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The effects of novel floorings on dustbathing, pecking and scratching behaviour of caged hens

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Abstract

From the year 2012, conventional battery cages for laying hens will be banned under the European Union Council Directive 1999/74/EC. Enriched cages, which include a perch, a nest area, and a pecking and scratching area will not be banned, and have certain advantages over other systems of egg production. Previous studies have shown that even when a pecking and scratching area is provided, most dustbathing occurs on the wire floor as sham dustbathing. This study investigated whether novel cage floor types could stimulate full expression of dustbathing behaviour, similar to that seen on loose litter. One hundred and forty four hens were housed in pairs in non-commercial enriched cages that differed only in that they contained one of four randomly allocated floor types. Floor types were conventional wire ('wire'), wood shavings ('litter'), conventional wire wrapped with garden twine ('string') and perforated rubber matting ('rubber'). Birds on litter or rubber performed fewer bouts of dustbathing than those on wire and string. However, bouts on litter were longer than those on the three other floor types. Overall, birds on litter or string showed a greater total duration of dustbathing than those on rubber, and birds on litter had a richer repertoire of dustbathing elements. Birds on litter performed significantly more pecking and scratching than those on string or rubber, which did not differ from those on wire. Birds on rubber and litter had poorer foot and feather condition than those on wire or string. Altering the cage floor produced minor changes in behaviour, and further novel floor types should be evaluated.

Keywords: *animal welfare, dustbathing, laying hens, novel flooring, pecking, scratching*

Introduction

Dustbathing is a behaviour found in a number of species of bird, particularly the Galliformes (Simmons 1964). It is a behaviour that shows a circadian rhythm and tends to occur mostly during the middle of the day (Vestergaard 1982; Vestergaard *et al* 1990) or when conditions are warm and bright (Hogan & van Boxel 1993; Duncan *et al* 1998). The behaviour consists of tossing and rubbing dust between the feathers to maximise contact between the dust and feathers (for a full description of the behaviour see van Liere 1992a). It is thought that dustbathing functions to maintain good feather and skin condition through the removal of stale lipids, which have been applied to the feathers from the uropygial gland (van Liere & Bokma 1987; van Liere *et al* 1991). Dustbathing may also function to help the removal of ectoparasites, although there is little evidence to support this theory (Borchelt *et al* 1973; van Liere 1992a).

Dustbathing behaviour appears to be strongly motivated and its performance increases following deprivation (Hogan *et al* 1991) suggesting that dustbathing may be a behavioural need satisfied only by performance of the behaviour. When housed on wire flooring, which lacks a suitable loose substrate, hens will perform a similar behaviour termed 'sham' dustbathing. Furthermore, featherless hens will also dustbathe, and show a similar increase in dustbathing following deprivation (Vestergaard *et al* 1999), suggesting that motivation to perform the behaviour exists even when it appears to serve no function.

Birds show a preference for dustbathing substrates. Sanotra *et al* (1995) demonstrated that naïve chicks initially showed no preference for any of a variety of substrates, and could be trained to dustbathe on apparently sub-optimal substrates, such as straw or feathers. However, when subsequently given a choice, the chicks preferred sand over feathers or straw. Vestergaard and Hogan (1992) demonstrated that red Burmese junglefowl show a preference for black sand over white sand of a finer grain size or feathers as a dustbathing substrate, regardless of rearing experience. They also found that, given equal rearing experience on various substrates, junglefowl preferred dustbathing on normal beach sand rather than white sand, dark sand or sawdust, but that this preference was not exclusive. When provided with peat, sand, sawdust and wood shavings, chickens reared on sawdust showed an almost exclusive preference for peat as a dustbathing substrate (Petherick & Duncan 1989). Therefore, the idea of a 'sensitive period' during which preference for a dustbathing substrate is established is not supported. Provided that adult hens have previously encountered wood shavings, for a brief period at any point during rearing, they will readily accept it as a substrate for dustbathing when adult (Nicol *et al* 2001).

Given that preferences for particular substrates have been clearly demonstrated in hens, an important progression is to

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discover what factors influence these preferences, as substrates vary in their effectiveness at removing excess lipids. Following a period of litter deprivation, hens provided with wood shavings spent more time dustbathing than those provided with sand, but the removal of lipids was the same (van Liere *et al* 1990). This suggests that wood shavings may be less effective at lipid removal and that birds must dustbathe for longer in order to achieve the same effect. This theory was confirmed in a further study by van Liere (1992b) who found that sand reached more areas of the feathers than wood shavings during dustbathing.

