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## On-farm assessment of environmental enrichment for broiler breeders

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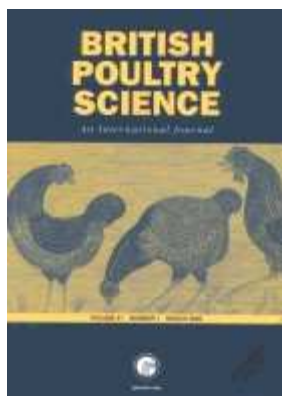
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**On-farm assessment of environmental enrichment for broiler breeders**

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**Table 1.** Resource use by female broiler breeders on a commercial farm at 5, 10 and 16 weeks of age: means of 24 observations at 10-minute intervals from 0830 to 1420 h. (Angular transformation with backtransformed means (%) in parentheses.) Treatments were no environmental enrichment (Control) or enrichment devices introduced at hatch (EE1) or at 8 weeks of age (EE2).

Factor		Total (N)	Proportion (%) of birds using resource				
Age, weeks	Treatment		Bale <sup>1</sup>	Wall	Drinker	Litter	Perch
5	Control	88.4	-	11.0 (4)	17.9 (9)	66.4 (84)	9.4 (3)
	EE1	98.6	32.4(28)	6.9 (1)	15.9 (7)	49.5 (58)	8.7 (2)
	EE2	91.2	-	9.9 (3)	16.1 (8)	68.7 (87)	8.8 (2)
10	Control	53.9	-	10.3 (3)	27.6 (22)	52.1 (62)	20.9 (13)
	EE1	66.7	24.6 (17)	7.9 (2)	25.6 (19)	41.6 (44)	17.0 (9)
	EE2	81.9	29.8 (25)	9.5 (3)	24.8 (18)	39.6 (41)	16.3 (8)
16	Control	49.1	-	6.8 (1)	26.5 (20)	49.3 (57)	27.0 (21)
	EE1	64.4	14.2 (6)	6.9 (1)	25.1 (18)	45.5 (51)	26.2 (20)
	EE2	63.1	15.5 (7)	6.4 (1)	26.6 (20)	43.5 (47)	26.1 (19)
SEDa <sup>2</sup>		9.96	1.67	1.66	3.23	2.42	2.08
SEDb <sup>3</sup>		10.56	1.23	1.62	3.16	2.81	1.97
Treatment		*	NS	NS	NS	***	NS
Age		***	***	*	***	***	***
Treatment x Age		NS	NS	NS	NS	***	NS

<sup>1</sup>Analysis of EE1 and EE2 at 10 and 15 weeks only; means for EE1 at 5 weeks are also presented (see text).

<sup>2</sup>Standard error of a difference between two ages.

1  
2  
3 10 <sup>3</sup>Standard error of a difference between two treatment means.  
4

5  
6 11 \*  $P < 0.05$ ; \*\*\*  $P < 0.001$ ; NS = not significant  
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**Table 2.** Mean number of acts of aggression recorded at different pen resources on a commercial farm of female broiler breeders at 5, 10 and 16 weeks of age. Treatments were no environmental enrichment (Control) or enrichment devices introduced at hatch (EE1) or at 8 weeks of age (EE2).

Factor		Aggression at resource, n/b/h		
Age, weeks	Treatment	Bale <sup>1</sup>	Drinker	Litter
5	Control	-	0.14	0.44
	EE1	(0.05)	0.00	0.38
	EE2	-	0.00	0.18
10	Control	-	0.25	0.65
	EE1	0.48	1.20	1.91
	EE2	0.05	0.00	0.86
16	Control	-	4.98	2.23
	EE1	1.93	3.19	1.28
	EE2	3.48	2.48	1.07
	SEDa <sup>2</sup>	1.625	2.012	0.418
	SEDb <sup>3</sup>	1.558	1.908	0.446
	Treatment	NS	NS	NS
	Age	NS	**	***
	Treatment x Age	NS	NS	*

<sup>1</sup>Analysis of variance results for EE1 and EE2 at 10 and 15 weeks only; the mean for EE1 at 5 weeks is also presented (see text).

<sup>2</sup>Standard error of a difference between two ages.

<sup>3</sup>Standard error of a difference between two treatment means.

\* =  $P < 0.05$ ; \*\* =  $P < 0.01$ ; \*\*\*  $P < 0.001$ ; NS = not significant

22 **Table 3.** Mean score for feather damage on different areas of the body of female  
 23 broiler breeders at 6, 12 and 18 weeks of age on a commercial farm. Treatments were  
 24 no environmental enrichment (Control) or enrichment devices introduced at hatch  
 25 (EE1) or at 8 weeks of age (EE2).


