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Effects of the addition of sand and string to pens on use of space, activity, tarsal angulations and bone composition in broiler chickens

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Abstract

Fast-growing broiler chickens use pen-space heterogeneously and have low activity levels, related in part to leg problems. The aim of this study was to test the effects of the addition of string and sand trays to rearing pens on the use of space, levels of activity and leg problems. Broiler chickens were reared in 12 pens (40 birds per pen). Drinkers and feeders only were present in the six control pens (C group), whereas the six other pens were enriched (E group) with two sand trays and string. Behaviour was recorded by scan and focal sampling on days 2–3, 13–14, 23–24 and 34–35. Bodyweight, the occurrence of tarsal deformities and the composition of tibiotarsi were measured on day 37. Chickens from the E group spent more time and stood more often in the area enriched with sand than did the C group birds. Chickens in the E group foraged in the sand throughout the rearing period, and their foraging activities were greater than those of the C group birds. They had little interest in the strings. Locomotor activity during standing bouts was enhanced in the E group on days 2–3 only. Bodyweight at day 37, the occurrence of tarsal deformities and the composition of tibiotarsi were not significantly different between groups. These results indicate that sand could attract chickens into areas that are usually rarely used, which may reduce problems resulting from their heterogeneous distribution. However, the results also indicate the difficulty of stimulating locomotion.

Keywords: *activity, animal welfare, broiler chickens, environmental enrichment, leg problems, use of space*

Introduction

Broiler chickens (*Gallus gallus*) are usually reared in a very bare environment. Under commercial conditions, the only furniture provided for broiler chickens comprises feeders, drinkers and brooders. Fast-growing chickens spend most of their time sitting or lying in such a bare environment (Murphy & Preston 1988; Bessei 1992), even if reared at a very low density (Arnould & Faure 1999, 2003a). In contrast, the main activity of red jungle fowl hens under semi-natural conditions is foraging for food in the environment by pecking the ground and scratching in leaf litter (Dawkins 1989).

There is a strong relationship between use of space and resource availability in wild and feral fowls (Mench & Keeling 2001). We observed in a previous study that broiler chickens prefer to stay close to food resources when possible, ie when reared at very low densities (Arnould & Faure 1999, 2003a). Chickens reared under commercial conditions are also unevenly distributed on the floor (Arnould *et al* 2001; Fraysse *et al* 2001). The high local densities in some areas may result in discomfort and poor production performance and may increase the occurrence of skin scratching (Proudfoot & Hulan 1985; Thomsen 1993) and health problems such as foot-pad dermatitis related to wet litter (Greene *et al* 1985). In fact, low activity levels, leg abnormalities and lack of stimulation by the environment probably contribute to the heterogeneous distribution of chickens across the floor.

The supplementation of environmental stimuli through provision of new objects for domestic fowls or turkeys is receiving growing attention, and beneficial effects of increasing complexity have already been reported in various species (for a review, see Jones 1996). Few studies have been performed concerning the effect of this increase in complexity on the use of space by chickens. It has been observed that offering a more complex environment (eg a bale of wheat straw, vertical panels lying vertical to the floor) in a peripheral area of the pen increases the use of this area by chickens, particularly when the sources of enrichment are changed daily, and that the availability of a bale of straw or peat moss also stimulates foraging activity (Newberry & Shackleton 1997; Newberry 1999). Because foraging activities have been shown to be related to high locomotor activity in chickens (Bizeray *et al* 2000b), giving access to new objects may stimulate locomotion and thus benefit leg problems, which can be reduced by increasing exercise (Reiter & Bessei 1998).

It has been proposed that the biological significance of the devices used in enrichment studies is of importance (Newberry 1995). Experiments have already been performed on dust-bathing and exploration in domestic fowl to evaluate the attraction of sand compared to other litter materials (Petherick & Duncan 1989; Vestergaard & Hogan 1992; Sanotra *et al* 1995). Although the preferences observed varied slightly according to the animals' previous experience and the choices given (peat moss, straw, wood shavings, feathers, sand etc), all of these experiments show that levels of pecking, scratching and dust-bathing are high on sand. It can therefore be supposed that sand has biological significance for chickens and might be attractive to them and stimulate activity. Furthermore, sand has good potential as a floor material because the performance and health of chickens reared on sand are not adversely affected (Bilgili *et al* 1999a,b). String devices can also be used to increase the complexity of the environment. The biological relevance of string is less obvious than that of sand. Bunches of string have been reported to be attractive for individually caged laying hens and chicks reared in pairs, and it has been suggested that provision of such devices could divert potentially injurious pecking away from other birds (Jones & Carmichael 1998; Jones *et al* 2000). However, it has not yet been established whether string is attractive for broiler chickens reared in large groups on a litter floor.