Although many studies of dustbathing have focused on how the behaviour and its functional consequences are affected by different substrates, there is, in contrast, little work on how such information can be applied to birds in commercial systems. From 2012, the use of conventional battery cages for housing laying hens will be banned under the European Union Council Directive 1999/74/EC. Because of unsolved problems, such as disease control and feather pecking in barn and free range systems, many farmers are keen to keep caged hens. Under the new Directive, furnished cages that provide more space per bird, a perch, a nest, and a pecking and scratching area will be permitted. However, no mention is made in the Directive specifically regarding dustbathing, so furnished cages may continue to be criticised by animal welfare groups. Current designs of pecking and scratching areas vary, but even when cages are designed to permit dustbathing (such as a litter area above the nestbox) more than 75% of dustbathing occurs on the wire cage floor as 'sham' dustbathing (Lindberg & Nicol 1997). Although it is possible that this may satiate the hens' dustbathing motivation, and may therefore be sufficient for welfare, a number of doubts remain; for example, 'sham' dustbathing on the wire may cause plumage damage and abrasion. Also, birds prefer litter substrates over wire and it has been shown that hens will even work, by pushing through weighted doors, to gain access to litter substrates (Widowski & Duncan 2000).

The floor of a cage is an unspecialised area (used mainly for walking and standing on) and the dustbathing that occurs here in the absence of a loose substrate is usually termed 'sham' dustbathing. It may be possible to modify the cage floor to make it more suitable for birds to satiate their dustbathing motivation. If so, and if it could be shown that such behaviour was performed in full with the same behavioural elements as dustbathing in a loose substrate and that dustbathing motivation returned to the same baseline level, this would be evidence that the performance of dustbathing was fully satisfactory. In such a case, the behaviour need not be referred to as 'sham' dustbathing. In a study looking at dustbathing behaviour in furnished cages, Lindberg and Nicol (1997) found few differences between the quality — in terms of incidence of behavioural components per unit time — of dustbathing bouts on litter in the 'dustbath' and 'sham' dustbathing bouts on the wire floor; the main difference observed was the total duration of the bouts.

In the natural environment, the non-dustbathing behaviours pecking and scratching have been demonstrated to occur for 60% and 34% of the active day respectively (Dawkins 1989), and so there may be additional welfare benefits in modifying the cage floor to encourage the occurrence of such behaviours. Furthermore, a modified cage floor would avoid problems such as the need to regularly provide fresh litter in the dustbath and eggs being laid in the litter.

The aims of this study were to assess the potential of two novel floor types (conventional wire wrapped with string, and perforated rubber matting) for use in furnished cages for laying hens. The novel floorings were evaluated for their potential to:

- allow dustbathing for a duration equivalent to that on a litter substrate;
- promote pecking and scratching behaviour;
- minimise plumage damage and abrasion.

Materials and methods

Animals and housing

One hundred and forty four 17-week-old laying hens (ISA Brown) were used. In order to study the effect of rearing experience, half of the birds had been reared on wood shavings litter and half on conventional wire floors. The hens were pair-housed in pens that provided a nest and a perch, which had previously been used in other studies of dustbathing behaviour (Nicol *et al* 2001). Pens were 0.5 × 1 m (width × depth), 0.6 m high at the front and 0.9 m high at the back. The floor was flat but the wire roof was sloped to allow a raised nest area at the rear of the pen. The pens were located in six identical rooms, each containing 12 pens. Each pen contained one of four different floor types: the first two were included as controls, and the second two were experimental floor types with properties intended to facilitate dustbathing. (1) Conventional wire flooring (wire), as this is the most common floor type in cages for laying hens. (2) Solid flooring with wood shavings (litter), which is commonly used as a substrate in commercial litter systems. Small wood shavings were used, approximately sized 1 cm^2, at a depth of approximately 2 cm. (3) Conventional wire flooring wrapped with garden twine (string). This was used as it had a soft brushy texture that might be expected to produce a similar sensation to a loose substrate when hens rubbed against it during dustbathing. (4) Rubber matting (rubber) perforated with holes of 1 cm diameter to allow droppings to fall through. This floor type was used as it was relatively soft and warm. Each room of 12 pens contained three pens of each different floor type.

