The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
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Can substrate in early rearing prevent feather pecking in adult laying hens?

IC de Jong*, BFJ Reuvekamp and H Gunnink

Wageningen UR Livestock Research, PO Box 65, 8200 AB Lelystad, The Netherlands
* Contact for correspondence and requests for reprints: Ingrid.dejong@wur.nl

Abstract

In The Netherlands, laying hen chicks are often reared without litter on the raised slatted area of a barn system or confined in the aviary system during the first two to five weeks after hatching, with chick paper or chicken wire on the floor. In the absence of a suitable pecking substrate, chicks may redirect their pecking behaviour to other birds, which possibly increases the risk of developing feather-pecking behaviour. The aim of this study was to determine whether housing on wood-shavings (WS treatment; n = 15 groups) as compared to housing on chicken wire (CW treatment; n = 15 groups) between day 1–20 could reduce feather pecking in adult birds. After day 20, all chickens were allowed wood-shavings as litter. Behavioural observations showed that CW chicks performed significantly less ground-pecking behaviour compared with WS chicks up to day 20. More CW chicks showed gentle feather pecking at day 7 and 14 as compared to WS chicks, and more CW chicks pecked at the feeder or drinker than WS chicks up to day 20. CW chicks showed rebound behaviour: the day after they were introduced to wood-shavings they displayed more ground-pecking behaviour compared to the WS chicks. Later on in the rearing period no noticeable differences between treatments were found in frequency of gentle and severe feather-pecking bouts. During laying, more gentle feather-pecking bouts were observed in CW than in WS groups but no differences in severe feather-pecking bouts were observed, nor in feather damage at the end of the trial. The results indicate that hens can display substantial flexibility in their pecking behaviour and that, despite more gentle feather pecking in CW hens in laying, the absence of substrate in early rearing does not increase the risk of developing severe feather-pecking behaviour when adult.

Keywords: *animal welfare, feather pecking, ground pecking, laying hens, ontogeny, substrate*

Introduction

A substantial body of research has been carried out on management practices that reduce the risk of feather pecking in commercial laying hen systems. Beak trimming (eg Lambton *et al* 2010) and reducing the light intensity (eg Drake *et al* 2010) are often used to control feather pecking in commercial flocks. However, very low light intensities impair eye development and visability (eg Kjaer & Vestergaard 1999; Prescott *et al* 2003). Hot-blade beak trimming raises welfare problems in its own rights, such as being painful and causing morphological changes (eg Freire *et al* 2011) and infra-red beak trimming, although considered more welfare-friendly as compared to hot-blade trimming, can be further optimised (Dennis & Cheng 2012). Several studies stressed the importance of rearing conditions in the development of feather pecking in adult hens (eg Van de Weerd & Elson 2006; Bestman *et al* 2009). A reduced stocking density, availability of litter of good quality and environmental enrichment in rearing reduce the risk of development of feather pecking (eg Van de Weerd & Elson 2006; Bestman *et al* 2009). In the laying period, for example, range use, the type of breed, feed form and access to litter have been identified in epidemiological studies as important factors in the development of feather pecking (eg Green *et al* 2000; Nicol *et al* 2003; Lambton *et al* 2010).

Although risk factors have been identified, research is ambiguous on the influence of the effect of substrate in the early rearing period. It has been suggested that the substrate used during early rearing may affect the risk of development of feather pecking when adult (Johnsen *et al* 1998; Dixon 2008). In particular, it has been suggested that substrates which promote foraging may reduce the risk of feather pecking. Huber-Eicher and Wechsler (1997) showed that providing chicks with a dustbathing substrate (sand) did not prevent feather pecking, but providing sand as well as long straw (dustbathing and foraging substrate) did prevent feather pecking, although observations were only given up to week 7. Hens reared in aviaries that had substrate (wood-shavings, straw) in the first two weeks showed less feather pecking at 5 and 14 weeks compared with hens that were housed on wire in the first two weeks, however, no observations were performed in adult hens (Huber-Eicher & Sebö 2001). Chicks raised in exploratory stimuli-rich environments in the first five weeks of life also showed reduced

feather pecking compared with chicks housed on wire, but there were no observations later in rearing or during laying (Chow & Hogan 2005). In the absence of a suitable pecking substrate, chicks may redirect their pecking behaviour to other birds (Blokhuis 1986; Johnsen & Vestergaard 1996). If this preference is permanent, there may be a substantial risk for the development of feather pecking. Others have shown that current environmental conditions count more than previous experience, as the effect of absence of litter in early rearing can be neutralised by providing adequate substrate later in rearing (Nicol *et al* 2001).

In commercial free-range and aviary systems in The Netherlands, laying hen chicks are often confined on the raised slatted area or in the aviary system until two to five weeks of age (dependent on the policy of the individual farmer) with either chick paper or chick wire (plastic wire with a small diameter for chick housing) on the floor. After this period, the chickens are allowed access to the whole system, including a substrate area, and the chick paper or chicken wire are removed from the slatted area or system. Usually no substrate is provided on the chick paper when the chickens are confined on the slatted area or in the system. If the early rearing period is important in the development of pecking behaviour of chicks, then housing in this system may present a risk for development of feather pecking later in life.