The aim of the present study was to determine whether the provision of sand and strings increases the use of space, the locomotor activity and/or the time spent standing for fast-growing chickens, and to establish whether any effect could be maintained until slaughter age. The effects of the treatments (bare versus complex environment) on tarsal angulations and bone composition were also assessed.

Materials and methods

Animals

This experiment was conducted with 480 unsexed chickens (PM3, Ross). They were fed *ad libitum* a two-phase standard diet comprising a starter ration (metabolisable energy [ME] = 3100 kcal kg^{-1}, crude protein [CP] = 22%, Ca = 1.15%, available P [Av P] = 0.42%) from 0 to 20 days of age and a grower diet (ME = 3100 kcal kg^{-1}, CP = 20%, Ca = 0.9%, Av P = 0.38%) from 20 to 37 days of age. An artificial lighting programme (23h L : 1h D, with darkness from midnight to 0100h) and a standard temperature programme were followed.

Experimental design

Twelve flocks of 40 chickens were reared separately in 2 m × 6 m pens (density = 3.3 birds m^{-2}). The pen floors were covered with a layer of wood shavings. Light was provided by two lamps and heat was provided by two brooders, located at each extremity of the pen. Each pen contained one drinker and two 1 m long feeders. There was no additional equipment in the six pens of the control group (C). In each of the six pens of the enriched group (E), six white polypropylene strings and two sand trays (one measuring 67 cm × 45.5 cm and the other measuring 67 cm × 35.5 cm, both 4 cm high) were added to the pens, the sand trays being located on the opposite sides to the feeding resources (Figure 1). Chickens could not sit on the edges of the sand trays as they were at litter level. This design allowed us to divide the pens into three virtual 4 m^2 areas, called 'Feeding resources' area (F), 'Middle' area (M) (enriched with strings in the E group), and 'Distal' area (D) (enriched with sand trays in the E group). Strings were hung in the centre of the pen (minimum distance between two strings = 10 cm). They were attached to a bar situated 1 m above the floor (the same bar was present in the control pens) and the height was corrected once per week (2–4 days before observation) so that the lowest height was about 1 cm above the head of a standing chicken. This height was chosen to force chickens to stand to peck the strings and thus to increase the possibility of an effect of the device on leg angulation and bone composition. Sand was added to the trays twice per week (2–3 days before observation and at the end of each observation day, ie day 10, day 14, day 24 and day 35). It was raked in the evening of the day before each observation day to remove droppings and wood shavings.

Behaviour observations and procedure

Chickens were observed at four ages over two-day periods (days 2–3, 13–14, 23–24, and 34–35) for 2 h per day, by two different observers (4 h per pen per two-day age period). Observations during a day were performed in a randomised design for one of three observation periods (1000h–1200h, 1300h–1500h or 1600h–1800h).

Three types of observation were performed for each 2 h period:

(A) The numbers of standing and lying chickens in each area of the pen (F, M and D areas) were counted using scan sampling (one scan every 90 s during 360 s, ie 5 scans) to evaluate the use of space and general activity of chickens.

(B) The location on the sand trays or the litter of each chicken present in the D area, and its behaviour (standing or lying, sand or litter pecking, sand or litter scratching, dust-bathing, or none of the previous behaviours), were recorded by scan sampling (two scans separated by 60 s) to measure sand tray use.

(C) Individual standing bouts (ie behaviour performed from the moment a bird stood up until the moment it lay down) were recorded by focal sampling using The Observer 3.0 software (Noldus Information Technology, The Netherlands) to evaluate locomotor and foraging activities. The behaviour patterns recorded during these standing bouts comprised the number of 1 m^2 squares crossed (pens were divided into 12 virtual squares), the number of litter and sand pecks and scratches (exploration), and the number of pecks at the strings. The presence or absence of eating and drinking activities during the standing bouts was recorded. Standing bout duration was also recorded.

