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The effect of quality and availability of foraging materials on feather pecking in laying hen chicks

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Abstract. Feather pecking resulting in feather damage, injuries and mortality causes severe welfare problems in laying hens. In the present study, we tested whether there is an inverse relationship between feather pecking and foraging behaviour (exploratory and manipulative behaviour away from the feeder). Forty-eight groups of 30 or 31 chicks, *Gallus gallus domesticus*, were reared in pens and provided with different types of foraging material. Feather pecking and foraging behaviour were quantified when the chicks were 4 and 5 weeks of age. In experiment 1, chicks with access to long-cut straw showed more foraging behaviour and less feather pecking than chicks that were provided with the same straw but in shredded form. On the other hand, there was no difference in foraging behaviour and feather pecking between chicks reared with access to long-cut straw and polystyrene blocks. In experiment 2, the importance of the form of the foraging material was confirmed. Chicks provided with polystyrene blocks performed more foraging behaviour and less feather pecking than chicks with access to polystyrene beads. The provision of an area with a layer of wood-shavings to promote scratching behaviour had no significant effect, however, on the incidence of feather pecking. In experiment 3, polystyrene blocks and beads were offered during the whole day or only in the morning. Both the quality and the availability of the foraging materials had a significant effect on foraging behaviour and a significant but opposite effect on feather pecking. Focal animal observations showed that the chicks performed different types of foraging behaviour at polystyrene blocks and beads. This suggests that not only the quantity but also the quality of foraging behaviour elicited by a given material may be important to prevent the development of feather pecking. Feather pecking should thus be considered as redirected foraging behaviour.

The housing of laying hens in battery cages is considered to be far from ideal, as the behaviour of caged birds is severely restricted in many respects (Nicol 1987; Dawkins & Hardie 1989; Hughes et al. 1989; van Liere 1992). However, alternative housing systems (e.g. deep litter system, tiered wire floor system), which allow the hens to engage in a variety of behaviour patterns, have the disadvantage that there may be more serious problems with feather pecking, causing injuries and mortality, than in battery cages (Appleby & Hughes 1991; Webster 1994). Beak trimming, a common measure to prevent feather pecking, is not a suitable solution to such problems, as it probably causes chronic pain (Duncan et al. 1989; Gentle et al. 1990), reduces responsiveness to novel stimuli (van Liere 1995) and leads to apathy (Craig & Lee 1990; Lee & Craig 1991). To promote the acceptance of alternative housing systems for laying hens it is therefore important to understand the causation of feather pecking and to identify housing conditions in which this abnormal behaviour does not develop.

In a previous study (Huber-Eicher & Wechsler 1997) we experimentally tested predictions of two current hypotheses on the causation of feather pecking: the 'dustbathing hypothesis' (Vestergaard & Lisborg 1993; Vestergaard et al. 1993; Vestergaard 1994) and the 'ground pecking hypothesis' (Blokhuis & Arkes 1984; Blokhuis 1986, 1989). In summary, we found that rearing laying hen chicks with access to sand for dustbathing did not prevent them from developing feather

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pecking that caused bloody injuries. The provision of long-cut straw resulted in an increase in foraging behaviour and a significant reduction in the rate of feather pecking. We therefore hypothesized that feather pecking is related to foraging behaviour as suggested by Hoffmeyer (1969), Wennrich (1975), Martin (1986) and Baum (1995).

In the present study we examined this hypothesis by inducing differences in foraging behaviour in laying hen chicks and measuring the rate of feather pecking when the chicks were 4 and 5 weeks old. Sixteen groups of 30 or 31 chicks were reared in each of three experiments. In experiment 1, the groups were provided with different foraging materials (long-cut straw, shredded straw or polystyrene blocks) to provoke differences in foraging behaviour. In experiment 2, polystyrene was offered in two forms (blocks or beads) to elicit different types of pecking behaviour. In addition, we varied scratching behaviour by giving half of the groups access to an area with a layer of wood-shavings. In experiment 3, the amount of time (whole or half day) that the chicks had access to polystyrene blocks or beads was varied. Assuming that feather pecking should be considered as redirected foraging behaviour, we expected an inverse relationship between these two types of behaviour in all three experiments.