All six rooms were kept on a 12 h light:dark cycle, with lights being turned on at 0600h and off at 1800h. In addition to the standard room lighting, three rooms each contained additional lighting comprising ten 60 W daylight bulbs, which were turned on between 1100h and 1500h every day in order to study the effect of additional lighting on dustbathing behaviour. Additional lighting had no effect on room temperature. Food was provided *ad libitum* from troughs in front of the pens and each pen contained two nipple drinkers.

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Procedure

Pairs of hens from the two rearing groups were randomly allocated to pens and given four weeks to acclimatise to the pens and floor types. Following this period, three sets of video recordings were taken of the hens at 21 weeks, 27 weeks and 31 weeks of age. During each set of recordings, 6 pens (one per room) were filmed from overhead for 4 h, from 1100h to 1500h each day, as previous scan samples showed that the majority of dustbathing occurred between these hours. This was continued for 12 days so that all pens had been filmed.

Analysis

Unless otherwise stated, all statistical analyses were performed using multifactorial ANOVA tests, and *post hoc* tests were performed using Fisher's protected least significant difference, in Statview. Non-parametric statistics (Kruskal-Wallis and Mann-Whitney *U* tests) were used when the data consisted of ordinal scores.

Dustbathing data

Video tapes were analysed for mean bout duration, mean number of bouts per 4 h and total duration of dustbathing (calculated from the sum of all bout durations) per 4 h per pen of two birds. A dustbathing bout began with the bird in a lying position and could include some or all of the following elements: scratching, vertical wing shaking, head or side rubbing, vigorous body shake, wing or leg stretch, pecking, and bill raking. Bouts were separated by at least 10 min. Data were analysed per pen of two birds, as individuals in pens were not independent of one another, but are reported as mean per bird for comparison with other studies. Total dustbathing duration was transformed using the arc-sine transformation and the mean number of bouts per bird was transformed using square-root transformation prior to statistical analysis.

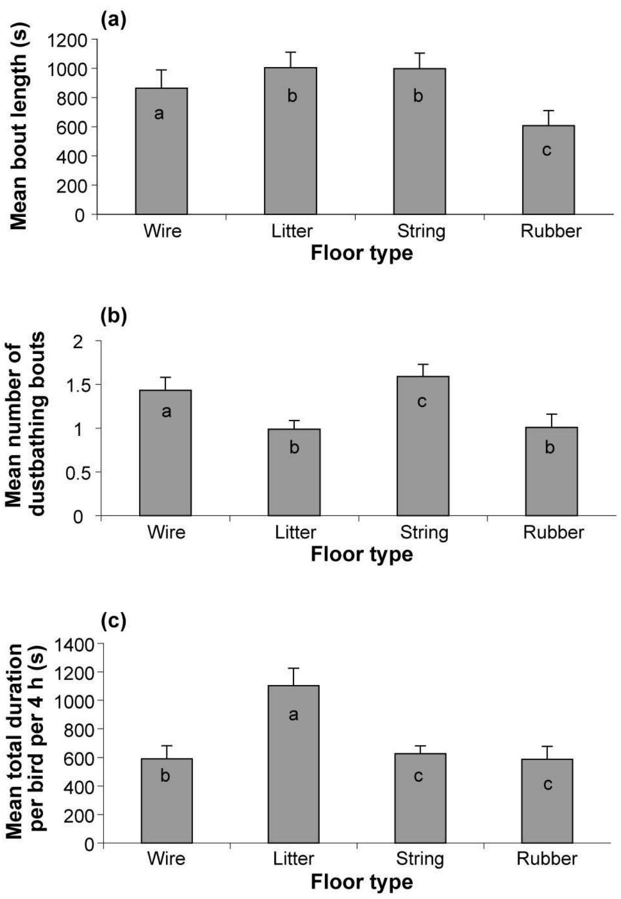
Dustbathing components

Dustbathing bouts were analysed using the Observer Program (Noldus 2003) to look at any differences in the structure of the behaviour between the four different floor types. All bouts were analysed for six pens on each of the floor types in the second and third set of recordings. Because of time constraints, the first set of recordings was not analysed as it was thought that any differences in dustbathing between floors would be more established in the second and third sets. A total of 122 bouts of dustbathing were observed and used for further analysis over a total of 20.7 h. The incidence of each of the previously listed behavioural elements in each dustbathing bout was recorded. In addition, time with head obscured in the feed trough was recorded.

