COMPARISON OF THE BEHAVIOUR OF BROILER CHICKENS IN INDOOR AND FREE-RANGE ENVIRONMENTS

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Abstract *Animal Welfare 1994, 3:* 179-192

The behaviour of broilers reared at pasture from 4 to 12 weeks of age on a low density diet supplied either indoors or outdoors, was compared with that of birds reared inside on deep litter. This single study found few differences in behaviour. Activity levels of birds outside were initially greater, but from six weeks of age lying increased to comparable levels in all groups.

Surprisingly little use was made of the extra space and facilities such as perches at pasture. It is proposed that the main reason for this was leg weakness as 80 per cent of the birds had a detectable gait abnormality at seven weeks of age. There was no evidence of reduced motivation to extend the behavioural repertoire, as, for example, ground pecking remained at significantly higher levels in the outdoor groups because it could also be performed from a lying posture.

Keywords: *animal welfare, behaviour, broiler chickens, free-range, leg weakness*

Introduction

Intensive rearing of broiler chickens is of welfare concern. Commercial systems do not provide all five freedoms used as indices of good welfare (Farm Animal Welfare Council 1988). In particular, birds may not be able to express most normal patterns of behaviour. The 'full' behavioural repertoire of broilers is, however, not yet established, as it is for laying hens (eg Wood-Gush *et al* 1978). Siegel (1984) reviews evidence that different strains do behave differently either in the same or in different environments. Another major welfare problem that has been identified in broilers is leg weakness (Sorensen 1989; Farm Animal Welfare Council 1992) that has both genetic and husbandry components (Kestin *et al* 1992).

Systems of 'free-range' broiler production are being commercially developed in which birds are reared at reduced stocking density (eg 11 birds/m^2 rather than 16 birds/m^2) on deep litter. Market weight is reached at around 11 rather than 6 weeks of age on a diet lower in metabolizable energy (ME) and protein. Pop-hole access to pasture is allowed after weeks three to four. However, anecdotal evidence from these systems, and experimental evidence from similar systems used for laying hens, indicates that birds do not fully utilize the outdoor areas (Keeling *et al* 1988). Potential welfare benefits may not be realized. Failure to range outside may be due to limited access and bullying at pop-holes, lack of cover outside (fear of flying objects), unattractiveness (muddy areas), large flock size and lack of motivation if a complete diet and water are provided indoors.

This study was designed to remove most of these potentially detractive factors and to see whether birds of a modern breed of white broiler (Ross I) would make use of a spacious, enriched, outdoor area and exhibit a broader range of behaviour. Their behavioural repertoire was compared with that of birds of the same genotype in an indoor deep litter system similar to commercial production. Birds in both systems were fed commercial 'free-range' diets (BOCM-Pauls, Ipswich, UK), but to control for the influence of diet, one indoor group was reared on a conventional high density broiler ration (Table 1). This was not used for the outdoor-reared groups as it would not reflect commercial practice.

Table 1 Diet analysis.

Diet	Protein (%)	ME (MJ/kg)	Fibre (%)
Free-range starter	19.70	12.02	4.22
Free-range finisher	17.43	12.37	3.61
Broiler starter	22.99	13.05	2.96
Broiler finisher	20.54	13.81	3.07

Methods

Husbandry

Day-old chicks of mixed sex were purchased in June and allocated at random to one of four groups of 60 birds. For the first three weeks, all groups were reared indoors in a controlled-environment broiler house in four adjacent pens with fresh wood shavings provided as litter. Husbandry was as for conventional intensive production. Food and water were provided *ad libitum* throughout the rearing period. Three groups had a free-range diet and one group a high density conventional diet. Lighting was 23 hours per day with one hour of dark at midnight.

