recorded in birds that were stocked at the low density throughout. When the person was introduced birds that were highly stocked in Week 2 had greater movement recorded than birds that were stocked at the low rate. Stocking rate in Week 4 did not affect the response.

TABLE 2. Frequency of behaviors recorded as incidents for broilers in treatments HH, HL, LH, and LL[1] from 8 to 26 d of age[2]

	Stocking density				Probabilities		
Behavior	HH	HL	LH	LL	Week 2	Week 4	Interaction[3]
	(no./h)						
Pecking inanimate objects							
Feed pecking	2.1	2.3	1.3	2.0	0.01	0.06	0.28
Water pecking	1.6	2.5	1.0	1.9	0.03	0.00	0.00
Floor pecking	1.7	2.8	1.5	2.5	0.23	0.00	0.00
Wall pecking	0.32	0.32	0.45	0.63	0.03	0.93	0.19
Total pecking	**5.7**	**7.9**	**4.2**	**6.9**	**0.01**	**0.00**	**0.00**
Interaction with other birds							
Body peck	1.07	0.89	0.61	0.93	0.07	0.35	0.02
Head peck	0.14	0.19	0.22	0.33	0.60	0.60	0.61
Vent peck	0.15	0.16	0.16	0.17	0.97	0.97	0.14
Chasing + display	0.67	1.04	0.71	1.13	0.98	0.02	0.00
Total	**2.02**	**2.27**	**1.69**	**2.57**	**0.56**	**0.07**	**0.00**
Stretching	1.5	1.4	1.1	1.7	0.56	0.27	0.52
Preening	3.8	4.4	3.3	4.2	0.23	0.01	0.04

[1]H = high stocking density, L = low stocking density, the first letter indicates the stocking density in Week 2 and the second letter indicates the stocking density in Week 4 (e.g., HL = high stocking density Week 2, low stocking density Week 4).

[2]Two pens of four birds each per mean.

[3]Interaction between Weeks 2 and 4.

TABLE 3. Time spent in major behaviors by male and female broilers from 8 to 26 d of age[1]

Behavior	Male	Female	SED[2]	Probability
	(min/100 min)			
Feeding	15.9	14.8	1.62	0.21
Standing	15.6	12.9	1.60	0.01
Walking	6.4	4.9	0.89	0.02
Resting	62.3	67.4	0.95	0.06
Sitting	34.6	34.1	3.87	0.68
Dozing	15.3	16.7	1.32	0.32
Sleeping	12.4	16.6	1.19	0.00

[1]Two pens of four birds each per mean.

[2]Standard error of the difference between two means.

The tonic immobility test demonstrated that the longest time for birds to right themselves occurred when they had been stocked at the high density in Week 2, and there was a tendency for immobility to be longest in birds that had been stocked at the high density in both Weeks 2 and 4.

DISCUSSION

The high stocking density adopted in this experiment (14 kg/m^2) appeared to be sufficient to cause restrictions on the birds' behavior, at least when applied in Week 4. Increased sleeping and dozing and reduced activity of birds in the high stocking density in Week 4 indicate a passivity response that reduced the birds' frequency of social interaction with conspecifics. The increase in time spent dozing and sleeping at the expense of sitting for birds in the high stocking density may reflect the immobilization function of sleep (Meddis, 1975), whereby it is believed to be of functional value to an animal to be immobilized during high risk periods, e.g., at night. No effect was observed on the total time spent lying, which is contrary to the hypothesis of Murphy and Preston (1988) that lying time is controlled by a combination of stocking density and total space availability. However the bird density in their study was low (14 birds per square meter) and they did not directly compare lying times at different densities, only a qualitative measure of restlessness.

A reduced degree of behavioral response to a high stocking density was evident when it was applied in Week 2, either because the birds were socially naive at this age or because the cumulative effects of an inadequate environment (at either stocking density) were more evident at Week 4 than 2. The high stocking density in Week 2 did, however, reduce locomotion and the amount of wall pecking, indicating a degree of restriction on environmental exploration. This may have occurred because at the same levels of locomotion the birds in the high stocking density would receive more stimulation from other birds, because of the greater frequency of birds in close proximity, than birds in the low stocking density. Wall pecking was probably reduced because the walls were shorter in this treatment and were often inaccessible because of the presence of other birds. The increase in feed and water pecking by birds in the high stocking density in Week 2 suggests that these may function as redirected behaviors, compensating perhaps for reduced wall pecking. It is also possible that the rates of intake of feed and water were reduced due to greater competition at the dispensers, or difficulty in avoiding the feeder and drinker at the high stocking density because they occupied a larger proportion of each pen. Uner *et al.* (1997) found that birds kept at high densities spent more time concentrated around feeders and drinkers.