For each pen during each 2 h period, observations were performed as follows: five scans of the total number of chickens (observation type A); two scans of the D area (observation type B); observation of about six individual standing bouts performed on different birds chosen at random (observation type C); five scans of the total number of chickens (observation type A); observation of about six individual standing bouts performed on different birds chosen at random (observation type C); five scans of the total number of chickens (observation type A); and two scans of the D area (observation type B).

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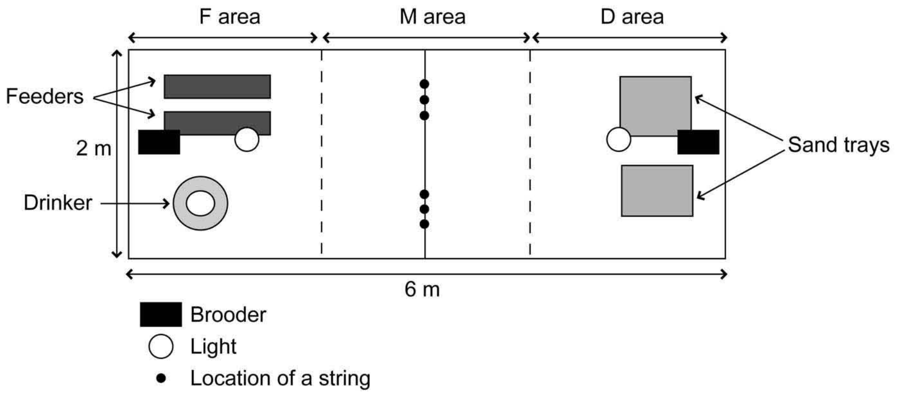
Figure 1

Diagram of a pen used for the enriched groups indicating the partitioning used to locate birds: feeding (F), middle (M) and distal (D) areas. The same design but without string or sand trays was used for the control groups.



We also used cameras to complete these observations and record the location of the chickens over a long period and when nobody was in the room. The locations of the chickens in the D area and in the sand trays were recorded with photographs taken every 30 min from 1030h to 0330h (32 scans) in five C pens and in five E pens on days 36–37.

The mean proportions of chickens observed pecking and/or scratching on the floor were calculated from all birds observed in the D area, to specify their activity in this area. Furthermore, the mean proportions of chickens pecking and/or scratching were calculated separately from the birds observed in the litter and from the birds observed in the sand to determine whether their activity was different according to their location in the litter or in the sand.

All standing bouts were summed and the occurrence of each behaviour pattern per minute was calculated by dividing the total number of each behaviour pattern observed during these standing bouts by the total duration of the standing bouts (about 30 min per pen for each of the four two-day age periods). All of the standing bouts were analysed together and were also analysed after being sorted into two types, 'feeding bouts' in which chickens undertook feeding activities (drinking or/and eating) and 'non-feeding bouts' (other bouts), since it has been reported that locomotion and exploration were more often observed during non-feeding bouts than during feeding bouts (Bizeray *et al* 2000a).

Mortality, weight, tarsal angulations and bone composition

Mortality and culls were recorded daily. Each bird was weighed at 37 days of age. Abnormal tarsal angulations (varus and valgus of the tarsal joint) were detected for each chicken just before slaughter at day 37, according to the classification of Leterrier and Nys (1992). Chickens were held by the wings and were classified as varus for medial deviation of the limb and valgus for lateral deviation. Angulations were considered severe when the angles between tibiotarsus and tarsometatarsus were greater than 45°. When leg abnormalities were not symmetrical, chickens were assigned to the group with the more severe inter-tarsal angulation. Chickens were classified in the different categories after visual assessment of angulations by a trained observer.

Eleven chickens per pen were randomly selected and their right tibiotarsi collected after slaughter. Fresh tibias were weighed to obtain hydrated weight and then defatted (24 h in ether), dried (105°C for 12 h) and weighed to obtain dry defatted weight. Bones were ashed (550°C for 14 h) and ash weight was calculated in relation to dry defatted weight.