At 24 days of age two groups on the free-range diet were moved to the two free-range (FR) areas, each made up of a paddock and an attached house. Paddocks were separated from each other by a chicken-wire fence thus enabling visual and vocal contact between the two groups (Figure 1). Each house had an indoor area (2.6x2.2m) with solid walls, one complete side of which was hinged at the top and was opened up to the paddock from 0830 to 1730h each day (providing shade and cover). A flat roof 1x2m suspended over two hurdles 1m high provided cover for birds and the feeders about 3m from the house. About halfway along each paddock, sand and soil were provided as dustbathing material on an area of concrete. Furthest from the house (area 6 in Figure 1), several leafy branches were driven into and laid on the ground as potential cover and perches. Most of the outdoor area was covered with an even leafy green grass sward of 5-10cm in length when the broilers were introduced to it. The overall stocking density in the outdoor areas was about 2.4m^2/bird. No supplementary lighting was provided at night.

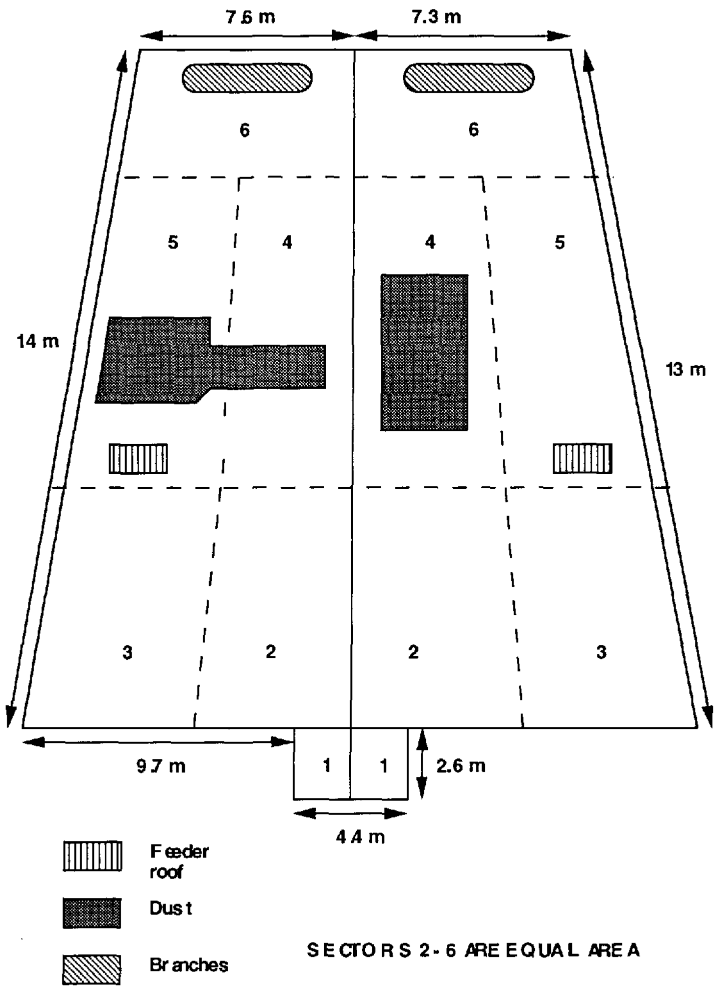

Figure 1 **Outdoor areas for free-range (FR) groups showing imaginary divisions (numbered) for analysis of area use.**

One group had the feeder outside during the day but in with the birds at night. This group is referred to in the tables and the rest of the paper as FR(out) denoting 'free-range fed outdoors'. The feeder remained indoors all the time for the other group, denoted FR(in). Full drinkers were provided inside and outside. To ensure a similar visual and spatial environment, empty feeders were placed in each pen in a corresponding position to the full feeder of the other group.

The other two groups remained indoors on deep litter throughout at a stocking density of 8 birds/m^2 because they were taken to a greater weight than usual. The group on the free-range low density diet is henceforth denoted as DL(low) for 'deep litter low density diet'. The other, on the conventional high density diet, is abbreviated to DL(high).

Environmental measurements

Temperature and relative humidity were recorded continuously indoors and outdoors by three clockwork thermohygrographs placed at a height of 1m. Light, dust and ammonia levels were also measured once a week following behavioural observations.

Light intensity was measured at floor level inside the pens using a portable dome light meter (Wallack, LKB, Croydon, Surrey).