Pecking and scratching

A one-zero sampling technique was used to analyse the amount of pecking and scratching that the birds performed. All recordings from all pens were watched for 30 s, every 10 min, and it was recorded whether one, both or neither bird performed ground pecking or ground scratching. These behaviours were recorded as occurring only when the bird was standing, in order to distinguish such behaviours from elements of dustbathing.

Figure 1



Effect of floor type on **(a)** mean bout length (significant differences: [bc] $P < 0.05$; **(b)** mean number of dustbathing bouts (significant differences: [ab] $P < 0.05$, [cb] $P < 0.005$); and **(c)** mean total duration of dustbathing (significant differences: [ab] $P < 0.001$, [ac] $P < 0.005$). Error bars indicate standard errors. Values shown refer to actual values, rather than values transformed for statistical analysis.

Foot and feather scoring

At 41 weeks of age the hens were scored for foot and feather quality. Scoring was carried out, on an ordinal scale, by a veterinarian who was experienced in poultry practice and unaware of the floor type on which each hen had been kept.

Hens were scored for feather cover on a scale of 0 (featherless) to 10 (fully feathered) over the whole body, although feathering on the neck area was disregarded as all birds lost feathers around the neck because of rubbing when feeding from the food troughs in front of the pens. Breast feather quality was scored, as it was mainly the breast feathers that came into contact with the substrate during dustbathing, on a scale of 0 (high quality) to 3 (low quality). Breast feather cleanliness was scored on a scale of 0 (clean) to 3 (dirty).

Foot condition was scored for the presence of sores or redness and lesions indicating poor foot quality on a scale of 0 (good condition) to 3 (poor condition).

The results of the foot and feather scoring were analysed using non-parametric tests (Kruskal-Wallis and Mann-Whitney *U* tests).

Table 1 Mean incidence per bout (± SE) of dustbathing components (comparisons are within rows).

Dustbathing component (per bout)	Wire	Litter	String	Rubber	Significant differences
Leg scratch	$25.5^b \pm 5.3$	$206.7^a \pm 33.5$	$33.4^b \pm 5.8$	$60.4^b \pm 12.8$	ab $P < 0.001$
Vertical wing shake	$14.8^b \pm 2.4$	$68.5^a \pm 9.8$	$20.9^b \pm 3.0$	$26.5^b \pm 4.8$	ab $P < 0.001$
Rubbing	$3.5^b \pm 0.7$	$34.3^a \pm 6.1$	$6.1^c \pm 1.3$	$11.8^d \pm 2.5$	ab, ac, ad $P < 0.001$
					db $P < 0.05$
Body shake	–	$0.1^a \pm 0.07$	$0.0^b \pm 0.0$	–	ab $P < 0.05$
Wing or leg stretch	0.0 ± 0.0	0.1 ± 0.1	0.3 ± 0.1	0.2 ± 0.1	–
Peck	$0.9^b \pm 0.3$	$161.1^a \pm 24.0$	$5.3^b \pm 1.4$	$16.9^b \pm 5.5$	ab $P < 0.001$
Bill rake	–	$60.3^a \pm 10.7$	$0.3^b \pm 0.3$	$0.4^b \pm 0.4$	ab $P < 0.001$

Table 2 Mean incidence per minute (± SE) of dustbathing components (comparisons are within rows).