Statistical analysis

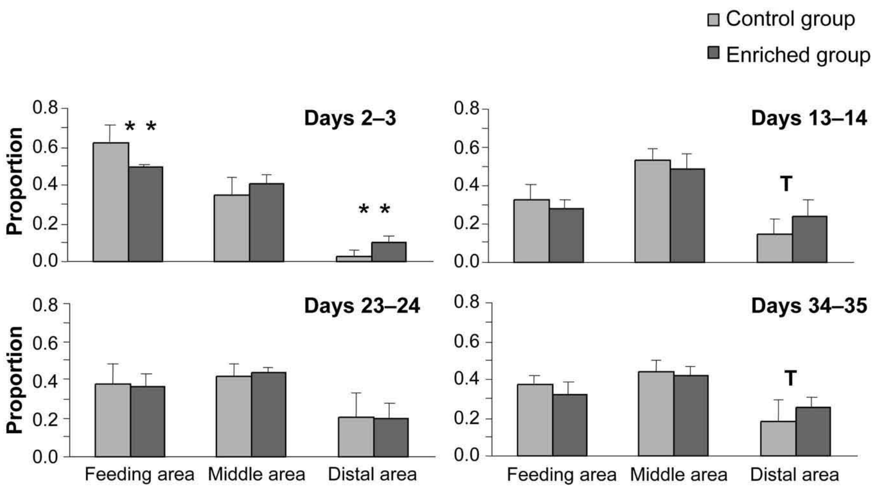
A mean value per pen was calculated for all of the data analysed. The number of chickens performing each behaviour and the number of chickens of the E flocks located in the D area, either on sand or on litter (data obtained by scan sampling), were corrected according to the mortality rate of each pen. Because the data were not normally distributed, they were analysed with non-parametric statistical tests. Treatment effects were tested with the Mann-Whitney U test; $n_1 = n_2 = 6$ except for the data obtained by photographs ($n_1 = n_2 = 5$ in this case). Age effects for each treatment and distribution between the F, M and D areas were analysed using the Friedman two-way analysis of variance. When a significant effect was obtained, the Wilcoxon signed rank test was used to compare each age and each area with the others. The χ^2 test was used to test the differences in occurrence of tarsal angulations between the two groups. Since we hypothesised that the environmental enrichment would induce more homogenous use of space, and would increase general, locomotor and foraging activities in the E groups, we used one-tailed tests to analyse these data. For all other data, two-tailed tests were used. Results shown are for one-tailed tests unless otherwise stated. Results are expressed as mean ± standard deviation. The P value for statistical reliability was 0.05. For $0.05 < P < 0.10$ we considered that the result tended towards significance.

Results

Distribution in pens

Over the entire experimental period, the proportions of chickens were significantly different between the three areas in the C group (F: 0.43, M: 0.43, D: 0.14; Friedman = 9, P = 0.01) and in the E group (F: 0.36, M: 0.44, D: 0.20; Friedman = 12, P = 0.002). The proportion of chickens in the D area for each treatment was significantly different from the proportions in the F and M areas

Figure 2



Proportion of chickens (mean ± standard deviation) in each area, at each age tested. $^{**}P = 0.01$; T: $0.05 < P < 0.10$; control versus enriched.

($z = 2.20$, $P = 0.03$ in both treatments, two-tailed). The proportions of chickens in the F and M areas were significantly different in the E group ($z = 2.20$, $P = 0.03$, two-tailed), but not in the C group ($z = 0.52$, ns [not significant], two-tailed). The proportions of chickens in the F area ($U = 12$, ns) and in the M area ($U = 16$, ns) were not significantly affected by the treatment. However, the proportions of chickens in the D area tended to be higher in the E group than in the C group ($U = 9$, $P = 0.08$).

The results obtained at each age tested are presented in Figure 2. At 2–3 days of age, there were significantly fewer chickens in the F area in the E group than in the C group ($U = 0$, $P = 0.002$). Conversely, there were more chickens in the D area in the E group than in the C group ($U = 2$, $P = 0.005$). In addition to the differences observed at days 2–3, the proportion of chickens in the D area tended to be higher in the E group than in the C group at days 13–14 ($U = 8$, $P = 0.06$) and at days 34–35 ($U = 9$, $P = 0.08$). The proportions of chickens in the F and M areas did not differ significantly between groups for any of the ages studied, except for the difference obtained at days 2–3 in the F area.