Dust levels were measured with a mains operated Rion KC 01A Airborne Particle Counter (Hawksley & Sons Ltd, Sussex) connected to a printer. The sampling probe was held at bird head height in the indoor areas of the outdoor pens and inside the indoor pens. Ammonia concentrations indoors near the birds were measured with Dräger tubes (Drägerwerk-AG-Lubeck, Germany).

Behavioural observations

Two types of observation were made simultaneously of all groups once a week for the first 10 weeks of age by a team of experienced observers. Data from week four onwards, ie after treatments had been imposed for one week, are used in the analyses.

1. Scan samples of all groups once a week for the first 10 weeks of age were recorded by two or three observers (one observer could record behaviour of two groups in the DL environment but only one group in the FR environment). The scans were at 5-minute intervals during 1 hour (1000-1100 GMT) providing 12 records per week of each behaviour. The number of birds engaged in each of the following activities was recorded in the same order every five minutes: lying; standing idle; walking; running/flying; perching; eating from feeder; drinking; scratching ground; pecking ground (including eating grass, worms etc); dustbathing; preening; wing stretching or flapping, and showing agonistic behaviour. Not all behaviours were mutually exclusive: for example a bird could be lying and preening; however when recorded as standing idle a bird could not be engaged in any other activity such as eating. The data were expressed as a mean percentage for each behaviour each week and were subject to arc sine square root transformation appropriate for percentages (Sokal & Rohlf 1981) prior to a repeated measures analysis of variance. Differences between means were further examined using Fisher LSD tests (Sokal & Rohlf 1981). Data from week four onwards, ie after treatments had been imposed, are used in the analyses.
2. Use of the outdoor area was recorded in two different ways. The pens were divided into the six imaginary areas (five in the paddock plus the house) shown in Figure 1.
   i. Focal bird observations: three birds in each FR group were selected at random and colour-marked (with a non-toxic spray dye) red, blue or green. There was no evidence that the marking of the birds affected either the behaviour of the individuals or of the flock. The sector that each of the coloured birds was in, was recorded at 10-minute intervals during the observation hour, from weeks four to ten.
   ii. Group area use: this was obtained by noting the number of birds in each sector at scanning intervals of 10 minutes during the period of behavioural observations. This was done at six, seven and eight weeks of age.

The analysis used was an index of spread of participation (SPI) (Dickens 1955; Shepherdson *et al* 1993) defined by the equation:

$$SPI = \frac{M(Na-Nb) + (Fa-Fb)}{2(N-M)}$$

where N = total number of observations of the subject(s)
M = mean frequency of observations on all enclosure sites (ie N/number of sites)
Na = number of sites with frequency of observation < M
Nb = number of sites with frequency of observation > M
Fa = total number of observations in sites Na
Fb = total number of observations in sites Nb

An SPI index of 1 defines minimum utilization of available space, with all time spent and/or all subjects observed in one area. An SPI index of 0 defines maximum utilization with all areas used equally.

Bird condition

The birds fed on the conventional broiler diet, DL(high), attained usual marketing weight (mean weight = 2.2±0.3kg) at seven weeks of age, but were kept on for the purpose of the experiment. At this time all groups were feather-scored on a scale from 0 (fully feathered) to 5 (almost naked). Overall dirtiness was assessed from 0 (feathers white: no caked dirt on legs and feet) through 2 (either moderate soiling all over body or variable soiling with no more than half the body or legs having caked dirt and most feathers free) to 4 (most of body and feet caked with dirt adhering the feathers to each other).

At seven weeks of age the ability of the birds to walk was also evaluated and they were assigned a gait score (Kestin *et al* 1992) from 0 (able to walk freely) to 5 (immobile).

Response to handling and transport

At seven weeks of age, DL(high) birds were caught, weighed and transported in plastic crates in a transit van for one hour. The other groups, on the free-range diet, were similarly transported at 12 weeks of age when they had reached marketing weight. A control group of 30 birds, made up of ten birds from each group, was crated but not transported. Immediately following transport all birds were tested to see whether a state of tonic immobility (TI) could be induced as a measure of fear (Cashman *et al* 1989). The test involved the birds being placed gently on their side and restrained for a maximum of 15 seconds as described by Jones (1986). If a bird did not go into TI at the first attempt it was allowed to stand up and further attempts were made to induce TI (to a maximum of five attempted inductions).