GENERAL METHODS

Subjects and Housing

We used 1471 white layer chicks ('Lohman Selected Leghorn' hybrids) in the three experiments. They were bought from a commercial breeder and introduced into the experimental housing conditions on the day after hatching. All individuals were females and not beak-trimmed. During the experiments they were housed in groups of 30 or 31 chicks at a density of 12.6 or 13.0 birds/m^2, respectively, which is close to the maximum density (14 chicks/m^2) permitted by the Swiss animal welfare legislation.

The experimental groups were kept in 16 pens of identical size (265 × 90 cm, height 235 cm) built side by side along a corridor in a stable. Chicks in adjacent pens had no visual contact, as the pens were separated by plywood walls. These walls were 190 cm high and allowed auditory contact between all groups in the stable. Day length was kept constant at 13 h (0500–1800 hours) with a 15-min twilight phase at the start and end of the day. Light intensity at the height of the animals was about 60 lx. The average daily temperature in the stable was 25.5°C (experiment 1), 22.2°C (experiment 2) and 24.4°C (experiment 3).

The floor of the pens was made of wooden slats (width 1 cm, 2.5 cm apart, 20 cm above the ground). In each pen there were two cup drinkers and a suspended feeder (diameter 30 cm). The feeder was automatically refilled, and the animals had ad libitum access to a commercial starter food. The feed was covered by a wire grid which allowed unrestricted feeding while at the same time effectively preventing the chicks from scratching or dustbathing in the mash. On the front of each pen there was a glass door (72 × 142 cm) opening on to the corridor from where behavioural observations were made.

Procedures

At arrival from the hatchery we randomly assigned the chicks to groups of 30 or 31 individuals and distributed them among the pens. Mortality was low in all three experiments (1: 1.4%; 2: 1.6%; 3: 0.6%) and most losses occurred in the first few days after hatching. At the beginning of the rearing period the slats were covered with a plastic grid (openings 2.0 × 2.0 cm, grid 2.5 mm). In addition, an area of 100 × 90 cm next to the corridor was covered with a perforated plastic mat (polyester tissue coated with PVC) for the first 10 days to make it easier for the chicks to walk on the grid. Up to day 5 (experiment 3), day 18 (experiment 1) or day 19 (experiment 2) the chicks were provided with extra heat from a red heating lamp (250 W) suspended next to the feeder. We then replaced it with a ceramic lamp (250 W) which provided heat but no light. This lamp was removed at the latest when the chicks were 4 weeks old.

During the third week of life (day 17/18) the chicks were subjected to the following procedures: change of the food structure from mash to pellets; removal of the plastic grid on the slatted floor; and handling in the same way as they would have been if marked with wing tags. The latter was done to reproduce all aspects of an experimental treatment that had regularly provoked an increase in feather pecking in chicks housed without adequate foraging material in previous experiments (Huber-Eicher & Wechsler 1997). In

weeks 3 and 5, vaccines against infectious bursitis (Gumboro) and infectious bronchitis, respectively, were added to the drinking water. Each day we systematically checked all pens at least once, and recorded the number of birds with bloody injuries on feathered parts of the body.

Ethical Note

All experiments were carried out under licence from the Swiss authorities. We minimized the number of groups used, the number of individuals in a group and the duration of the experiments. We avoided unnecessary pain by frequently checking all pens for injured individuals. Regular checks were done twice a day (at 0700 hours and between 1600 and 1800 hours), except for 2 days of experiment 1 on which there was only one check a day. On most days there was a third check at midday. In addition the pens were checked during behavioural observations when the observer moved from one pen to the next and during the cleaning and rearranging of the treatments which had to be done roughly every second day. All injuries to the rump as well as serious injuries to other parts of the chick's body were covered with tar immediately upon detection. We observed 254 injuries (among 1471 birds) of which we treated 223 with tar. The tar treatment effectively prevented other chicks from pecking at the wounds. Pens with newly injured birds were checked more frequently. Additional pens were available to separate seriously injured individuals from their group, and we had procedures to stop the induced feather pecking if necessary (reduction of light intensity, provision of long-cut straw). None of these measures was ever required, however, in the experiments described here.