Dustbathing component (per min)	Wire	Litter	String	Rubber	Significant differences
Leg scratch	$4.9^b \pm 0.8$	$11.0^a \pm 1.2$	$4.8^b \pm 0.5$	$5.7^b \pm 0.5$	ab $P < 0.001$
Vertical wing shake	3.1 ± 0.3	4.0 ± 0.3	3.8 ± 0.5	3.3 ± 0.4	–
Rubbing	$0.7^b \pm 0.2$	$2.0^a \pm 0.2$	$1.0^c \pm 0.2$	$1.1^d \pm 0.2$	ab $P < 0.001$
					ac $P < 0.001$
					ad $P < 0.01$
Body shake	–	0.0 ± 0.0	0.0 ± 0.0	–	–
Wing or leg stretch	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	–
Peck	$0.2^b \pm 0.1$	$9.6^a \pm 0.6$	$1.0^c \pm 0.3$	$3.2^d \pm 1.0$	ab, ac, ad, db $P < 0.001$
Bill rake	–	$4.7^a \pm 0.9$	$0.0^b \pm 0.0$	$0.0^b \pm 0.0$	ab $P < 0.001$

Results

Effect of floor type on dustbathing behaviour

Significant differences were found between floor types in the total duration of dustbathing ($F = 2.77$, $df = 3{,}196$, $P < 0.05$), the mean number of dustbathing bouts ($F = 4.824$, $df = 3{,}196$, $P < 0.005$), and the mean dustbathing bout length ($F = 7.336$, $df = 3{,}169$, $P < 0.001$). *Post hoc* analysis showed that birds housed on litter and on string performed a significantly longer total duration of dustbathing than birds on rubber. Birds on wire and string performed significantly more bouts of dustbathing than those on litter or rubber, and birds housed on litter performed significantly longer bouts of dustbathing than birds housed on wire, string or rubber. The significant differences, following *post hoc* analysis, are shown in Figure 1.

Dustbathing components

Component incidences were calculated both as mean incidence per bout of dustbathing and mean incidence per minute of dustbathing, to examine whether bouts differed in total quantity of behavioural components as well as quality of bouts.

Significant differences in the incidence per bout of dustbathing observed between different floor types were found for the following components of dustbathing: leg scratch ($F = 27.917$, $df = 3{,}118$, $P < 0.001$); vertical wing shake ($F = 21.287$, $df = 3{,}118$, $P < 0.001$); rubbing ($F = 22.565$, $df = 3{,}115$, $P < 0.001$); body shake ($F = 3.193$, $df = 3{,}118$, $P < 0.05$); and pecking ($F = 55.451$, $df = 3{,}118$, $P < 0.001$). *Post hoc* analysis revealed a number of differences between the floor types (Table 1). Mostly, the differences revealed a far richer repertoire of behavioural elements in the dustbathing that was observed on litter, compared with the other substrates. However, birds on rubber performed more rubbing than birds on wire, and birds on string performed some body shakes that were never observed on wire or rubber. Bill raking was performed on litter, string and rubber but never on wire.

Significant differences in the incidence per minute of observed dustbathing between different floor types were found for the following components of dustbathing: leg scratching ($F = 12.582$, $df = 3{,}118$, $P < 0.001$); rubbing ($F = 7.203$, $df = 3{,}118$, $P < 0.001$); and pecking ($F = 63.068$, $df = 3{,}114$, $P < 0.001$). *Post hoc* analysis revealed a number of differences between the floor types (Table 2). Mostly, the differences revealed a greater intensity in the expression of behavioural components in dustbathing performed on litter, compared with any other substrate. However, birds on rubber performed more pecks per minute during dustbathing bouts than birds on wire.

A significant difference was found in the proportion of dustbathing bouts during which the bird had her head in the feed trough ($F = 9.394$, $df = 3{,}118$, $P < 0.001$). Birds housed on litter spent a mean of 0.35% of each dustbathing bout with their head in the feed trough (SE ± 0.3). This was significantly less time than those on wire (mean = 38.8%,

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SE ± 5.3, $P < 0.005$), string (mean = 38.9%, SE ± 5.5, $P < 0.01$) and rubber (mean = 34.9%, SE ± 7.0, $P < 0.05$).