Results

Environment

Birds in both environments (DL and FR) experienced a similar range of temperatures from 10-29°C with a mean of 20°C indoors and 17°C outdoors. Relative humidity varied from 40-91% outdoors and 30-82% indoors but was typically around 70% in both environments. Light levels outdoors varied from 20,000 to 80,000 lux at midday; three orders of magnitude greater than the average 17 lux indoors.

The number of inspirable dust particles (in the range 0.5-5μm) rose with time as expected (owing to increase in bird surface area, and insufficient ventilation to remove the dust) in the deep litter pens but was at least an order of magnitude less than those reported by Madelin and Wathes (1989) as stocking density in the room as a whole was low. Dust levels in area 1 of the outdoor pens were comparatively low (Figure 2). Ammonia levels were so low as to be undetectable by Dräger tubes except in week 4 when a level of 5ppm was measured in the DL environment.

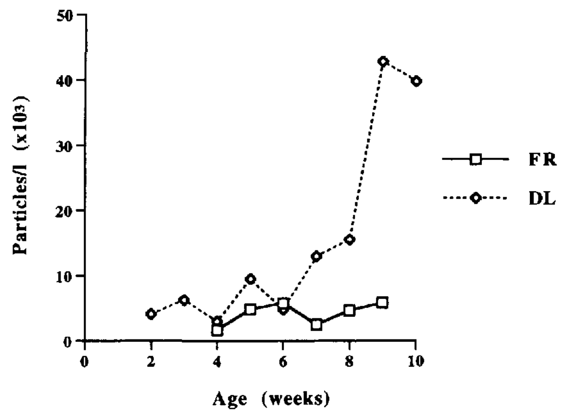

Figure 2 Mean number of inspirable dust particles at bird head height in the DL and in area 1 of the FR environments.

Table 2 Percentage of birds of all groups performing different activities during weeks 4-10 between 1000 and 1100h.

Activity	Week 4	5	6	7	8	9	10	Mean
Lie	52.7	64.4	79.3	77.5	85.5	85.4	88.9	76.3
Stand idle	3.9	2.2	1.5	2.8	1.4	2.4	2.8	2.4
Walk	9.5	7.2	4.3	3.7	3.9	2.6	1.6	4.7
Run	1.2	1.5	0.5	0.4	1.0	0.1	0.1	0.7
Eat	13.3	4.5	3.2	4.3	3.9	2.8	3.3	5.0
Drink	2.5	1.9	2.6	1.9	2.5	2.7	1.6	2.2
Peck ground	7.8	9.0	7.3	5.8	6.7	6.4	6.4	7.1
Dustbathe	0.8	0.2	0.7	1.1	1.6	0.7	0.1	0.7
Preen	5.9	7.2	5.0	4.7	6.1	6.6	6.2	6.0
Wing stretch	1.0	1.0	0.6	0.5	1.2	0.7	0.9	0.8
Show agonism	0.5	0.3	0.6	0.4	0.5	0.2	0.2	0.4

Behaviour

Scan sampling

Mean percentage time spent on each activity for broilers aged four to ten weeks (except ground scratching and perching where observations were too few for analysis) is given in Table 2. There were no significant treatment effects for lying, standing, walking, eating, dustbathing, preening, wing stretching or agonistic encounters. More walking was seen in DL birds at 4 weeks of age (13.8% as against 5.2% of FR birds) but this subsequently reverted to lower levels. There was a significant treatment effect on running behaviour (F = 3.52; *df* 3,27; P<0.05) with FR(out) birds observed running more than either DL group reared indoors. FR(in) birds also ran more often than DL(high) birds (Figure 3). There was also a significant treatment effect on ground pecking behaviour (F = 31.72; *df* 3,27; P<0.0001). *Post hoc* comparisons showed that both FR groups performed significantly more ground pecking than both DL groups (Figure 4).