As previous research was ambiguous on the effect of litter in early rearing on the development of feather pecking when adult (Huber-Eicher & Wechsler 1997; Johnsen *et al* 1998; Huber-Eicher & Sebö 2001; Nicol *et al* 2001; Dixon 2008) we studied, in a previous experiment, whether early provision of substrate would permanently direct pecking behaviour towards the substrate and would reduce the risk of feather pecking later in life. Although we clearly showed that providing substrate in early rearing stimulated ground pecking, no clear effects on the development of feather pecking were found. This might have been caused by the fact that severe feather pecking did not develop at all in that particular experiment (de Jong *et al* 2013).

Here, we report the results of a subsequent proof-of-principle experiment where the most contrasting treatments from the previous experiment were tested again, namely rearing laying hen chicks on chicken wire or wood-shavings during the first three weeks of life. We hypothesise that hens housed on substrate in the early rearing would develop less feather pecking as compared to hens housed on chick wire in early rearing.

Materials and methods

Study animals and housing

On day 1, 720 day-old chicks (Lohmann Brown Lite, non-beak trimmed), obtained from a commercial hatchery, were randomly distributed over 30 experimental pens (1.50 × 1.0 × 2.30 m [length × width × height]; 24 chicks per pen). Each pen consisted of a litter area (1.0 × 1.0 m; length × width) at the front side and a raised slatted area (0.50 × 1.0 × 0.52 m) in the back. Two perches were present per pen (47 and 90 cm above the slatted area). The pens were arranged in two rows of 15 within one house. Pens were separated with wire mesh covered with a sheet of hardboard plate (next to the litter area and raised slatted area, height; 1 m) so that substrate could not spread to neighbouring pens. Hens stayed in these pens until the end of the experiment (40 weeks of age). In practice, the number of days the chicks are confined in the system is highly variable (until 14 to 35 days of age), although the majority of farmers seem to keep the birds in the system until three weeks of age. Therefore, in this experiment, the chickens were confined on the raised slatted area up to 20 days of age. The raised slatted area was either covered with chicken wire (plastic wire with a small diameter [0.5 cm] commonly used for chicks, treatment CW; n = 15 pens) or chick paper (brown; thickness 70 g m^{-2}) with a layer of wood-shavings of 1 cm (treatment WS; n = 15 pens). Pens were randomly assigned to treatments. Mash feed was provided in a feeder pan on the raised slatted area and available *ad libitum*. Water was available *ad libitum* from three drinking nipples. From 20 days of age onwards the chickens had access to the entire pen (1.50 × 1.0 m [litter area: 100 × 100 cm]) where all chicks had woodshavings in the litter area. The chicken wire or the chick paper with wood-shavings on the raised slatted area were removed at 20 days of age. Because the chickens were too young to get up to the raised slatted area, a ramp was installed until eight weeks of age. Mash feed was provided in a feeder pan on the littered floor. Water was provided *ad libitum*.

At 16 weeks of age, at the start of the laying period, the groups were reduced to 12 hens per pen by randomly removing birds from each pen. From 16 weeks onwards pelleted feed was provided. The experiment was terminated at 40 weeks of age.

The light schedule as indicated by the breeding company was used. This meant that on days one to two, 24 h of light was given and subsequently the light period was reduced weekly until 9 h of light per day from 5 to 16 weeks of age. From 16 weeks of age the light duration increased again by 1 h per week to 14 h of light at 21 weeks of age. The light intensity was approximately 20 lux at animal height in the litter area. The light was turned on at 0730h. Since little feather pecking was observed by 21 weeks of age, it was decided to increase the light intensity to about 40 lux in the litter area (70 lux at the raised slatted area) to stimulate feather pecking (Riber *et al* 2007). The vaccination scheme, as provided by the hatchery, was used.

The experiment was approved by the Animal Care and Use Committee of Wageningen UR Livestock Research, Wageningen, The Netherlands.

Weights, mortality and production

Mortality was recorded daily by the stockpersons. If known, the cause of death was recorded. All animals were weighed at the start of the experiment, at the start of the laying period (20 weeks of age) and at the end of the experiment (40 weeks of age), using group weighing of all birds per pen. Feed intake was measured every two weeks. During laying, the number of eggs was recorded daily, as well as average egg weight, number of floor eggs and the number of second grade eggs.

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Behavioural observations

Early rearing period until 21 days of age

Behaviour was directly observed by two researchers on days 4, 7, 14 and 21 (on day 21 all chicks had access to the whole pen and wood-shavings in the litter area). Observers were blind to the experimental treatments from 21 days of age onwards. At day 1, two randomly chosen chicks were marked with a permanent marker and on the specified days (4, 7, 14 and 21) the number of ground pecks (pecks directed at the substrate or chicken wire) were recorded during 2 min per chick between 1000–1300h according to de Jong *et al* (2013). Pens were randomly assigned to an observer who observed both birds consecutively. The order of birds in a pen was determined prior to observation by drawing of lots. Birds were re-marked once per week.