Behaviour in the D area and use of the sand trays

Although the sand trays covered only 14% of the D area surface, 34 ± 7% of chickens in the E group present in the D area were located in the sand trays. At days 2–3 the number of chickens in the D area was low (Figure 2); however, 56 ± 26% of the chickens observed in this area were in the sand trays. This proportion tended to decrease with age (minimum at days 34–35: 27 ± 6%; Friedman = 6.8, $P = 0.08$). Furthermore, the density of chickens in the E group observed in the D area was significantly greater in the sand trays than in the litter throughout the rearing period (sand: 4.7 ± 0.8 birds m^{-2}; litter: 1.4 ± 0.3 birds m^{-2}; $z = 2.2$, $P = 0.01$) and for each age tested ($P = 0.01$ in all cases). These results are confirmed by those obtained from the photographs of the D area taken at days 36–37, which showed that there were significantly fewer chickens in this area in the C group than in the E group (3.8 ± 2.0 birds versus 7.7 ± 1.9 birds; $U = 1$, $P = 0.008$). The difference was attributable to the numbers of chickens present in the sand trays, as there was no significant difference between the groups in the number of chickens in the litter (C group: 3.8 ± 2.0 birds; E group: 5.8 ± 1.4 birds; $U = 5$, ns; two-tailed).

The mean proportion of chickens pecking and scratching (exploring) on the floor in the D area (sand and/or litter) was significantly higher in the E group than in the C group (0.21 ± 0.07 versus 0.08 ± 0.04, $U = 2$, $P = 0.005$). In the E group, the chickens' activity varied according to their location in the litter or in the sand. The proportion of chickens observed exploring in a standing position in the sand decreased from 0.53 at days 2–3 to 0.10 at days 34–35, and the mean proportion of chickens observed exploring in a lying position increased from 0.14 at days 2–3 to 0.29 at days 34–35. The proportions varied from 0.06 to 0.01 (exploring in a standing position) and from 0.03 to 0.04 (exploring in a lying position) in the litter. In the C group, few chickens were in the D area at days 2–3 and no pecks and scratches were observed. The mean proportion of chickens observed exploring in a standing position decreased from 0.11 at days 13–14 to 0.01 at days 34–35, and the mean proportion of chickens observed exploring in a lying position decreased from 0.06 at days 13–14 to 0.03 at days 34–35. Dust-bathing was observed in the sand only, and on few occasions (at days 23–24 and days 34–35 only).

General activity

There was no significant difference between groups for the mean proportion of lying chickens over the entire experimental period (C group: 0.75 ± 0.02; E group: 0.74 ± 0.02; $U = 12$, ns), nor for the mean proportion at each age. However, the D area contained a greater proportion of lying chickens in the C group than in the E group ($U = 5$, $P = 0.02$, Figure 3), whereas there was no significant difference between groups in the F area ($U = 10$, ns) and M area ($U = 18$, ns). In both groups, age significantly increased the proportion of lying chickens (from 0.60 ± 0.06 at days 2–3 to 0.85 ± 0.03 at days 34–35 in the

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C group, and from 0.58 ± 0.05 at days 2–3 to 0.85 ± 0.05 at days 34–35 in the E group (Friedman = 13.4 and $P = 0.004$ in both groups).

Locomotor activity and exploration

In total, 1740 standing bouts were recorded over the entire experimental period (868 bouts in the C group and 872 bouts in the E group). There was no significant difference between groups for the mean duration of the standing bouts throughout the rearing period (C group: 57.3 ± 9.8 s, E group: 60.8 ± 3.1 s, $U = 17$, ns) or at each age tested, nor for the number of squares (sq) crossed per minute (C group: 1.2 ± 0.1 sq min^{-1}; E group: 1.2 ± 0.2 sq min^{-1}; $U = 16$, ns). However, at days 2–3, chickens in the E group crossed more squares per minute than did chickens in the C group, but the difference disappeared as early as days 13–14 (Figure 4). At least 54% of the bouts did not include crossing squares at any age tested.

The number of pecks and scratches in the litter per minute did not differ between the C group and the E group (C group = 2.2 ± 0.7 events min^{-1}, E group = 2.3 ± 1.2 events min^{-1}, $U = 17$, ns). However, when we considered pecking and scratching in the litter and in the sand together, there was a significant difference between groups (C group = 2.2 ± 0.7 events min^{-1}; E group = 4.4 ± 1.2 events min^{-1}; $U = 3$, $P = 0.008$). From the first days of life to days 23–24, chickens in the E group pecked and scratched more often on the floor than did those in the C group (Figure 5).

Results concerning the strings are not reported because they were too rarely observed (42 events for about 28 h of observation). Pecking and pulling at a string was observed at all ages except at days 13–14.