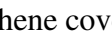
Factor		Feather damage score	
Age, weeks	Treatment	Wings/back	Tail/vent
6	Control	0.72	0.09
	EE1	0.75	0.05
	EE2	0.86	0.06
12	Control	1.44	1.48
	EE1	1.29	1.35
	EE2	1.14	0.14
18	Control	1.93	2.55
	EE1	1.77	2.58
	EE2	1.87	2.78
SEDa <sup>1</sup>		0.107	0.226
SEDb <sup>2</sup>		0.117	0.225
Treatment		NS	NS
Age		***	***
Treatment x Age		NS	NS

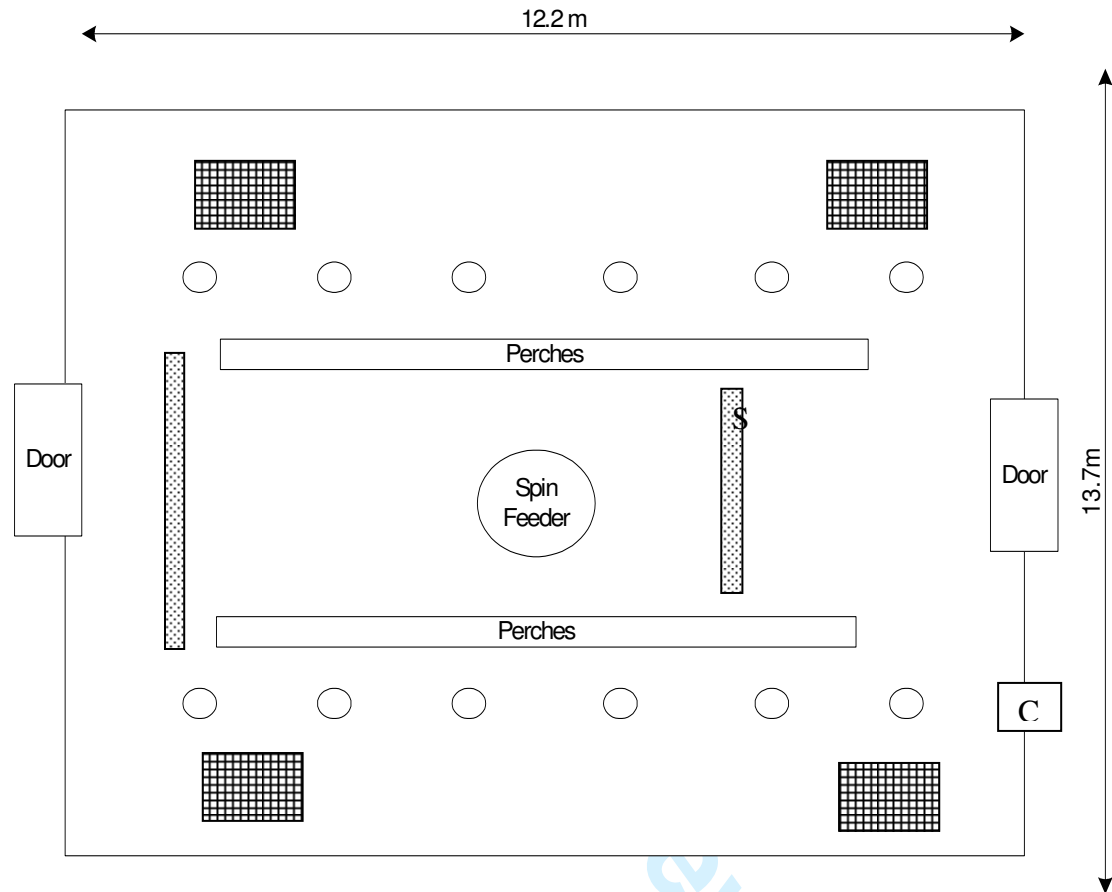
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28 <sup>1</sup> Standard error of a difference between two ages.

29 <sup>2</sup> Standard error of a difference between two treatment means.

30 \*\*\*  $P < 0.001$

**Figure 1.** Schematic plan view of one of the three pens in each of the four rooms. C = camera;  = polythene covered bale of wood shavings;  = batons with bunches of polypropylene string



1 **Figure 2.** Scores for condition of string bunches.

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Review Only



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5 **On-farm assessment of environmental enrichment for broiler breeders**  
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54 4PQ.  
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56  
57 **Abstract** 1. A field experiment was conducted with commercial broiler  
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5 breeder females to assess the hypothesis that the provision of bunches of  
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8 string and bales of wood shavings would provide attractive environmental  
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10 enrichment and improve welfare by decreasing aggression and feather  
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12 damage.

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16 2. The experiment was a randomised block factorial design conducted in a  
17  
18 commercial flock of 21 600 female broiler breeders in 12 pens of 1800  
19  
20 chicks. Treatments were environmental enrichment (4 plastic coated bales of  
21  
22 wood shavings and 50 bunches of string) from hatch (EE1) or 8 weeks of  
23  
24 age (EE2) and a control treatment with no environmental enrichment. There  
25  
26 were 4 replicates (rooms).  
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32 3. Bird activity was videotaped at 5, 10 and 16 weeks of age and  
33  
34 subsequently scored for the number of birds using the perch or pecking at a  
35  
36 bale, drinker, litter and section of the wall at 10-min intervals for 4 h  
37  
38 throughout the photoperiod (24 times/d). Aggression was assessed by  
39  
40 determining the number of aggressive acts in 2-min intervals during 8  
41  
42 periods of the day. The skin and feather condition of 25 birds in each pen  
43  
44 were scored at 6, 12 and 18 weeks and the condition of the string bunches  
45  
46 were scored at the end of the experiment.  
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54 4. The proportion of birds pecking the bales, wall and litter declined and the  
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56 proportion pecking at the drinker and using the perch increased with age.  
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5 The number of birds pecking at the bale was similar in EE1 and EE2 at 10  
6  
7 and 16 weeks of age.  
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10 5. The string bunches were not extensively used. The condition of the  
11  
12 bunches of string in EE2 was worse than in EE1 at the end of the  
13  
14 experiment.  
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16  
17 6. The number of aggressive acts increased with age and there was no  
18  
19 consistent difference between treatments.  
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23 7. There was an increase with age in the damage score for feathers over the  
24  
25 back and wings and around the tail and vent but no differences between  
26  
27 treatments.  
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31 8. Provision of litter in the form of unopened bales of wood shavings was a  
32  
33 commercially acceptable form of environmental enrichment, but there was  
34  
35 no evidence that behavioural changes associated with feed restriction,  
36  
37 including the prevalence of aggression, were improved.  
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## 45 46 INTRODUCTION