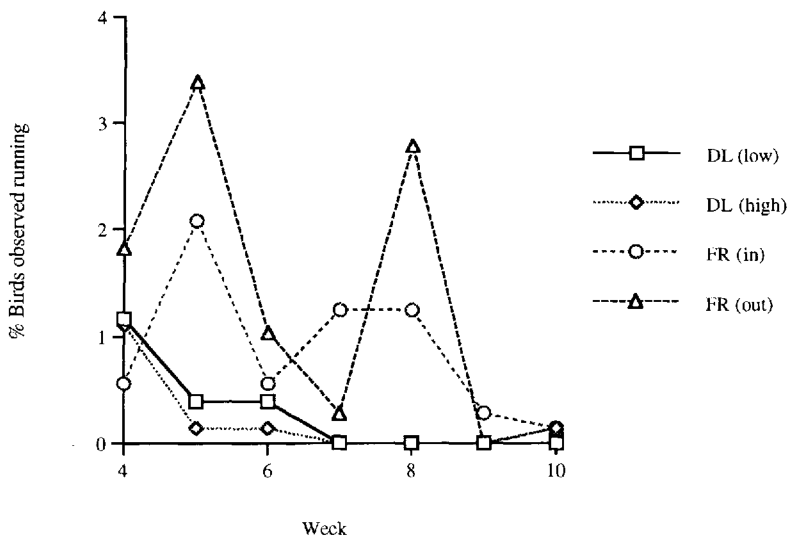

Figure 3 **A comparison of running behaviour in broilers reared free-range (FR) and on deep litter (DL) shown for weeks 4-10.**

Newberry and Hall (1988) found that both the area used by broilers and the distance moved per hour declined significantly between four and nine weeks of age. We therefore performed regression analyses to examine the effect of treatment on the age-related increase in lying behaviour. Separate regressions were run for each treatment group from week four onwards. The best curve fit was obtained with significant linear regressions for the two groups reared indoors and with significant second-order polynomial regressions for the two free-range groups. These are shown in Figure 5 which indicates less lying during the first fortnight that the FR birds were outdoors (weeks four and five) but little effect of husbandry system on lying behaviour from week six onwards.

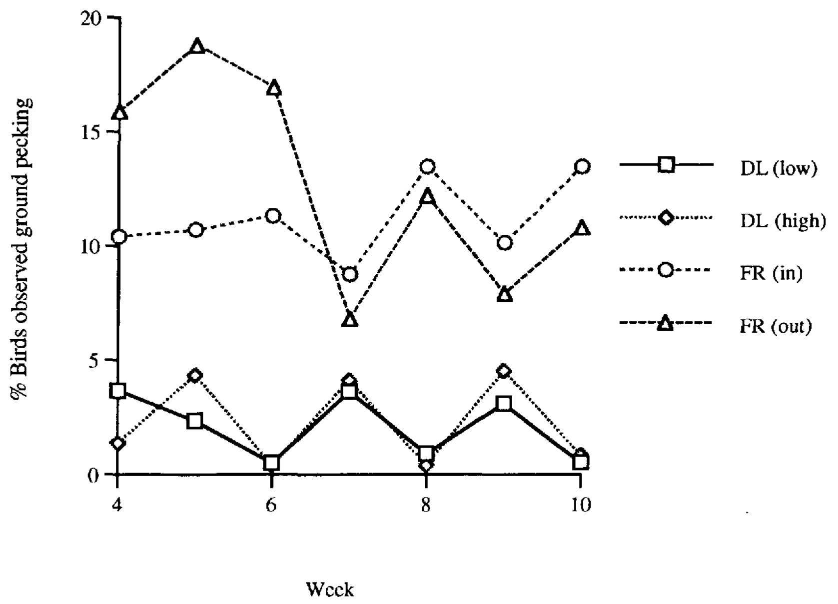

Figure 4 **A comparison of ground pecking activity in broilers reared free-range (FR) and on deep litter (DL) shown for weeks 4-10.**