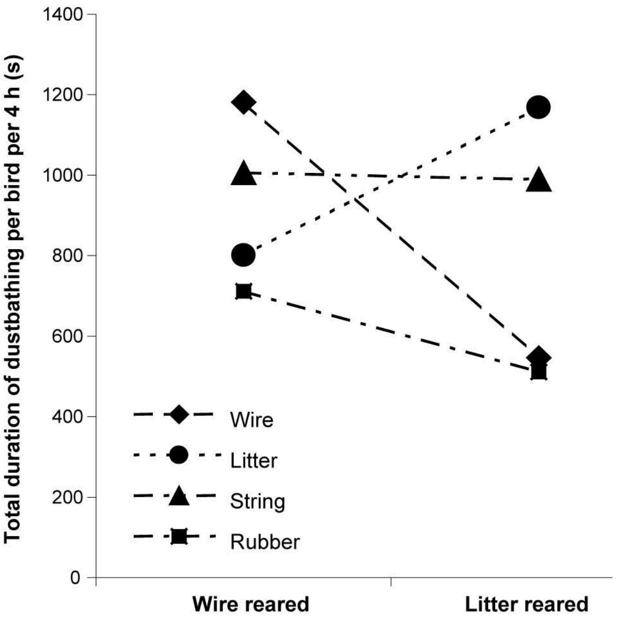
Effect of additional lighting

The presence of additional lighting had no significant effect on mean bout length ($F = 0.561$, $df = 1{,}198$, $P > 0.05$), mean number of bouts per 4 h ($F = 0.046$, $df = 1{,}171$, $P > 0.05$) or total duration of dustbathing per bird per 4 h ($F = 0.053$, $df = 1{,}198$, $P > 0.05$) on any of the floor types.

Effect of rearing experience

No significant differences were found between birds reared on wire and those reared on litter in mean bout length ($F = 0.73$, $df = 1{,}171$, $P > 0.05$), mean number of bouts per 4 h ($F = 0.604$, $df = 1{,}198$, $P > 0.05$) or total duration of dustbathing per bird per 4 h ($F = 1.632$, $df = 1{,}198$, $P > 0.05$). However, a significant interaction was found between floor type and rearing treatment ($F = 3.594$, $df = 3{,}192$, $P < 0.05$) on the total duration of dustbathing. Rearing treatment had little effect on total duration of dustbathing for birds housed on string or rubber flooring. Litter-reared birds performed more dustbathing than wire-reared birds when housed on litter; conversely, wire-reared birds performed more dustbathing than litter-reared birds when housed on wire (Figure 2).

Figure 2



Interaction between floor type and rearing treatment; effect on total duration of dustbathing.

Pecking and scratching

Significant differences were found between floor types and the amount of pecking ($F = 34.399$, $df = 3{,}187$, $P < 0.001$) and scratching ($F = 19.526$, $df = 3{,}187$, $P < 0.001$) (Table 3). *Post hoc* analysis showed that birds on litter pecked more than birds on wire, string and rubber. Similarly, birds on litter scratched more than birds on wire, string and rubber.

Feather and foot scoring

Significant differences were found between floor types in feather cleanliness ($H = 56.376$, $df = 3$, $P < 0.001$), feather cover ($H = 15.261$, $df = 3$, $P < 0.005$) and foot condition ($H = 15.138$, $df = 3$, $P < 0.005$) (Table 4).

Birds on wire had significantly cleaner feathers than those on litter and than those on rubber. Birds on litter and string had significantly cleaner feathers than those on rubber.

Birds on wire had significantly better feather cover than those on rubber. Birds on litter had significantly better feather cover than those on string and rubber.

Birds on wire had significantly better foot condition than those on rubber and than those on litter. Birds on string had significantly better foot condition than those on rubber. No significant differences in feather quality were found between floor types ($H = 0.968$, $df = 3$, $P > 0.05$).

Discussion

The main aim of this study was to assess two novel floorings (string and rubber) for potential use in furnished cages to encourage full expression of dustbathing behaviour (similar to that displayed on a loose litter substrate), to minimise plumage damage, and to promote pecking and scratching. Birds housed on the novel floor type string were found to perform a similar total duration of dustbathing as those housed on litter. The string flooring also resulted in birds having similar feather quality to those on litter (although feather cover was poorer) and good foot condition. Birds housed on rubber were observed to perform less dustbathing than those on litter and were found to have poor feather and foot condition. Neither of the two novel floors appeared to promote pecking or scratching.