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48  
49 Environmental enrichment (EE) can improve poultry welfare, productivity  
50  
51 and profitability by reducing fear, aggression and feather pecking (Gvaryahu  
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53 *et al.*, 1994; Huber-Eicher and Wechsler, 1998; Jones, 2001*b*; Jones *et al.*,  
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5 2000a; Newberry, 1995). Furthermore, substrates that elicit foraging or  
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8 dustbathing reduce the risk of feather pecking (Nicol *et al.*, 2001; Norgaard-  
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10  
11 Nielsen, 1997). Jones (1999a) showed that chicks increased their use of an  
12  
13 environment when it was enriched. A bunch of white strings was an  
14  
15 attractive pecking stimulus for various strains of laying hens and sustained  
16  
17 the birds' interest in groups of adult hens and chicks (Jones and Carmichael,  
18  
19 1999b, 1999c). Other forms of environmental enrichment, such as compact  
20  
21 discs (King, 2001), straw (Huber-Eicher and Sebo, 2001; Hubereicher and  
22  
23 Wechsler, 1997; Johnsen *et al.*, 1998) and bales of wood shavings (Blokhuis  
24  
25 and Haar, 1992; Burkhart *et al.*, 1983; King, 2001; Nicol *et al.*, 2001), also  
26  
27 exerted beneficial effects, including reduced aggression. Kells *et al.* (2001)  
28  
29 studied the effect of EE on the behaviour of broiler chickens on commercial  
30  
31 farms. They found that broilers were more active in terms of walking and  
32  
33 running and sat for less time in enriched houses, even when observed away  
34  
35 from the EE (bales of wood shavings). King (2001), in experiments with  
36  
37 limited replication, showed that bales of wood shavings and the provision of  
38  
39 CDs reduced aggression in commercial broiler breeders and that bales also  
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41 increased foraging in the litter and reduced pecking at the drinkers and walls.  
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54 The notion of a sensitive period for imprinting or the formation of  
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56 preferences is commonly accepted, though this does not imply irreversibility  
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5 (Jones *et al.*, 2000a; Sanotra *et al.*, 1995). However, the introduction of  
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8 enrichment stimuli at different ages has yielded inconsistent results. Nicol *et*  
9  
10 *al.* (2001), for example, suggested that provision of wood litter shavings at a  
11  
12 range of ages during rearing reduced feather pecking in adults whereas  
13  
14 Huber-Eicher and Sebo (2001) proposed that its provision during the first 2  
15  
16 weeks was the most effective. In fact, they recommended, “that laying  
17  
18 chicks raised in aviary systems get access to litter from day 1 on”. Access to  
19  
20 string from 1 day of age caused greater reductions in feather pecking among  
21  
22 birds from a line showing high rates of this behaviour than did later exposure  
23  
24 but reduction of pecking-related damage in caged commercial layers was  
25  
26 apparent, regardless of whether string was introduced at 1 day or 16 weeks  
27  
28 of age (McAdie *et al.*, 2005).  
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38 The body weight gains of female broiler breeders are limited by  
39  
40 feed restriction to enhance reproductive efficiency and decrease mortality  
41  
42 (Hocking *et al.*, 2002). The degree of feed restriction relative to *ad libitum*  
43  
44 feeding changes with age and becomes substantial from 6 to 8 weeks of age.  
45  
46 Feed-restricted birds spend less time resting and more time foraging  
47  
48 (scratching and pecking the litter), drinking and spot pecking at the walls  
49  
50 than birds fed *ad libitum* (Hocking, 2004). We have shown that the  
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52 provision of litter may decrease the propensity for aggression in feed-  
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4 restricted broiler breeders (Hocking *et al.*, 2005) and we postulate that the  
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6 provision of environmental enrichment will have a beneficial effect in  
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8 reducing aggression and the frequency of so-called abnormal (stereotypic)  
9  
10 wall pecking.  
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14  
15 The aim of the present study was to identify the welfare  
16  
17 consequences of introducing environmental enrichment (EE) at two ages in  
18  
19 rearing flocks of female broiler breeders in a commercial setting. Two forms  
20  
21 of EE were utilised: polythene covered bales of wood shavings and bunches  
22  
23 of string (Jones, 2001a; Jones *et al.*, 2000b; Jones *et al.*, 2002; Jones and  
24  
25 Rayner, 2000). In order to examine the effect of age and habituation on the  
26  
27 use of EE they were introduced at hatch (EE1) or at 8 weeks of age (EE2),  
28  
29 when the degree of feed restriction has become significant. The hypotheses  
30  
31 tested were that environmental enrichment will decrease aggression by  
32  
33 alleviating frustration of thwarted feeding behaviour caused by feed  
34  
35 restriction and increasing the opportunities for non-damaging oral activity,  
36  
37 and that the novelty of introducing EE at 8 weeks will elicit greater use  
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39 compared with its introduction at hatch through lack of early habituation.  
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## 51 52 53 54 MATERIALS AND METHODS 55 56 57 58 59 60