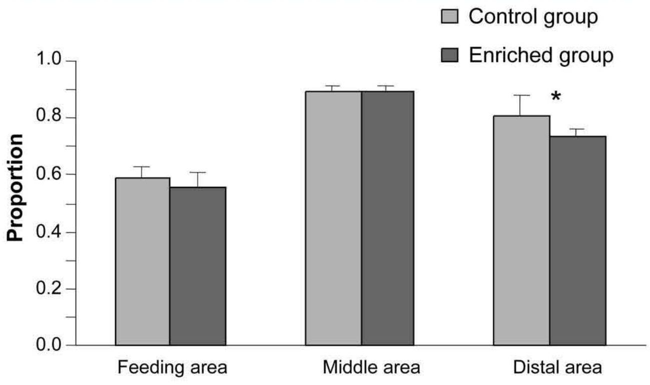
Feeding bouts

In total, 531 feeding bouts were recorded (272 bouts in the C group and 259 bouts in the E group). There was no difference between groups in the mean total duration of feeding bouts throughout the rearing period (C group: 123.2 ± 27.0 s; E group: 135.0 ± 23.3 s; $U = 14$, ns) or for each age tested. The frequency of squares crossed per minute and the rate of pecks and scratches in the litter or sand per minute were not significantly affected by the treatment.

Non-feeding bouts

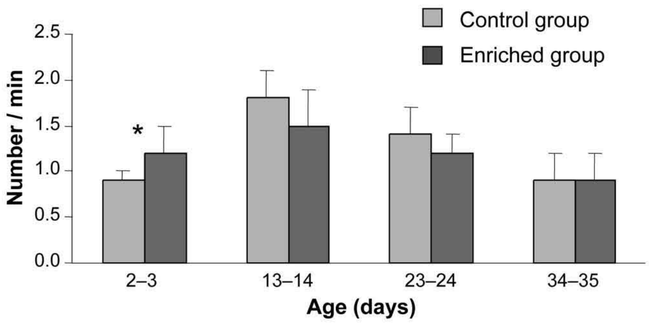
In total, 596 non-feeding bouts were recorded in the C group and 613 in the E group. Chickens in the E group performed longer non-feeding bouts than did those in the C group throughout the rearing period (C group: 26.9 ± 3.5 s; E group: 30.1 ± 3.3 s; $U = 6$, $P = 0.03$). This effect was observed at days 2–3 (C group: 15.5 ± 6.2 s; E group: 34.2 ± 8.9 s; $U = 1$, $P = 0.003$), but not at the other ages observed. The number of pecks and scratches directed at the sand and the litter during non-feeding bouts was higher in the E group than in the C group at days 2–3 (C group: 0.7 ± 0.6 events min^{-1}; E group: 5.7 ± 3.1 events min^{-1}; $U = 0$, $P = 0.002$), with a higher number of pecks and scratches in litter in the E group at this age (C group: 0.7 ± 0.6 events min^{-1}; E group: 2.3 ± 0.9 events min^{-1}; $U = 1$, $P = 0.003$). The rate of exploration (pecks and scratches) directed toward the litter and sand per minute remained, or tended to remain, higher in the E group at days 13–14 (C group: 8.2 ± 4.2 events min^{-1}, E group: 11.9 ± 5.3 events min^{-1}; $U = 9$, $P = 0.08$), days 23–24 (C group: 3.5 ± 2.8 events min^{-1}; E group: 7.5 ± 3.6 events min^{-1}; $U = 6$, $P = 0.03$) and days 34–35 (C group: 2.1 ± 2.3 events min^{-1}; E group: 4.0 ± 2.7 events min^{-1}; $U = 9$, $P = 0.08$).

Figure 3



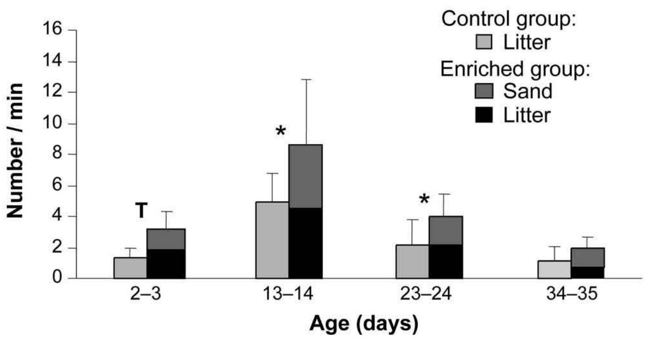
Proportion of lying chickens (mean ± standard deviation) in each area. *$P \leq 0.05$; control versus enriched.