Furthermore, four times a day (twice in the morning, twice in the afternoon), instantaneous scan sampling was carried out, counting numbers of chicks involved in eating/drinking (pecking at the feeder/drinker), ground pecking (pecking at the wire or substrate), gentle feather pecking (gentle pecking at the tips of feathers or down of other birds, sometimes stereotyped in form, usually without a response from the receiver), severe feather pecking (pecking at or pulling the feathers of other birds [and sometimes eating them], usually leading to a response from the recipient), aggressive pecking (a single peck directed at the head), and comfort behaviour (wing flapping, stretching, preening and dustbathing) (de Jong *et al* 2013). Behaviours were not mutually exclusive. Pens were randomly assigned to an observer. All observations took place between 0830 and 1630h.

Rearing and laying period from 4 to 40 weeks of age

Observations were carried out at 4, 8, 15, 20, 26, 32, 36 and 40 weeks of age. At each age, bouts of feather pecking were recorded during 20 min per pen for all birds by two observers according to Riber *et al* (2007). Gentle feather pecking, severe feather pecking and gentle feather pecking towards dustbathing hens were separately recorded (because of the association of gentle feather pecking at dustbathing hens with explorative pecking at particles in the plumage [Riber *et al* 2007]). A bout was defined as a continuous period of feather pecking which was considered terminated when no feather pecking took place within a period of 5 s.

Furthermore, at 15 and 40 weeks of age, but at days separate from the above observations, scan sampling was used to record the number of birds eating/drinking, and performing floor-directed pecking, gentle/feather pecking, severe feather pecking, aggressive pecking, and comfort behaviour (wing flapping, stretching, preening and dustbathing) (for definitions, see above). Also, the number of animals in the litter, on the raised slatted area, in the nests and sitting on the perches, were counted. These bird counts were repeated four times: twice in the morning and twice in the afternoon.

In addition, during the second part of the observations, focal sampling was carried out on two randomly selected hens (these were not marked) for 5 min per hen by two observers, using a Psion hand-held computer and the Observer software (Version 6.0, Noldus, Wageningen, The Netherlands). An observer observed both hens in a pen consecutively. The following mutually exclusive behaviours were recorded: eating/drinking; foraging (pecking at and scratching the litter); gentle feather pecking; gentle feather pecking at dustbathing hens; severe feather pecking; comfort behaviour (wing-flapping, stretching and preening); dustbathing; moving (walking, running, flying); inactive (sitting, lie down, rest); and other behaviour (for definitions, see above).

For all observations, pens were randomly assigned to an observer.

Table 1 Scoring system for feather and skin damage (adapted from Bilcik & Keeling 1999).

Score	Description feather damage	Description skin damage
0	Plumage smooth	Skin healthy
1	Feathers rough	Slight skin damage
2	Feathers broken	Skin damage, scratches
3	Feathers shaggy	Skin mildly wounded
4	Balding	Skin seriously wounded
5	Bald	–

Feather damage

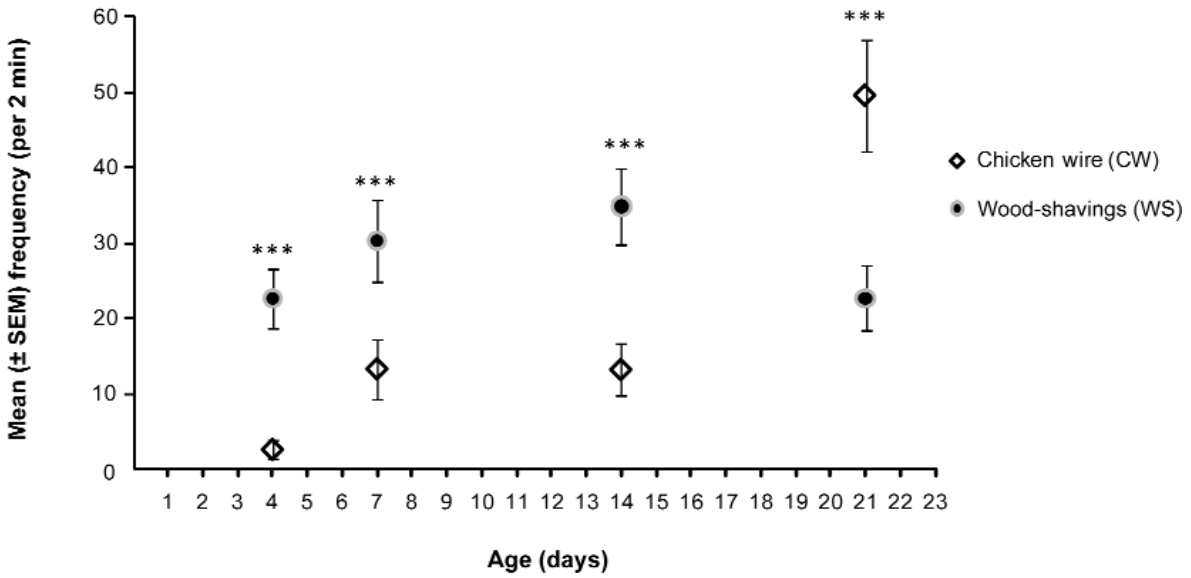
At the end of the rearing period, at 15 weeks of age, and at the end of the experiment, at 40 weeks of age, feather damage was determined according to the scoring system in Table 1 for the following body parts: comb, head, neck, belly, back, wings, tail, thigh, shin.