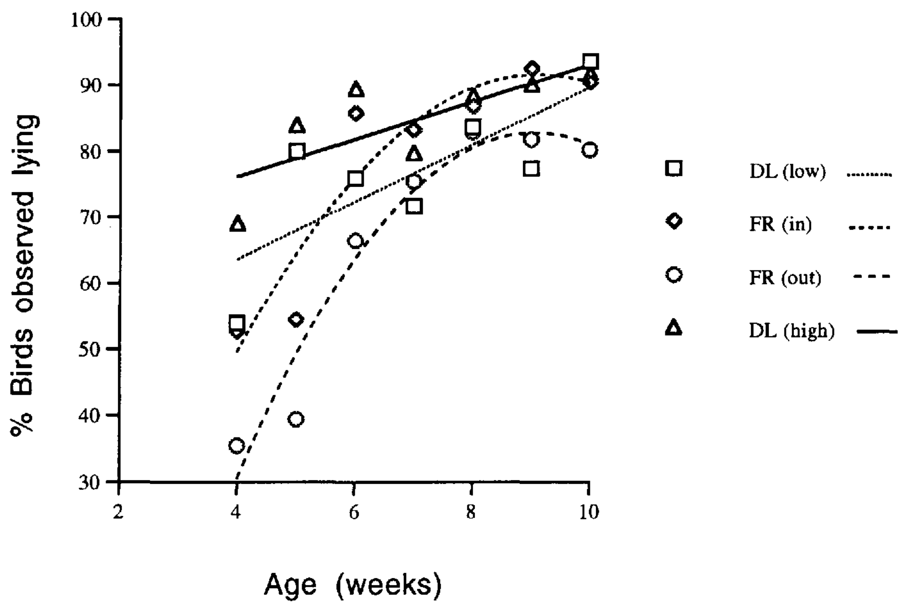

Figure 5 **Increased lying behaviour with age: best-fit curves for FR and DL reared broilers.**

Focal bird observations
SPI indices were calculated for the colour-marked birds to assess the extent of individual bird movement. A Mann-Whitney *U* test showed no significant difference for the focal birds between the two FR groups in their use of the area available, with overall mean SPI indices of 0.76 for those fed indoors and 0.80 for those fed outside. These high values indicate limited movement of individual birds between areas during the observation period of one hour. Although there were significant differences between weeks in the SPI indices (Kruskal Wallis $H = 14.7$, $P<0.02$), no consistent trend with age (from 4-10 weeks) was apparent.

Group area use
SPI indices were calculated to assess overall utilization of outdoor space by FR birds. A Mann-Whitney *U* test showed no significant difference in the use of space between the two groups. The overall mean SPI index was 0.50 for FR(in) and 0.47 for FR(out). These lower indices suggest that birds were not all in one area. Nonetheless, utilization of the space available was still notably unequal (Table 3). On average, about a third of the birds in each group were to be found in area three, near the house. Few birds were seen in areas four and five at this time of day. Almost four times as many birds in FR(out), which were fed outdoors, were seen at the far end of their run (area 6) as birds from FR(in) which tended to stay in or close to the house and their feeder.

Table 3 Mean percentage of birds observed in the areas shown in Figure 1 between 1000 and 1100h at 6-8 weeks.

Area	FR (in)	FR (out)
1	23.4	13.9
2	28.1	16.2
3	32.8	37.2
4	1.9	1.5
5	7.1	7.2
6	6.7	24.0

Bird condition
The feather scores for the groups are shown in Figure 6. Birds with fewer feathers tended to be smaller and to have moulted their down before becoming fully feathered. There was no evidence of feather pecking in any of the groups. A Kruskal-Wallis test showed that group DL(low) had significantly poorer feather cover than the FR groups ($H = 10.24$, $P = 0.017$). These three groups were all on the free-range diet. The opportunity for FR birds to supplement their diet with grass, worms and insects could explain this difference. Improved maintenance of plumage and exposure to weather (rain, sun etc) might also have had an influence.