The increased interaction with conspecifics by birds in the low stocking density in Week 4 was greater when the birds had also been in the low stocking density in Week 2. To this extent the effects of stocking density were cumulative. The increased interaction with conspecifics at high stocking densities was confined to the nonaggressive forms: body pecks and chasing. Blokhuis (1986) has shown that feather (or body) pecking is motivationally connected with floor pecking. Increases were not evident in the potentially damaging head and vent pecking, which were both rare. The latter occurs principally in birds that have just laid and the red coloration of the vent, and later blood, provides a stimulus to the bird to peck (Appleby *et al.*, 1992).

The absence of treatment effects when birds were tested for motion in an empty pen, but the increase in tonic immobility of birds that had been in the high stocking density, when measured by inversion, suggests that the empty pen test did not test for fear. The problems with interpretation of the behavior of animals placed in novel test arenas have been discussed by Russell (1983). The high variation in activity of birds in the empty arena may derive from the varied sources of motivation for locomotion in such a novel circumstance—exploration, escape from the isolation or novelty of the situation. This may restrict the value of the test for assessing fear responses.

Activity was considerably reduced in the second and third tests when specific stimuli were positioned in the pen. This reduction in activity may have been because the pen itself was familiar to the birds and a reduced escape reaction was evoked, or the stimuli themselves,

TABLE 4. Frequency of behaviors recorded as incidents for male and female broilers from 8 to 26 d of age[1]

Behavior	Male	Female	Probability
	(no./h)		
Pecking at inanimate objects	6.5	5.8	0.38
Interaction with other birds	2.4	1.9	0.04
Stretching	1.4	1.4	0.79
Preening	3.9	3.8	0.98

[1]Two pens of four birds each per mean.

TABLE 5. Movement of broilers in treatments HH, HL, LH, and LL[1] in an empty pen and in the presence of a dominant bird, a person and a novel object, and the duration of tonic immobility following inversion[2]

	Stocking density				SED[3]		Probabilities		
Treatment	HH	HL	LH	LL	2/4[4]	Interaction[5]	Week 2	Week 4	Interaction[5]
	(no. times threshold exceeded/5 min)								
Empty pen	6,043	4,717	8,570	5,914	840	1,188	0.30	0.33	0.73
Dominant bird	124	84	57	173	38	53	0.72	0.23	0.01
Person	120	164	51	40	36	50	0.00	0.58	0.36
	(s/broiler)								
Tonic immobility	193	134	75	125	30	42	0.04	0.89	0.08

[1]H = high stocking density, L = low stocking density, the first letter indicates the stocking density in Week 2 and the second letter indicates the stocking density in Week 4 (e.g., HL = high stocking density Week 2, low stocking density Week 4).

[2]Two pens of four birds each per mean.

[3]Standard error of the difference between two means.

[4]Week 2 or 4.

[5]Interaction between Weeks 2 and 4.

being familiar, may have reduced the response to the test. Some specific effects of treatment were recorded in response to the stimuli placed in the pen. The greater response to the presence of a bird by birds stocked at the low density throughout may derive from the increased activity of these birds during the behavior study. The situation may have been less fearful than an empty pen or a pen with a person in it, and the increased activity of birds in treatment LL may not have been escape but investigational behavior. Additionally, birds kept at the low stocking density had had more interactions with other birds and this may have increased their reaction.

The response to the person was limited to increased activity by birds stocked at the high rate in Week 2. This suggests that these birds may have been more inclined to react to human presence than when the high stocking rate was imposed later on. The high stocking rate may have facilitated greater bonding between birds and the observed response to the human was essentially one of escape.

The tonic immobility test by inversion in a cradle gave a clear indication that fear was increased by the high stocking density imposed in Week 2, with an indication that it was greatest for birds that experienced the double period of high stocking density. The greater response to high stocking density in Week 2 than 4 is surprising, as behavior was generally more influenced by the high stocking rate imposed in Week 4 than 2, and the test arena demonstrated that birds kept at the high stocking rate in Week 2 were more active in the presence of a familiar person. This reaction to human presence may constitute escape attempts, whereas the stimulus of manual inversion in the cradle was sufficiently severe to invoke the tonic immobility response.

It is concluded that a high stocking density reduces activity in broiler chickens, and that birds stocked at a high density in the first half of life show a greater reaction to people and the longest tonic immobility in response to a stressful stimulus.

ACKNOWLEDGMENTS

The authors acknowledge the help of Z. Varga in conducting the experiment, and thank H. Bradshaw and R. Kirkden for useful comments on the manuscript.

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