Statistical analysis

All analyses were performed using the statistical software Genstat (Genstat 2010) and with pen as experimental unit. Production data and scores for feather and skin damage were analysed with ANOVA for continuous variables or logistic regression analysis (Generalised Linear Model; GLM) for percentages. Pair-wise comparisons were carried out on significant treatment effects using *t*-tests (procedure PAIRTEST). Frequencies for pecking in the early rearing period (until 21 days of age) were analysed using a repeated measurements analysis (GLMM). Analysis was performed on average frequencies of the two birds per pen. Treatment, age, observer and their interactions were included as fixed effects, and pen and age were included as random effects in the model. Subsequently, an *F*-test for fixed effects was performed. Correlations between subsequent observations for the same pens were included in the repeated measures analysis. Effects of treatment were analysed against variance between pens, effects of age and interaction between treatment and age were analysed against variance within pens. In case of significant overall treatment effects, a *t*-test was performed for pair-wise analyses (procedure PAIRTEST).

Counts of birds performing different behaviours (until 21 days of age, and at 15 and 40 weeks of age) were expressed as

Figure 1



Mean (± SEM) frequency of ground pecking during the early rearing period. Note that after 20 days of age all treatments had wood-shavings in the litter area. *** $P < 0.001$.

percentages of birds in a group performing a particular behaviour. Repeated measurements analysis (GLMM) as described above was used to analyse these percentages, but now with pen, age and observation period included as random effects in the model and a Wald test for fixed effects. In case of significant overall treatment effects, a *t*-test was performed for pair-wise analyses (procedure PAIRTEST).

Since the number of animals in a pen differed between the rearing period and the laying period, and could vary due to mortality, the number of feather-pecking bouts was expressed as the number of bouts per hen per 20 min. For this variable, a repeated measurements analysis (GLMM), as described above, was used with treatment, age and their interaction as fixed effects, and pen and observer as random effects. Subsequently, Wald tests for fixed effects were performed and PAIRTEST to compare treatments per age in case there was a significant overall treatment effect.

Results of focal sampling of behaviours in two randomly selected hens at 15 and 40 weeks of age were analysed with a log-linear regression for frequencies (GLM procedure) or ANOVA (duration and average duration of behaviours) with treatment as fixed effect. Analysis was performed on averages of the two birds per pen. Prior to the analysis, a log +0.1 transformation was carried out for all dependent variables.

Results

Bodyweight, mortality and production

There were no significant differences in mortality during rearing and laying. Average mortality during rearing was 2.22 vs 1.11% for CW and WS groups, respectively. Average mortality during production was 8.3 vs 11.9% for CW and WS groups, respectively. The main reason for mortality during the production period was cannibalism/cloaca pecking, which was observed from 23 weeks of age in several pens (six WS pens, four CW pens). There were no differences in bodyweight, feed intake and production results between CW and WS groups (data not shown).

Behaviour

Early rearing period until 21 days of age

A significant overall treatment and age effect was found for ground pecking ($P < 0.05$ and $P < 0.001$ for treatment and age, respectively). In addition, a significant interaction between age and treatment was found ($P < 0.001$). CW hens exhibited significantly less ground pecking than WS hens during the early rearing period (pair-wise comparisons; $P < 0.001$ at 4, 7 and 14 days of age; Figure 1). However, on day 21, when all groups were provided with wood-shavings, ground-pecking frequency was significantly higher in CW compared to WS hens (pair-wise comparison; $P < 0.001$; Figure 1). Also, the frequency of ground pecking increased with age (pair-wise comparisons between all ages; $P < 0.001$).

Not only the frequency of ground pecking, but also the number of chickens pecking at the ground differed significantly between the treatments (overall treatment effect; $P < 0.05$). In addition, a significant overall age effect was found ($P < 0.001$) and an interaction between age and treatment ($P < 0.001$). On days 4, 7 and 14 more WS than CW chickens showed ground pecking, but on day 21 (when all groups were provided with substrate) significantly more CW chickens pecked at the ground than WS chickens (pair-wise comparisons; $P < 0.001$ at all ages; Figure 2). The number of chickens showing ground pecking increased significantly with age (pair-wise comparisons between all ages; $P < 0.001$).