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5 Broiler breeder females (Ross 308, Aviagen, Newbridge, Edinburgh) on a  
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7 commercial rearing farm were housed at 1-d old in two poultry sheds that  
8  
9 were divided by a large area used for food storage and servicing the birds.  
10  
11 Each half shed (room) was divided into 4 pens: there were three large pens  
12  
13 approximately 14 m wide x 12 m long and a smaller pen that was used for  
14  
15 the separate feeding of birds that were under weight. The three larger pens  
16  
17 were randomly assigned to one of the three experimental treatments. There  
18  
19 were 1800 1-d-old chicks placed in each of the large pens at the start of the  
20  
21 experiment (21 600 birds in total) and birds were removed from 4 weeks of  
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23 age to the small pen if under weight. The birds were returned at random to  
24  
25 the larger pens when they were considered large enough. The placement of  
26  
27 pen furniture and environmental enrichment devices are presented  
28  
29 schematically in Figure 1. The A-frame perches were 83 cm high and there  
30  
31 were three levels approximately 25 cm apart. Bird weights were recorded  
32  
33 automatically and feed allowance was adjusted regularly to achieve the  
34  
35 breeder's recommended target body weight gains described in the  
36  
37 management manual. The daily allocation of feed was distributed at 08.00 h  
38  
39 by a spin feeder suspended from the roof in the centre of each pen. A  
40  
41 standard commercial vaccination programme was followed to protect the  
42  
43 birds against common diseases. The photoperiod during the observation  
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5 period was 8 h light in each 24 h period (lights on from 07.30 to 15.30 h).  
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8 The birds were not beak trimmed and light intensity (mean of 5 observations  
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10 in each pen) ranged from 6 to 8 lux. .  
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### 14 15 16 **Environmental enrichment**

17  
18 Plastic covered bales of white wood shavings (79 cm long x 38 cm wide x  
19  
20 28 cm high) were placed in each of the 4 corners of the enriched pens  
21  
22 (Figure 1). The bales were replaced when they were first exhausted at 6  
23  
24 weeks and every 2 weeks thereafter and the stockmen removed the plastic  
25  
26 when the bale had been destroyed. Regardless of condition, fresh bales were  
27  
28 provided to the experimental pens at the start of each week of video  
29  
30 recording.  
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38 Ten bunches of white polypropylene string were attached to wooden  
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40 batons 1.7 m long. Two batons were suspended from a roof truss at one  
41  
42 location and three at a second (Figure 1) in each of the enriched pens. The  
43  
44 batons could be raised and lowered by pulling on a suspending rope attached  
45  
46 to the ends of each baton and looped through two eyelets screwed into a  
47  
48 crossbeam. The batons were raised as the birds grew so that the top of the  
49  
50 string bunches was just above the bird's heads and could be raised to over 2  
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52 m when necessary for management reasons. Bunches of string were made  
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4 from 8 strands of white polypropylene string doubled to form two lengths of  
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6 approximately 16 cm (see Figure 2).  
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## 10 11 12 **Observations**

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15 One video camera was fixed to the wall of each pen at a height of about 2 m  
16  
17 above the litter so that a view of all the main features in one half of the pen  
18  
19 was visible. The lens was focussed and the angle of the camera was  
20  
21 standardised by observing birds within a fixed area between the roof  
22  
23 supports. Two rooms were video taped on each of two days over the entire  
24  
25 photoperiod at 5, 10 and 16 weeks of age before the video recorders were  
26  
27 moved to the second shed. The tapes were subsequently played back and  
28  
29 scored as follows. Resource use was assessed by recording the numbers of  
30  
31 birds associated with each of 5 resources: the bale of shavings, drinker and  
32  
33 perch closest to the camera, the litter between the two middle roof supports  
34  
35 and the wall between these two posts. The area of the drinker was defined as  
36  
37 the circumference of the drinker plus one bird length. The observations were  
38  
39 repeated every 10 min from 08.30 to 09.20, 10.30 to 12.20 and 13.30 to  
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41 14.20 h for a total of 24 observations at each age.  
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53 Aggression was defined as a vigorous peck aimed at the head,  
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55 comb, neck or back that resulted in the immediate withdrawal of the  
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4 recipient, usually with accompanying vocalisation, a similar aggressive  
5 threat or chasing. The numbers of aggressive interactions (pecks) performed  
6 by birds at the bale, drinker and litter areas as defined above were  
7 determined during 2 min at 30 min intervals at 8.30 and 09.00, 10.30 to  
8 12.00, 13:30 and 14:00 h for a total of 8 observation periods for each pen at  
9 5, 10 and 16 weeks of age.