Figure 4



Number of squares crossed per minute (mean ± standard deviation) during standing bouts. *$P \leq 0.05$; control versus enriched.

Figure 5



Number of exploring events (pecks and scratches) per minute (mean ± standard deviation) directed at the litter or sand during standing bouts. *$P \leq 0.05$; T: $0.05 < P < 0.10$; control versus enriched.

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Table 1 Bodyweight (mean ± standard deviation) and bone quality of the right tibia.

	Control group	Enriched group	*U*	*P*
Bodyweight at day 37 (g)	2117.4 ± 80.4	2126.1 ± 42.0	17	0.87
Dry defatted/hydrated weights (%)	36.5 ± 0.5	36.3 ± 0.7	13	0.42
Ash/dry defatted weights (%)	44.3 ± 0.4	44.8 ± 0.7	11	0.26

P: Mann-Whitney *U* test, two-tailed

Growth, tarsal angulations and bone composition

The mortality rate was 3.75% at day 37 (nine chickens in each group). There was no significant difference between groups for live bodyweight, bone dry content and ash percentage at day 37 (Table 1). The total percentage of chickens with abnormal tarsal angulation was not affected by treatment (C group: 14.2%; E group: 19.8%; $\chi^2 = 2.20$, ns). The percentages of chickens with severe angulations were low in both groups (C group: 1.3%; E group: 3.0%).

Discussion

Our results clearly show that sand trays are attractive for chickens. Provision of sand trays resulted in more homogeneous distribution of chickens in pens, but failed to improve tarsal angulations and bone composition at slaughter age. Locomotion was stimulated only while chickens were young, while enhancement of exploration lasted up to the fourth week of age.

Broiler chickens use pen space heterogeneously in commercial and experimental conditions (Preston & Murphy 1989; Newberry & Hall 1990; Arnould & Faure 1999, 2003a,b; Arnould *et al* 2001). In a previous study, Arnould and Faure (1999, 2003a) observed that chickens reared at a low density spontaneously limited their physical efforts and that the majority stayed near feeders and drinkers. The enrichment we used in the present experiment resulted in greater use of the areas further from the feeders and drinker. Chickens were attracted by the area containing sand at ages as young as 2–3 days and this effect persisted. This can be explained primarily by the chickens' high interest in sand. Indeed, Sanotra *et al* (1995) reported that when hens had the choice between sand, straw and wood-shavings as a substrate for dust-bathing they preferred sand. Knierim (2001) confirmed that sand stimulates dust-bathing and pecking behaviour compared to straw. Little dust-bathing was observed in our experiment but it always occurred on sand and never on wood-shavings. In addition, our results clearly indicate that pecking and scratching at the floor were highly stimulated in the trays containing sand. These behaviour patterns probably have a high biological significance for the birds, since red jungle fowl spend a lot of their time foraging for food when they are in a stimulating (semi-wild) environment (Dawkins 1989). This could explain the attractive effect of the sand. The sand trays may also help the chickens to identify their own location in the pen. In a study on the effect of vertical covers (panels that stood in a vertical fashion perpendicular to the floor) on the use of space in chickens, it was observed that birds were attracted by them (Newberry & Shackleton 1997; Cornetto & Estevez 2001). The authors' hypothesis was that these covers might be considered as shelters against predators. However, 'covers' which consisted only of a frame without a mesh wall hanging on them were also attractive (Cornetto & Estevez 2001), although they could not be considered as shelters in this case.

The use of the area containing strings (M area) was almost identical in the E and C groups. Although it has been reported that chicks and hens of laying strains are attracted by bunches of string when they are added to their cages (Jones & Carmichael 1998; Jones *et al* 2000), it seems difficult to attract chickens reared in pairs to the less-preferred part of the cage when enriched with various objects: table tennis ball, rubber tubing and bunches of string (Jones & Carmichael 1999). In our study, chickens did not seem to be frightened by the strings. However, they spent little time pecking at them. The lack of attractiveness of the strings compared to results obtained in laying hens (Jones & Carmichael 1998; Jones *et al* 2000) could be explained by the fact that chickens' attraction toward the strings was not sufficiently strong to offset their difficulties with walking and remaining in a standing position. In both groups, the M area was the area with the highest resting time (about 90% of lying chickens). The lower light intensity in the M area may also partly explain this result (about 60 lux in the M area versus 80 lux in the F and D areas and 200 lux immediately below the lamps in these two areas), as aged chickens have been reported to prefer lying where the light intensity is low (6 lux versus 20 lux; Davis *et al* 1999). In our experiment, the light intensity gradient might have influenced the spatial distribution of chickens and their activity in this area and might have interacted with the effects of objects added to the environment.