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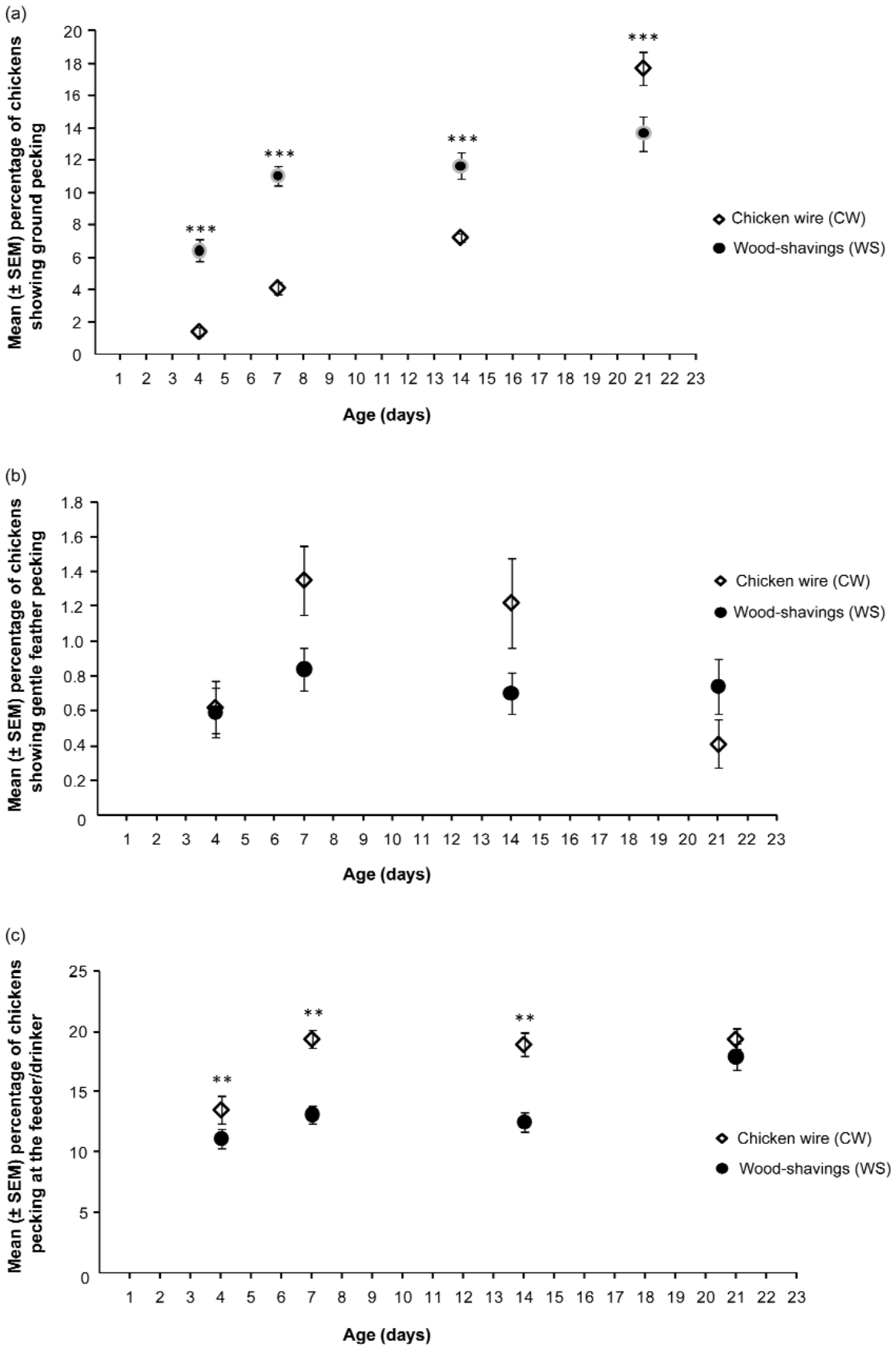
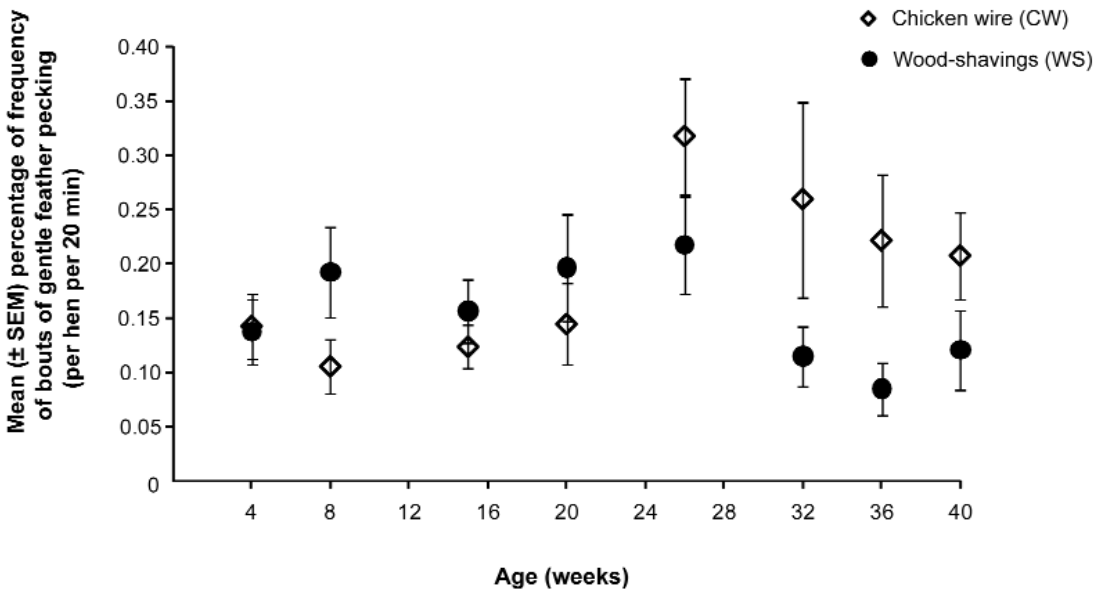
Figure 2