10  
11 Skin and feather condition was assessed at 6, 12 and 18 weeks.  
12 Birds were penned in one corner of each pen and 25 birds selected at random  
13 (bird nearest observer). The feathers and skin over the back and wings, tail  
14 and vent, neck (including the breast) and the head and comb area were  
15 examined and scored. Scores for feather damage were assigned according to  
16 a subjective assessment by the same person of the proportion of feathers that  
17 were broken or damaged as follows: none (score 0), 1-25% (1), 25-50% (2),  
18 50-75% (3) and 75-100% (4).

19  
20 The condition of individual bunches of string were scored at 8 and  
21 18 weeks of age on a 5-point scale (Figure 2).

## 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 **Statistic analysis**

44  
45 The experiment was a randomised block design with three treatments  
46 (Control, EE1 and EE2). The total number of birds observed at the 5  
47 resources was calculated and the mean total number observed in each pen,  
48 age and time was analysed by a split-plot model with effects for Room, Pen  
49 within Room, Treatment and Age. The proportion of the total number of  
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5 birds that were counted at the different resources was analysed after angular  
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7 transformation of the proportion (% +1). Total counts of aggression at each  
8  
9 resource were converted to rate/h and then transformed to rate/bird/h by  
10  
11 dividing by the mean number of birds observed at that resource in that pen  
12  
13 on the day of the observations. The residual errors for these data were  
14  
15 approximately normally distributed. The effect of age on resource use and  
16  
17 aggression around the bales was limited to data from EE1 and treatment  
18  
19 comparisons to EE1 and EE2 at 10 and 16 weeks of age only. Feather scores  
20  
21 for different body parts for each pen were averaged and analysed by the  
22  
23 same model without transformation.  
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## 35 RESULTS

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40 The total numbers of birds using each resource at different ages are  
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42 presented in Table 1. The total numbers of birds in each resource area  
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44 declined with age (means for 5, 10 and 16 weeks respectively were 92.7,  
45  
46 67.5 and 58.9, sed 6.10,  $P < 0.001$ ). The mean total number of birds observed  
47  
48 for Control, EE1 and EE2 respectively were 63.8, 76.6 and 87.7 (sed 4.99,  
49  
50  $P < 0.01$ ) and reflected the absence of observations (birds) around the bale in  
51  
52 the control treatment The proportions of the total number of birds that were  
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5 observed using each resource was therefore analysed and means are given in  
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7  
8 Table 1. There were declines with age in the proportion of birds using the  
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10 bale, pecking the wall ( $P<0.05$ ) and foraging in the litter ( $P<0.001$ ) and an  
11  
12 increase in the proportion of birds around the drinker and on the perch  
13  
14 ( $P<0.001$ ). Means (back transformed) for the proportion of birds  
15  
16 surrounding the bale in EE1 at 5, 10 and 16 weeks respectively were 32.4  
17  
18 (28.8), 24.6 (17.4) and 14.2 (6.0),  $sd$  2.81,  $P<0.1$ ). The decline for EE2 was  
19  
20 similar to that for EE1 and a similar proportion of birds used the bale at 10  
21  
22 and 16 weeks on both EE1 and EE2 (respective treatment means were 19.4  
23  
24 (211.1) and 22.7 (24.8),  $sd$  1.23,  $P<0.08$ ). The interaction of treatment x  
25  
26 age was significant ( $P<0.001$ ) for the proportion of birds using the litter  
27  
28 (Table 1): the proportions were higher when bales of shavings were not  
29  
30 present (in the control and EE2 treatments at 5 and the control at 10 weeks  
31  
32 of age) but the differences between the control and both enrichment  
33  
34 treatments were relatively small and not significant at 16 weeks.  
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46 The mean number of acts of aggression in birds surrounding the  
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48 bale, the drinker and in the observed area of the litter increased with age  
49  
50 (Table 2). Analysis of EE1 also showed an increase with age in aggression  
51  
52 at the bale: means at 5, 10 and 16 weeks respectively were 0.05, 0.48 and  
53  
54 1.93 /h/bird,  $sd$  0.0.371,  $P<0.01$ . There was no effect of treatment (EE1 vs.  
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5 EE2) on the prevalence of aggression at the bale or the drinker but there was  
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8 an age x treatment interaction ( $P<0.05$ ) for aggression at the litter associated  
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10 with high subclass means for aggression in EE1 at 10 weeks and the control  
11  
12 at 16 weeks of age (Table 1).  
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15  
16 Overall mortality averaged 1.5% from hatch to 18 weeks and there  
17  
18 were no observed cases of feather loss or skin lesions at the time of  
19  
20 assessing the condition of the integument at 6, 12 or 18 weeks of age in the  
21  
22 sample of recorded birds. Feather damage scores for wings and back feathers  
23  
24 and for the tail and vent areas were combined and results are presented in  
25  
26 Table 3. There was an increase ( $P<0.001$ ) in feather damage scores for both  
27  
28 body areas but no differences between the three treatments.  
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35 The batons holding the string were removed from the pens before  
36  
37 they were scored at the end of the experiment and mean scores for each  
38  
39 baton could only be assigned to treatment. The standard error between pen  
40  
41 means at 9 weeks (0.1503) was therefore used to estimate the standard error  
42  
43 between treatment means. The mean scores for EE1 at 9 and 18 weeks  
44  
45 respectively were 1.12 and 1.51 ( $t>2.55$ ,  $P<0.05$ ) and the mean score for  
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47 EE2 at 18 weeks was 2.39 ( $t>5.86$ ,  $P<0.01$  compared with EE1 at 18 weeks).  
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## DISCUSSION