There were clear differences between the dustbathing behaviour of birds housed on litter and those housed on the three other floor types used. In particular, birds dustbathing on litter performed fewer bouts, but of a greater duration than birds on the other floor types. The greater number of shorter bouts observed on wire, string and rubber may reflect a degree of frustration. Hens have been observed to perform shorter bouts of preening than normal when frustrated (Duncan & Wood-Gush 1972) and it is possible that frustration may also result in shorter bouts of dustbathing. The birds may frequently begin dustbathing bouts but end them after a shorter time than on litter as they are less satisfying. Dustbathing without a loose substrate may not provide birds with sufficient feedback to carry out full bouts containing all the necessary elements of the behaviour. In contrast to the study by Lindberg and Nicol (1997), clear differences in the quality of dustbathing were observed. The incidences of behavioural components of dustbathing, including scratching, vertical wing shaking and rubbing per bout were found to be significantly less on string and rubber than on litter, and more similar to that found on wire. It is possible that this may be a result of the shorter dustbathing bouts observed on these floors, and may reflect a further degree of frustration. Additionally, the incidences per minute of scratching and rubbing were fewer in the non-litter substrates. The incidences of pecking and bill raking

Table 3 Effect of floor type on scratching and pecking (± SE). Means with differing superscript are significantly different at $P < 0.001$ (comparisons are within columns).

Floor type	Mean percentage of scans in which scratching was observed (± SE)	Mean percentage of scans in which pecking was observed (± SE)
Wire	$3.5^a \pm 0.7$	$5.7^a \pm 1.3$
Litter	$12.4^b \pm 1.5$	$23.2^b \pm 1.8$
String	$3.7^a \pm 0.6$	$7.4^a \pm 1.0$
Rubber	$5.3^a \pm 0.8$	$9.0^a \pm 1.2$

Table 4 Effect of floor type on feather and feet scoring. Numbers (± SE) refer to means of scores obtained from all birds (comparisons are within columns).

Floor type	Feather cleanliness	Feather quality	Feather cover	Foot quality
Wire	$0.2^{ac} \pm 0.1$	0.6 ± 0.1	$7.0^a \pm 0.5$	$0.0^a \pm 0.0$
Litter	$0.8^{ad} \pm 0.3$	0.9 ± 0.3	$7.2^b \pm 0.4$	$0.4^b \pm 0.1$
String	$0.6^a \pm 0.1$	1.0 ± 0.4	$5.8^c \pm 0.5$	$0.1^c \pm 0.1$
Rubber	$1.9^b \pm 0.1$	0.6 ± 0.1	$5.9^d \pm 0.4$	$0.6^d \pm 0.1$
Significance	ab $P < 0.001$ cd $P < 0.05$		ad $P < 0.005$ bd $P < 0.001$ bc $P < 0.05$	ad $P < 0.001$ cd $P < 0.005$ ab $P < 0.05$

were also significantly fewer on the non-litter substrates. However, this may be because such behaviours were occurring in the feed trough, where the head was obscured from view. During dustbathing bouts on the three non-litter floor types, compared to on litter, the birds spent a significantly greater proportion of bouts with their head in the food trough pecking and bill raking, indicating that it may be highly preferable to the birds to have a loose substrate for the performance of these behaviours.

The absence of the functional consequences of dustbathing without a loose substrate, ie the removal of stale lipids, may disrupt the behaviour further. However, it is important to note that, although sham dustbathing on conventional wire is unlikely to be as effective in the removal of lipids as a loose substrate, birds are still motivated to perform this behaviour in the absence of a suitable loose substrate (Vestergaard *et al* 1999). Since differences were found in dustbathing behaviour between the non-litter substrates, it is reasonable to hypothesise that there may be differences in the degree to which such sham dustbaths satiate dustbathing motivation. Further study is necessary to look at the motivational consequences of dustbathing on various non-litter substrates.

Although it appears that in this study litter was the optimal substrate in terms of encouraging dustbathing behaviour, the feathers of hens housed on litter and rubber tended to be dirtier than those of hens on wire or string, possibly because of greater contact with droppings. On litter, the droppings remained in the shavings until the weekly cleaning of the pens. Despite perforations, the droppings also tended to adhere to the rubber and would be in contact with the feathers, particularly when the hens were dustbathing. However, the wire and string floorings allowed the droppings to fall through easily and so the hens were never in contact with their droppings and their feathers remained clean.