Behavioural Observations

Data collection focused on the occurrence of feather-pecking interactions and on the amount of time the chicks spent on different activities. Both data sets were recorded using the software system 'The Observer 3.0' (Noldus Information Technology, Wageningen, The Netherlands). In weeks 4 and 5 every group was observed for two periods of 30 min each, once in the morning (0800–1100 hours) and once in the afternoon (1300–1600 hours). The observations were made by a single observer on 3 consecutive days in each week. The sequence of the observed groups was randomized over all 3 days for both morning and afternoon observations. During the observations we recorded 'all occurrences' (Altmann 1974) of feather-pecking interactions between individuals. Repeated pecks directed at the same individual were recorded as one feather-pecking interaction, as we found it impossible to count the exact number of feather pecks in a group of 30 chicks. An interaction ended when there were no more pecks during a period of 4 s. Only pecks at feathered parts of conspecifics were classified as feather pecking. Pecks at legs, beaks, combs or wattles were neglected, as such pecks could be under the control of another behaviour system. In the results, numbers of feather-pecking interactions are given as feather-pecking interactions per 30 individuals per 30 min.

The 'all occurrences' sampling was briefly interrupted every 5 min for a 'scan sample' (Altmann 1974). In each scan we recorded the number of chicks engaged in exploratory and manipulative foraging behaviour performed away from the feeder. Foraging behaviour was defined as follows: the chick is pecking at the floor or at other parts of the pen (but not at the feed) or it is standing/moving with its head in a lower position than the rump. For each pen we calculated the percentage of chicks engaged in foraging behaviour, using all scan samples of weeks 4 and 5.

Statistical Analysis

The pens were treated as independent observational units. In experiment 1, there were three experimental housing conditions, and we analysed the data using exact permutation tests for two independent samples (Siegel & Castellan 1988). Bonferroni corrections were applied to multiple comparisons. In experiments 2 and 3, there were four housing conditions (2×2 factorial design) and we analysed the data by two-way ANOVA and exact permutation tests for paired replicates (Siegel & Castellan 1988). Prior to the ANOVA, square-root and arcsine square-root transformations (Sokal & Rohlf 1981) were applied to rates and percentages, respectively. However, untransformed data are given in the text, the tables and the figures. Data on the occurrence of injuries in experiments 1 and 2 were not suitable for statistical analysis, as there were no injuries in 7 and 10 out of 16 pens, respectively. These data are

therefore presented in a descriptive way. In experiment 3 there were injuries in all but one pen, and the data were analysed by ANOVA after square-root transformation. Statistical tests are two-tailed with an alpha level of 0.05. ANOVAs were performed using SYSTAT (Wilkinson 1992).

EXPERIMENT 1

In previous experiments we had shown that the provision of long-cut straw promoted foraging behaviour in laying hen chicks and that this coincided with reduced rates of feather-pecking interactions (Huber-Eicher & Wechsler 1997). It was not clear, however, whether this effect was due to some property of the straw (e.g. nutritive value, content of fibres) or to the fact that the chicks could direct specific elements of foraging behaviour (pecking, pulling, tearing, striking) at the long-cut straw. In experiment 1 we further analysed the observed effect by offering chicks three types of foraging material. Five groups were each provided with long-cut straw ('straw long' condition) or with the same kind of straw but in shredded form ('straw shredded' condition) to elicit different behavioural elements with two forging materials that differed only in form. Assuming that the performance of foraging behaviour is crucial to prevent the development of feather pecking, we expected that the chicks would show more foraging behaviour and fewer feather-pecking interactions when provided with long-cut straw which induces elements of foraging behaviour (pulling, tearing, striking) that are not possible with shredded straw (parts less than 5 mm). Six more groups were provided with blocks of polystyrene ($6.5 \times 4.4 \times 100$ cm) as a foraging material ('polystyrene block' condition). In a pilot study (unpublished data) we had observed that this material is attractive for laying hen chicks and elicits elements of foraging behaviour that are also observed with long-cut straw (pecking, tearing, striking). We therefore tested whether polystyrene blocks, without nutritive value, have a similar effect on the incidence of feather pecking as long-cut straw.

Methods

The three foraging materials were offered to the chicks in PVC troughs 6.5×100 cm and 4.4 cm high. Every 3.0 cm there was a bar (width 0.6 cm) across the top of the troughs to prevent the chicks from standing in the troughs and scratching in the foraging material. The troughs were fixed to the slats in the middle of each pen parallel to the long side of the pens. To ensure that the chicks could reach the material from day 1 on, we placed the foremost 10 cm of each trough on the plastic mat covering the slats. We regularly refilled the troughs to guarantee that the chicks had ad libitum access to the foraging materials.