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8 The relative use of the two enrichment devices was compared by observing  
9  
10 the proportion of birds using the bales as pecking targets and the condition  
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12 of the string bunches. The increased number of birds foraging in the litter on  
13  
14 EE1 and EE2 probably reflects the attractiveness of the bales of wood  
15  
16 shavings and the limited area available for pecking at the bale and may also  
17  
18 explain the interaction between treatment and age for the proportion of birds  
19  
20 using the litter.  
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27 The evidence from this experiment is consistent with the  
28  
29 results of an unpublished Ph.D. thesis (King, 2001) in showing extensive use  
30  
31 of the bales of wood shavings: the bales were surrounded by active birds  
32  
33 from at least 5 weeks of age in EE1 when the birds were able to puncture the  
34  
35 plastic covering the bales, resulting in their destruction regular replacement.  
36  
37  
38 In contrast to the experiments of King (2001), there was no change in the  
39  
40 proportion of birds perching, pecking at the drinker or wall and there was a  
41  
42 decrease in the number of birds foraging away from the environmental  
43  
44 enrichment devices. The differences between the studies could be associated  
45  
46 with the lack of replication in King's research, differences in methodology  
47  
48 or the use of twice as many bales in her experiment. Bales of wood shavings  
49  
50 are a relatively expensive but biosecure resource and our use was additional  
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5 to the usual farm allocation that maintained the litter in a dry friable state.  
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8       Whereas the bales attracted more birds to the total area under  
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10 observation (about one third of the pen), there were more birds foraging in  
11  
12 the litter in the control pens. This suggests that the bales have no more effect  
13  
14 in diminishing frustrated feeding behaviour than litter elsewhere in the pen  
15  
16 and that they may have attracted the bird's interest merely because they were  
17  
18 clean or novel. In addition the plastic surrounding the bales of wood  
19  
20 shavings may itself have been an attractive pecking target. The bales were  
21  
22 available to the chicks on EE1 as soon as the brooding surrounds were  
23  
24 removed at 14 d but little use was made of them until 4 weeks and they were  
25  
26 first replaced at 6 weeks of age. It is likely that the birds could not make full  
27  
28 use of the resource before 5 weeks because they were unable to puncture the  
29  
30 plastic, as noted above.  
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40       Initially the string attaching the bunches of string to the batons  
41  
42 became entangled and was manually freed and three birds also hanged  
43  
44 themselves on them. Surrounding the lower part of each suspending string  
45  
46 with 40 cm split water drinker tubing solved the problem and the devices for  
47  
48 EE2 were fitted with these additions from their introduction at 8 weeks of  
49  
50 age. The bunches of string introduced at 8 weeks in EE2 were initially used  
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52 extensively, after which comparable and comparatively little interest in the  
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5 bunches of string was observed in both treatments. Unfortunately the video  
6  
7 recording of the string devices was not clearly visible and we could not  
8  
9 accurately determine the numbers of birds using them.  
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13 The lack of sustained interest in the string bunches contrasts with  
14  
15 the continued interest in these devices in caged laying hens (McAdie *et al.*,  
16  
17 2005). It is possible that the motivation to peck at these devices in feed-  
18  
19 restricted broiler breeders is different from that in laying hens. If interest in  
20  
21 the latter is associated with adult grooming behaviour or the need for oral  
22  
23 manipulation of long roughage (for nest building, for example), then the  
24  
25 relative lack of interest in sexually-immature broiler breeders could be  
26  
27 explained.  
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35 Extensive initial interest in the string bunches in EE2 could be  
36  
37 associated with novelty and the subsequent lack of interest due to  
38  
39 habituation. King (2001) reported continued interest in CDs throughout her  
40  
41 experiment but habituation has been noted for CDs and a number of other  
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43 attractive pecking targets assessed commercially (D. Harrower, personal  
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45 communication).  
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51 The rates of aggression in this experiment were surprisingly high,  
52  
53 particularly at 16 weeks. The sum of the means for EE1 at 10 weeks was  
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55 relatively high compared to the control and EE2 (more than 3 vs. less than  
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5 1/h/bird). At 16 weeks the rate for the control was relatively high at the  
6  
7 drinker and litter but was not dissimilar to EE1 and EE2 if the rates of  
8  
9 aggression at the bale were included (total treatment means were 8.2 vs 6.3  
10  
11 and 7.0/h/bird respectively for control, EE1 and EE2). Statistical analyses of  
12  
13 combined data failed to provide any support for the suggestion that  
14  
15 environmental enrichment decreased aggression (results not shown). To our  
16  
17 knowledge, the extent of feather damage in feed-restricted broiler breeders  
18  
19 has not been previously reported. We expected that, with trivial numbers of  
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21 culls for pecking damage, there would be little evidence of feather loss or  
22  
23 damage and the state of the feathers was not readily apparent until the birds  
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25 were handled and the plumage examined carefully.  
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35 The high rates of aggression (Table 2) could be the cause of the  
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37 feather damage. Alternatively, high feather damage scores might indicate  
38  
39 that extensive oral manipulation of feathers occurred although this was not  
40  
41 observed in the videos. Small pieces of missing feather and abraded barbs  
42  
43 might be associated with pecking at pellets or particles of feed in the  
44  
45 plumage at the time of feed distribution by the overhead spin feeders.  
46  
47 Alternatively the birds may manipulate their own feathers but this seems  
48  
49 unlikely as it was not observed in the videos, nor has it been reported in  
50  
51 other experiments. Furthermore, if it did occur, we would have expected  
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5 greater use to be made of the bunches of string.  
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8         The birds in this commercial flock showed very little wall pecking or  
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10 object pecking, in contrast to reports of experiments utilising small pens (De  
11  
12 Jong *et al.*, 2005; Hocking *et al.*, 1993; Hocking *et al.*, 2001; Savory and  
13  
14 Maros, 1993). The proportions of birds pecking the drinker were comparable  
15  
16 whereas scratching and pecking at the litter was slightly higher than in  
17  
18 small-scale experiments. Perches have not generally been included in the  
19  
20 latter whereas up to 26 % of the birds used them in our commercial  
21  
22 environment (Table 1). The results suggest that relying on behavioural  
23  
24 assessment of welfare in small-scale experiments with feed-restricted broiler  
25  
26 breeders may need to be re-evaluated. The extensive air pecking reported by  
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28 King (2001) was not observed in our field study.  
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38         In conclusion we have shown that environmental enrichment in the  
39  
40 form of bales of wood shavings attracted more birds to that location but the  
41  
42 total proportion foraging in the litter and at the bale were similar to the  
43  
44 control treatment. The proportion of birds pecking at the drinker was not  
45  
46 affected by environmental enrichment. Bunches of string were used as  
47  
48 pecking targets but the birds appeared to habituate to them and they were  
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50 apparently not used extensively after initial interest. There was no consistent  
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52 effect of environmental enrichment on aggression and rates of aggression  
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5 were relatively high. We conclude that environmental enrichment in the  
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7 form of bales of wood shavings and bunches of string had little or no effect  
8  
9 on alleviating the frustration of feeding motivation in feed-restricted broiler  
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11 breeders.  
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43 **Table 1.** *Resource use by female broiler breeders on a commercial*  
44 *farm at 5, 10 and 16 weeks of age: means of 24 observations at 10-*  
45 *min intervals from 08.30 to 14.20 h. (Angular transformation with*  
46 *back-transformed means (%) in parentheses.) Treatments were no*  
47 *environmental enrichment (control) or enrichment devices*  
48 *introduced at hatch (EE1) or at 8 weeks of age (EE2).*  
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Factor		Total	Proportion (%) of birds using res			
Age (weeks)	Treatment	(N)	Bale <sup>1</sup>	Wall	Drinker	Litter
5	Control	88.4	-	11.0 (4)	17.9(9)	66.4 (84)
	EE1	98.6	32.4(28)	6.9 (1)	15.9 (7)	49.5 (58)
	EE2	91.2	-	9.9 (3)	16.1 (8)	68.7 (87)
10	Control	53.9	-	10.3 (3)	27.6 (22)	52.1 (62)
	EE1	66.7	24.6 (17)	7.9 (2)	25.6 (19)	41.6 (44)
	EE2	81.9	29.8(25)	9.5 (3)	24.8 (18)	39.6 (41)
16	Control	49.1	-	6.8 (1)	26.5 (20)	49.3 (57)
	EE1	64.4	14.2 (6)	6.9 (1)	25.1 (18)	45.5 (51)
	EE2	63.1	15.5 (7)	6.4 (1)	26.6 (20)	43.5 (47)
SEDa <sup>2</sup>		9.96	1.67	1.66	3.23	2.42