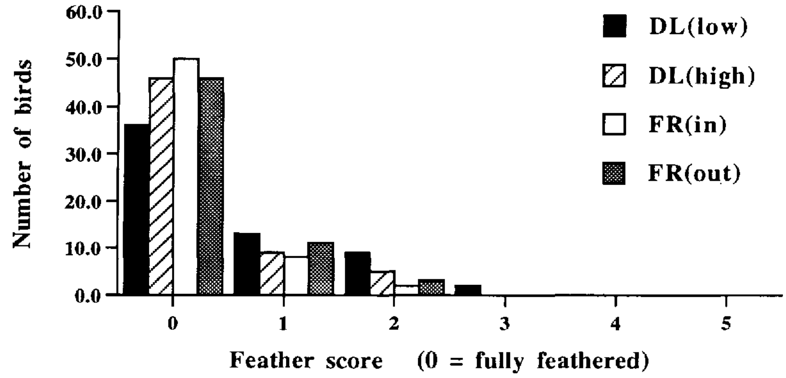

Figure 6 **Feather scores at seven weeks of age.**

The majority of birds in the two DL groups had a dirtiness score of 1 or 2: a reflection of the higher stocking density. Of the FR groups, almost half the FR(out) birds were clean (score 0) and the rest slightly dirty (score 1). Whereas in FR(in), only 20 per cent of the birds were clean, most being slightly dirty with 14 per cent scoring 2. The indoor area in this pen became dirtier because the feeder was sited there constantly. Thus feeding outdoors could reduce the requirement for litter as well as keeping birds cleaner.

Gait score

Gait scores are summarized in Figure 7. A Kruskal-Wallis test revealed no significant difference between groups in their mean gait score ($H = 4.08$, $P = 0.25$). Most birds in the FR groups rated 1 or 2 on the scale, with fewer having a good score of 0 than indoor-reared birds on the same diet, DL(low). Birds on the high density diet, DL(high), had the worst gait scores with 17 per cent scoring 3 or 4.

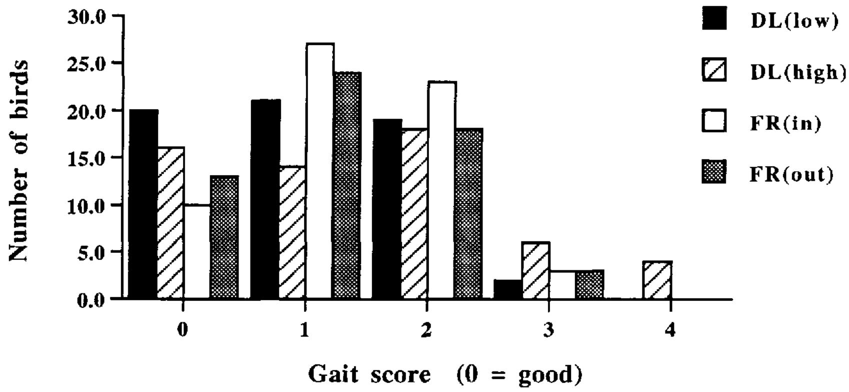

Figure 7 **Gait scores at seven weeks of age.**

Response to handling and transport
There were no significant differences between groups in the length of time the birds spent in an induced state of tonic immobility following transport at 12 weeks of age. The mean duration of tonic immobility for all birds was 356.6s (standard error 35.7s). However there was some effect of husbandry system on the number of attempts to induce TI. An analysis of variance followed by *post hoc* comparisons (Fisher LSD) showed birds in the FR(out) group needed fewer ($P<0.05$) inductions than those in groups FR(in) or DL(low).

Performance
Of the three groups fed the free-range diet, those reared indoors [DL(low)] were significantly ($P<0.001$) heavier (4.49±0.08kg) than either FR group, of which FR(out) at 4.08±0.08kg was non-significantly heavier than FR(in) at 3.96±0.09kg. Although the FR birds appeared to be healthy, ill-health may have been a reason for reduced performance outdoors where there was a mortality of three per cent compared with none indoors. The slightly lower average air temperature and increased activity could also have contributed to this.

Discussion

The unexpected finding of this study was that broilers made limited use of the greatly increased space and environmental enrichment provided for the FR groups. This suggests that either the birds lacked the motivation to use these areas, or were somehow prevented from using the extra facilities.

There appeared to be no social factors limiting access to the outdoor area: all birds came out in the morning and used both indoor and outdoor areas freely. Agonistic encounters were rarely seen which is in accord with Murphy and Preston (1988) who never observed agonism in a commercial flock of broilers on deep litter. The cover provided outdoors was used, and appeared satisfactory for the broilers to hide from aeroplanes and wild birds flying overhead. The responses of the birds to handling and transport indicated that levels of fear were not high. Weather was good and thermally comfortable. Thus there appeared to be no social, psychological or physical barriers to prevent the broilers from using the outdoor areas.