Mean (± SEM) percentage of chickens showing (a) ground pecking, (b) gentle feather pecking and (c) pecking at the feeder/drinker in the early rearing period. Note that after 20 days of age all treatments had wood-shavings in the litter area. *** $P < 0.001$; ** $P < 0.01$.

Figure 3



Mean (± SEM) percentage of bouts of gentle feather pecking per hen during the 20-min observation period in the rearing and laying period. After 20 weeks of age the light intensity was increased. Pecks at feathers of dustbathing hens are not included in this figure.

No overall treatment effect was found for gentle feather pecking, but there was a significant interaction between age and treatment ($P < 0.05$). Figure 2 shows that on day 7 and 14 more CW chicks showed gentle feather pecking compared with WS chicks, even though only a small percentage of birds showed this behaviour. The difference between treatments was absent at day 21 when all chicks had access to wood-shavings in the litter area. A significant effect of age was found (overall treatment effect; $P < 0.05$). At days 4 and 21 the number of birds showing gentle feather pecking was significantly lower compared with days 7 and 14 (pair-wise comparisons; $P < 0.05$).

In addition, the percentage of animals pecking at the feeding trough/drinking nipple was significantly higher in CW than WS at 4, 7 and 14 days of age (overall treatment effect; $P < 0.001$; pair-wise comparisons at days 4, 7 and 14; $P < 0.001$; Figure 2). In addition, there was a significant interaction between age and treatment ($P < 0.01$). Between 4 and 14 days of age, more CW chicks were pecking at the feeding trough/drinking nipple whereas at day 21 there were no differences between the treatments. There was a significant age effect ($P < 0.001$), in that fewer chicks pecked at the feeding trough or drinking nipple on days 4 and 21 compared to days 7 and 14 ($P < 0.001$).

Severe feather pecking was observed, but prevalences were too low for reliable analysis. There were no differences between the treatments for the other behaviours (data not shown).

Feather pecking bouts between 4–40 weeks of age

Figure 3 shows the frequency of bouts of gentle feather pecking. No overall treatment effects were found for the number of gentle feather-pecking bouts, but there was a significant interaction between age and treatment ($P < 0.05$). During laying, CW hens showed more gentle feather-pecking bouts whereas during rearing more gentle feather-pecking bouts were observed in WS hens. Also, an overall age effect was found ($P < 0.01$); gentle feather-pecking bouts were more frequent at 26 weeks of age compared with 4, 8, 15, 36 and 40 weeks of age and more frequent at 20 weeks of age compared with four weeks of age ($P < 0.01$).

Figure 4 shows the bouts of gentle feather pecking specifically directed at dustbathing hens. There were no significant overall treatment effects. A significant overall age effect was found ($P < 0.001$): the number of bouts of gentle feather pecking to dustbathing hens was significantly higher at four weeks compared with weeks 8, 15, 26, 32, 26 and 40. In addition, the number of bouts was significantly higher at 20 weeks compared with weeks 8, 15, 26, 36 and 40 (pair-wise comparisons; $P < 0.01$ at all ages).

Figure 5 shows bouts of severe feather pecking. No overall treatment effects or interactions between age and treatment were found for severe feather-pecking bouts. A significant overall age effect was found ($P < 0.001$). When individual ages were compared, it was found that the number of bouts of feather pecking from 26 weeks of age onwards was significantly higher than at 20 weeks of age ($P < 0.001$). So, after the light intensity was increased, the frequency of severe feather pecking increased significantly.