SEDb <sup>3</sup>	10.56	1.23	1.62	3.16	2.81
Treatment	*	NS	NS	NS	***
Age	***	***	*	***	***
Treatment x age	NS	NS	NS	NS	***

<sup>1</sup>Analysis of EE1 and EE2 at 10 and 15 weeks only; means for EE1 at 5 weeks are also presented (see text).

<sup>2</sup>Standard error of a difference between two ages.

<sup>3</sup>Standard error of a difference between two treatment means.

\*  $P < 0.05$ ; \*\*\*  $P < 0.001$ ; NS = not significant

**Table 2.** Mean number of acts of aggression recorded at different pen resources on a commercial farm of female broiler breeders at 5, 10 and 16 weeks of age. Treatments were no environmental enrichment (control) or enrichment devices introduced at hatch (EE1) or at 8 weeks of age (EE2).

Factor		Aggression at resource, n/b/h		
Age (weeks)	Treatment	Bale <sup>1</sup>	Drinker	Litter
5	Control	-	0.14	0.44

	EE1	(0.05)	0.00	0.38
	EE2	-	0.00	0.18
10	Control	-	0.25	0.65
	EE1	0.48	1.20	1.91
	EE2	0.05	0.00	0.86
16	Control	-	4.98	2.23
	EE1	1.93	3.19	1.28
	EE2	3.48	2.48	1.07
	SEDa <sup>2</sup>	1.625	2.012	0.418
	SEDb <sup>3</sup>	1.558	1.908	0.446
	Treatment	NS	NS	NS
	Age	NS	**	***
	Treatment x age	NS	NS	*

<sup>1</sup>Analysis of variance results for EE1 and EE2 at 10 and 15 weeks only; the mean for EE1 at 5 weeks is also presented (see text).