Neither was there any evidence against motivation to use the facilities outdoors. At four weeks of age the FR broilers were fairly active, perching and ground scratching being occasionally observed, and walking and running occupying some five to six per cent of their time. But even on a moderate diet, weight gain was still rapid. By week seven the FR birds were spending most of the time lying, no different from their contemporaries indoors (Figure 5). The analysis of space utilization confirmed limited movement between areas and use of the available space outdoors for both FR groups. It was noticed, but not quantified, that a lying posture was increasingly chosen with age for eating from the feeder in all four groups and for ground pecking (eating grass) in the outdoor groups.

This evidence indicates a progressive change in the motivation or ability of the birds to perform non-lying behaviours. It is difficult to suggest why motivation to perform behaviours involving standing should diminish. However, the ability to perform these particular behaviours could selectively diminish as leg weakness and joint abnormalities would reduce mobility with age. It is also likely that the musculature became progressively unable to support the body-weight for long periods (ie the birds 'outgrew their strength').

Newberry and Hall (1988) suggested leg stiffness as one of the reasons for a halving in distance moved by older broilers and a reduction of area use from $134m^2$ at four weeks of age to $49m^2$ at nine weeks of age at a low stocking density of 7.5 birds/m^2. The present gait scores indicate that most birds had some abnormality in their gait (Figure 7) and in the more disabled birds (gait score >2) this could have prevented them from perching and taking more exercise.

Different methods of sampling the behaviour of broilers have been used in the few studies reported in the literature. Despite these differences and those of strain and environment, there is good agreement between studies, including those reported here, in time budgets of broiler chickens. Table 4 compares results for major behaviours between studies.

Newberry *et al* (1988) found no effect of time of day on feeding, drinking and walking behaviour and only slightly ($P<0.05$) greater standing and general activity following the morning caretakers' visit. Murphy and Preston (1988) also found no effect of time of day or sex on their behaviour data. Their detailed observations of focal birds suggest the main reason for congruence between studies: that broilers change activity extremely frequently. Individual birds aged 4-7 weeks changed activity between 57 and 107 times per hour with median bout lengths of between 9 and 43 seconds depending on activity. We are confident therefore that our behaviour data are representative.

Table 4 A comparison of some published values of selected activities of broilers (mean percentage time).

Reference	Lying	Standing	Eating	Drinking
1	64	*20	11	5
2	73	*19	6	2
3	73	6	6	3
4	76	2	5	2

* includes walking and other activities

1 Murphy and Preston (1988): focal bird sampling for one hour between 0950 and 1630h

2 Preston *et al* (1983): 24-hour observations

3 Newberry *et al* (1988): scan sampling over 24h at 30-minute intervals

4 Present study: scan sampling over one hour at 5-minute intervals

Although deemed an important activity for both layers and jungle fowl (eg Blokhuis 1984), dustbathing occupied on average less than 1 per cent of the time of broilers in this study and was never observed by Murphy and Preston (1988) in their 19 focal broilers. Red jungle fowl were observed ground pecking in over 60 per cent of observations (Dawkins 1989): considerably more than the average 2 per cent of time seen in DL broilers or even the 12 per cent for FR broilers in this study. Whereas ground scratching was seen in over 30 per cent of observations of red jungle fowl (Dawkins 1989), in this study it was seen too infrequently for analysis possibly as a result of poor mobility and dexterity in the broilers.

Animal welfare implications
We conclude that genetic selection for high growth rate, with associated heavy weight and leg weakness, may prevent broilers from performing certain behaviours even if they are motivated to do so. Unless motivation to perform certain behaviours has also been bred out, which is unlikely (for example broiler-breeders show normal perching behaviour, Appleby *et al* 1988), it is probable that their limited mobility is accompanied by some behavioural frustration. There would be welfare benefits if commercial breeders concentrated on developing strains of broiler chickens with improved musculo-skeletal strength.

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