Other behaviour at 15 and 40 weeks of age

At 15 and 40 weeks of age, no differences were found in the number of animals performing eating/drinking, floor-directed pecking, gentle feather pecking, severe

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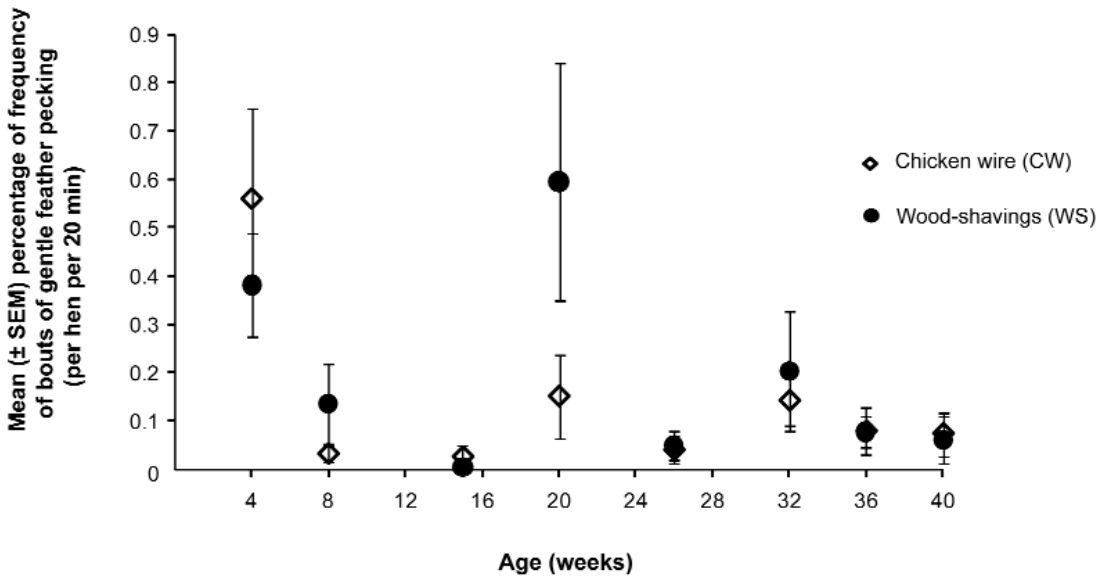
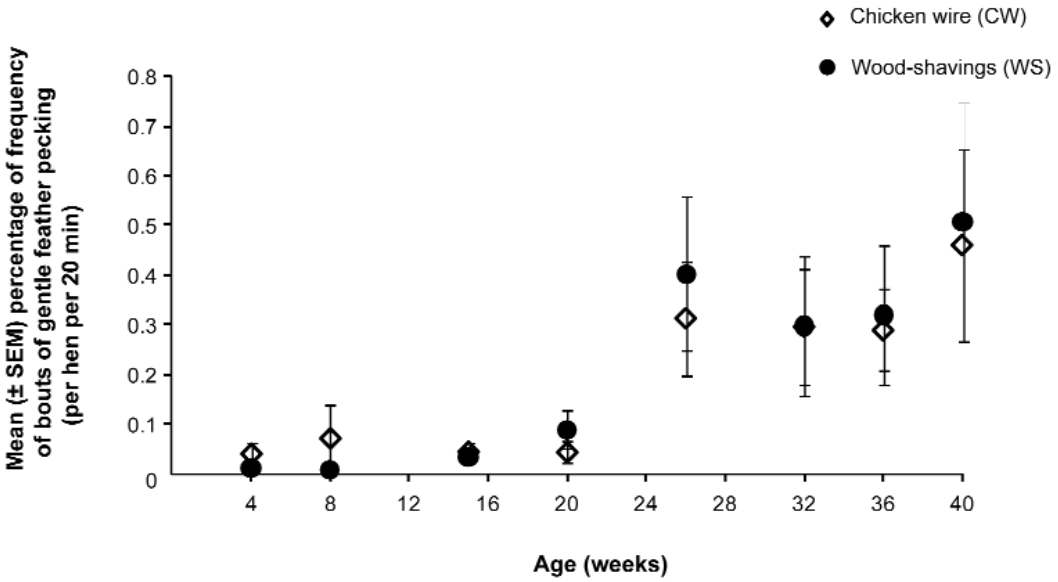
Figure 4



Mean (± SEM) percentage of bouts of gentle feather pecking at dustbathing birds per hen during the 20-min observation period in the rearing and laying period. After 20 weeks of age the light intensity was increased.

Figure 5



Mean (± SEM) percentage of bouts of severe feather pecking per hen during the 20-min observation period in the rearing and laying period. After 20 weeks of age the light intensity was increased.

feather pecking, aggressive pecking, and comfort behaviour, nor in the number of animals being in various locations of the pen. The continuous observations of two randomly chosen hens per pen showed only one significant difference in the frequency and duration of various behaviours observed at 15 weeks of age. The duration of movement (walking, running, flying) was significantly longer for CW than for WS hens (77.8 [± 10.4] vs 50.1 [± 9.8] s per 5 min observation for the CW and WS hens, respectively; $P < 0.05$).

Feather damage

Table 2 shows the scores for feather and skin damage at 15 and 40 weeks of age. At the end of the rearing period the plumage was generally in good condition and there were no significant differences between the treatments. No skin damage was found at the end of the rearing period. At 40 weeks of age no differences were found between treatments in feather and skin damage. Increased scores for the the laying period compared with the rearing period indicated a deteriorated feather cover during laying.