Hens housed on rubber had poorer feather cover than those housed on wire or litter. This may be related to the dirtier feathers. However, some birds on litter had poor feather cleanliness but good feather cover, and so dirt on the feathers did not inevitably cause feather loss. The good feather cover of hens housed on litter supports the idea that dustbathing in a loose substrate functions to maintain feather quality and cover (van Liere & Bokma 1987; van Liere *et al* 1991). Properties of the rubber flooring appeared to cause feather loss by adhering slightly to feathers, particularly during dustbathing, and a number of feathers were observed to have become stuck to the rubber.

Wire and string both resulted in significantly better foot condition than rubber, and wire resulted in significantly better foot condition than litter. However, there were few observations of very poor foot condition on any of the floor types. As with feather cleanliness, this result may have been because of the greater contact with droppings on the litter and rubber floorings.

Neither of the two novel floor types significantly increased pecking or scratching behaviour above the baseline levels observed on wire. Birds housed on litter performed significantly more pecking and scratching than those on the other floor types. This may indicate that pecking and scratching are behaviours that can be encouraged only by the provision of a loose litter substrate. It is possible that different solutions may be required to promote pecking and scratching behaviour from those required to promote dustbathing, but there may still be benefits in the provision of a loose litter pecking and scratching area in the design of furnished cages, even if it is unsuitable for dustbathing.

Rearing experience had no effect on the dustbathing behaviour of birds housed on the two novel floor types, but birds housed on litter and wire performed a greater total duration of dustbathing when housed on the substrate on which they were reared. Nicol *et al* (2001) found that there was some importance of substrate experience around day 60 of life in laying hens' subsequent dustbathing behaviour. As our birds were acquired at 17 weeks old, they were kept on their rearing substrate at this age. This suggests that, in order to promote dustbathing behaviour, it may be advantageous to rear birds on the same substrate that they will subsequently be housed on in adult life, particularly if a novel flooring can be identified for use in furnished cages.

The aim of this study was to examine the principle of providing modified flooring, but it is recognised that the cages we used are not representative of the current commercial practice. Currently available furnished cages are designed for larger groups of chickens; five, eight, ten, twenty and some cages for forty to sixty birds. Such cages have different solutions to providing a pecking, scratching and dustbathing substrate (eg Big Dutchman 2004; Patchett Engineering 2004). Because the dustbathing behaviour of hens is socially facilitated it is important that future research on flooring types is conducted under commercial conditions.

The results of this study demonstrate that novel substrates can modify and affect dustbathing behaviour. Rubber flooring was not suitable for use in furnished cages as it did not encourage dustbathing behaviour and also resulted in poor feather condition. Although the string flooring did not function as well as litter as a dustbathing substrate, it did encourage dustbathing and allowed hens to maintain healthy plumage and feet. Neither of the novel floor types resulted in the full rich sequences of dustbathing observed on litter, although behavioural components never seen on wire, such as body shaking and bill raking, were observed on string. However, litter is not an option in commercial cage systems for hygienic reasons and the prevention of floor eggs, and so any alternative flooring that results in behaviour close to that shown on litter may have welfare benefits. Testing of further floor substrates may enable identification of a material that permits a full expression of dustbathing behaviour.

Animal welfare implications

Because of various disadvantages of alternative systems, such as disease control, feather pecking and cannibalism, many farmers are likely to use furnished cage systems after the 2012 ban on conventional battery cages. Flooring that allows droppings to pass through results in improved hygiene but restricts pecking, scratching and dustbathing behaviour. It is important that cages used to replace the conventional cages allow birds to perform as many of their natural behaviours as possible. This study demonstrates that a novel floor type can result in a change in behaviour from that on conventional wire and can encourage a greater total duration of dustbathing. However, the novel floors did result in shorter bouts of dustbathing than on loose litter, which may reflect a degree of frustration. This may be mitigated by rearing on the novel floor, and as this study demonstrates, familiarity may affect dustbathing behaviour. If birds spend additional time engaged in dustbathing, pecking and scratching, it is possible that problems with feather pecking may be reduced. Poor feather condition has been shown to result in feather pecking (McAdie & Keeling 2000) and may cause heat loss. Thus, a facility that promotes dustbathing, and therefore feather maintenance, may reduce feather pecking and improve thermoregulation and feed efficiency. This study demonstrates that there is potential for the use of alternative floor types in furnished cages and suggests that there is a need for further studies to identify their optimum characteristics.

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