Although the use of space was more homogenous, the time chickens spent standing (measured by scan sampling) was not increased in the E group, except in the area containing sand (D area). Moreover, locomotor activity during standing bouts was increased only at days 2–3. This temporary increase could be explained by the fact that as early as two weeks of age, locomotor activity could not be stimulated because of the incompatibility between bodyweight and walking ability, as suggested previously by Newberry and Hall (1990). The attraction for the devices used could be related to the difficulties in walking. Our results indicate that chickens often pecked at the litter in a standing position during the initial rearing period, whereas they pecked mostly in a lying position during the finishing period. However, Reiter and Bessei (2001) reported that a reduction in load-bearing on the legs in broiler chickens (by use of a suspension device) resulted in an increase in the daily distance

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travelled until four weeks of age, but this effect disappeared at five weeks of age. Another explanation could be that at the end of the rearing period, sand and strings have lost some of their attractiveness because the extra furniture was the same throughout the experimental period. More frequent changes in the environment, for instance by changing the trays' location or content regularly, might have enhanced this attraction. However, regular changing of objects to ensure continuing novelty could be only partly effective in maintaining chickens' exploration levels, since Newberry (1999) observed a reduction in the attractiveness of novel objects after five weeks of age. The attractiveness of the objects, especially strings in our experiment, could also have been increased by the use of movement, because young chicks reared in conditions of different visual complexity are more active when the object is continuously moving (Broom 1969).

Increasing the complexity of the environment neither improved bone composition nor decreased the occurrence of tarsal angulations. This result is not surprising; although our hypothesis was that the increase in locomotor activity would improve leg condition, this physical stimulation was probably too low to be effective. Tibial bone density can be improved by walking on a treadmill, but walking distances (200 m per day) are quite high in this situation compared to spontaneous displacement (Reiter & Bessei 1995). Our results confirm that it is difficult to stimulate physical activity in chickens. One reason may be the high energy cost of locomotion, since these birds are heavy and they waste a lot of energy in waddling (Abourachid & Renous 1993). Another reason may involve pain, since walking seems to be painful even in chickens with good walking ability (McGeown *et al* 1999). This would explain why broiler chickens spend so little time standing or walking. Most of the attempts to reduce leg problems by enriching the environment have been only moderately effective (Leterrier *et al* 2001). Reduction in bodyweight increases locomotor activity (Reiter & Bessei 2001) and feed restriction allows better use of extra furniture (Koene *et al* 1999). For example, chickens reared on a 16h L : 8h D cycle to reduce growth spent an average of 6.7% of time on apparatus comprising perches, dustbaths and platforms interconnected with perches. This use of the enrichment devices resulted in a significant decrease in leg problems (Mench *et al* 2000, 2001). It seems, then, that combinations of extra furniture and lighting or feeding programmes reducing early growth rate should be tested further.

Animal welfare implications

In conclusion, adding sand trays to the chickens' environment stimulated use of the available surface in the rearing pen by inducing greater use of the area further from the drinker and feeders. The impact of adding strings above chickens' heads cannot be clearly determined by this experiment. Judging by the interest of the chickens observed, the effect is more likely to be attributable to the sand than to the strings. Providing sand trays enhanced chickens' foraging activities, especially at the beginning of the growing period. However, this type of enrichment has only a partial effect on general activity and does not improve bone composition or the occurrence of tarsal angulations. The positive effects on the use of space, activity and leg problems would probably be enhanced and last longer if more novelty was added throughout the rearing period.

These results indicate that increasing the complexity of the environment would help broiler chickens to be more active and would reduce high local densities of birds in some areas of the pens. However, in this experiment, chickens were in small pens, and the size of the groups and the density in the pens were low compared to those commonly used under commercial conditions.

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