Table 2 Mean (± SEM) scores for feather and skin lesions for CW and WS hens as measured at 15 and 40 weeks of age. Averages of scores of all body parts are shown as well as scores for individual body parts likely to be affected by feather pecking. A higher score means more feather or skin damage.

Body part	CW hens	WS hens
15 weeks of age		
Feathers		
Back	0.37 (± 0.06)	0.34 (± 0.03)
Wings	0.87 (± 0.03)	0.85 (± 0.02)
Tail	0.74 (± 0.10)	0.54 (± 0.05)
Average of all body parts	0.37 (± 0.01)	0.34 (± 0.01)
Skin		
Back	0	0
Wings	0	0
Tail	0	0
Average of all body parts	0	0
40 weeks of age		
Feathers		
Back	1.84 (± 0.24)	2.07 (± 0.31)
Wings	1.30 (± 0.08)	1.31 (± 0.06)
Tail	2.18 (± 0.36)	2.25 (± 0.30)
Average of all body parts	1.46 (± 0.04)	1.44 (± 0.05)
Skin		
Back	0.10 (± 0.05)	0.32 (± 0.14)
Wings	0	0
Tail	0.36 (± 0.11)	0.51 (± 0.18)
Average of all body parts	0.19 (± 0.01)	0.21 (± 0.02)

Discussion

The results of this study show that litter provided in the first three weeks of life directed pecking behaviour to the ground. Layer chicks housed on chicken wire showed less ground pecking than chicks housed on wood-shavings, and more birds housed on chicken wire performed gentle feather pecking. This is in line with other studies (Huber-Eicher & Sebö 2001; Chow & Hogan 2005; de Jong *et al* 2013). When wood-shavings were provided in the litter area to all groups at 21 days of age, rebound behaviour was seen in the birds that had previously been housed on chicken wire. At that time they showed significantly more floor-directed pecking than chickens that were previously housed on wood-shavings. Although only measured at pen level and not at the individual level, the differences in pecking at a very young age did not seem to result in differences in severe feather pecking or differences in feather damage in adult hens.

The observations during the early rearing period (up to 20 days of age) are in accordance with a previous study that the provision of litter in the early rearing period stimulates ground pecking (de Jong *et al* 2013). The results of the present experiment also indicate that in the absence of suitable substrate, chickens redirect their pecking behaviour. Results of bird counts indicated that in the absence of litter, part of the birds' time budget which would normally be allocated to ground pecking, is instead allocated to pecking at other birds and the feeding trough and nipple drinkers. This confirms earlier research on the relationship between ground pecking and feather pecking (Blokhuis & Harkes 1984; Blokhuis & Vanderhaar 1989; Huber-Eicher & Wechsler 1997, 1998; Huber-Eicher & Sebö 2001).

Analysed over the remaining rearing period (4 to 15 weeks of age), differences in feather-pecking behaviour between CW and WS treatments disappeared. This work supports the argument that young hens are still quite flexible and can adapt their behaviour despite their previous experience with a particular substrate. This is in line with Nicol *et al* (2001) who showed that current substrate is the most influential factor for pecking behaviour at any age. In that experiment, laying hens kept on substrate showed less feather pecking and more ground pecking compared to layers kept on slatted floors, regardless of previous experience with slatted floors or wood-shavings.

Whereas early rearing conditions did not affect severe feather-pecking behaviour, there seems to be a long-term effect of the early rearing conditions on gentle feather pecking as the CW treatment showed more gentle feather-pecking bouts in laying than the WS treatment. These observations suggest pecking preferences may re-appear under more stressful conditions, such as increased light intensities as applied in the current experiment. Nicol *et al* (2001) and Sanotra *et al* (1995) showed that early imprinting on a substrate can be substituted during the later rearing period when a better substrate is provided. However, others (Vestergaarrd & Lisborg 1993; Chow & Hogan 2005) suggested that early imprinting cannot be reversed. More research is needed to elucidate if there is a sensitive period for pecking preferences in chickens and if these are reversible or not. This might also help to further define the optimal rearing environment for laying hens.

Gentle feather pecking differs from severe feather pecking in that it does not lead to damage and usually induces no response in the receiver. The relationship between gentle and severe feather pecking is yet to be fully clarified. Newberry *et al* (2007) showed that chickens showing much gentle pecking were not the hens that later showed severe feather pecking. Earlier research had already suggested that there was no relationship between gentle and severe feather pecking (McAdie & Keeling 2002; Chow & Hogan 2005).

The absence of differences in plumage damage at the end of the laying period is in accordance with the behavioural observations.

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Animal welfare implications and conclusion

In the absence of a suitable substrate in early rearing, laying hen chicks may redirect their pecking behaviour to other chicks, or the feeder and drinker. However, the absence of substrate in early rearing up to 20 days of age did not increase the risk to develop severe feather pecking when adult. On the other hand, the chicks housed on wire in early rearing showed significantly more gentle feather-pecking bouts when adult as compared to chicks always housed on wood-shavings, indicating a long-lasting effect of early rearing conditions.

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