<sup>2</sup>Standard error of a difference between two ages.

<sup>3</sup>Standard error of a difference between two treatment means.

=  $P < 0.05$ ; \*\* =  $P < 0.01$ ; \*\*\*  $P < 0.001$ ; NS = not significant

**Table 3.** Mean score for feather damage on different areas of the body of female broiler breeders at 6, 12 and 18 weeks of age on a commercial farm. Treatments were no environmental enrichment (control) or enrichment devices introduced at hatch (EE1) or at 8 weeks of age (EE2).

Factor		Feather damage score	
Age (weeks)	Treatment	Wings/back	Tail/vent
6	Control	0.72	0.09
	EE1	0.75	0.05
	EE2	0.86	0.06
12	Control	1.44	1.48
	EE1	1.29	1.35
	EE2	1.14	0.14
18	Control	1.93	2.55
	EE1	1.77	2.58
	EE2	1.87	2.78
SEDa <sup>1</sup>		0.107	0.226
SEDb <sup>2</sup>		0.117	0.225

Treatment	NS	NS
Age	***	***
Treatment x age	NS	NS

<sup>1</sup>Standard error of a difference between two ages.



<sup>2</sup>Standard error of a difference between two treatment means.

\*\*\*  $P < 0.001$

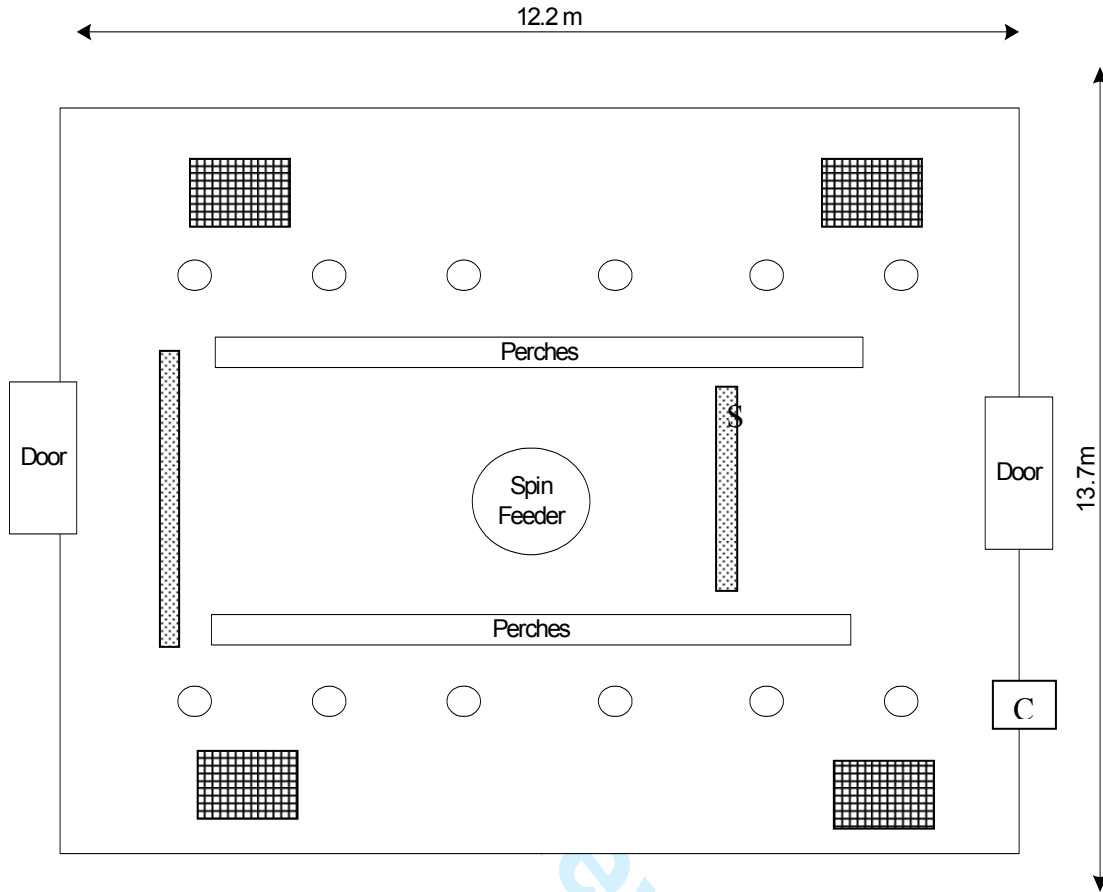
#### □ Legends for Figures

#### Figure 1

**Figure 1.** Schematic plan view of one of the three pens in each of the four rooms. C =

camera;  = polythene covered bale of wood shavings;  = batons with

bunches of polypropylene string



**Figure 2**

Scores for condition of string bunches.

**Figure 2.** Scores for condition of string bunches.

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