Up to day 25 after hatching, the troughs were loosely filled with long-cut straw. At this age the chicks could too easily tear out the straw, so the loose straw was replaced by bundles of the same straw tied up with string. We produced shredded straw by shredding the long-cut straw twice, resulting in particles with a length of less than 5 mm which the chicks ingested with a single peck. Polystyrene blocks with two degrees of hardness (15 kg polystyrene/m^3 and 30 kg polystyrene/m^3) were used in succession. The softer type was provided only up to day 22, as it was too easily decomposed by the chicks at this age.

In weeks 1 and 2, we checked whether the chicks actually used the materials as a foraging substrate. All pens were scanned at intervals of 20 min on 1 day per week, and the number of chicks engaged in foraging behaviour at the trough (i.e. legs on the trough and/or head within 5 cm of the trough) was recorded. There were seven scans in the morning (0800–1200 hours) and seven scans in the afternoon (1345–1730 hours) per week.

In weeks 4 and 5 we recorded feather-pecking interactions and foraging behaviour of the chicks (see General Methods). As in weeks 1 and 2, the number of chicks engaged in foraging behaviour at the trough was recorded in the scan samples. Because the data from the straw long condition were compared with both the straw shredded and the polystyrene block condition, the alpha level was adjusted to 0.025 (Bonferroni correction).

Results

Chicks in all pens used the materials provided as a foraging substrate in the first week after hatching. In weeks 1 and 2 a mean of 7.0% (straw long, $N = 5$, range 5.2–8.7), 7.2% (straw shredded, $N = 5$, range 5.9–8.1) and 10.2% (polystyrene block, $N = 6$, range 7.1–13.9) of all group members were engaged in foraging at the troughs.

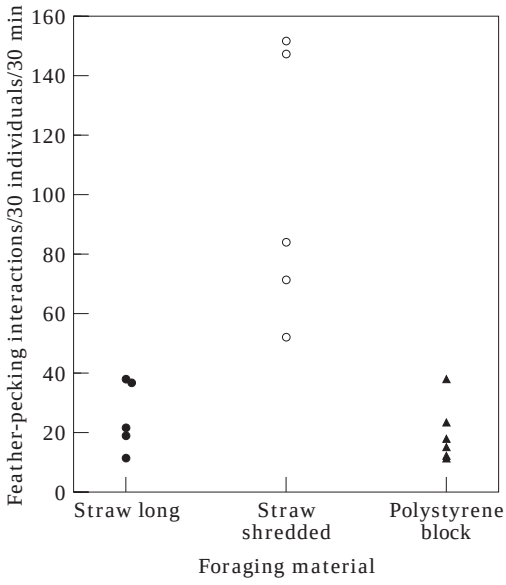

Figure 1. Rates of feather-pecking interactions in groups of chicks reared with access to long-cut straw (straw long condition, ●), shredded straw (straw shredded condition, ○) or blocks of polystyrene (polystyrene block condition, ▲).

In weeks 4 and 5, a significantly higher percentage of chicks in the straw long condition were foraging at the troughs than in the straw shredded condition (exact permutation test for two independent samples: $N_1 = N_2 = 5$, mean values are 22.1 and 10.5, $P = 0.008$). No statistically significant difference was found between the straw long condition and the polystyrene block condition ($N_1 = 5$, $N_2 = 6$, mean values are 22.1 and 17.8, $P = 0.03$).

The rate of feather-pecking interactions was significantly lower in the straw long than in the straw shredded condition ($N_1 = N_2 = 5$, mean values are 30.1 and 101.7, $P = 0.008$; Fig. 1), but did not differ between the straw long and the polystyrene block condition ($N_1 = 5$, $N_2 = 6$, mean values are 30.1 and 20.4, $P = 0.47$).

Bloody injuries caused by feather pecking occurred in all three housing conditions. However, such injuries were much more frequent in the straw shredded condition (51 injuries in four out of five pens) than in the straw long condition (six injuries in one out of five pens) and in the polystyrene block condition (nine injuries in three out of six pens).

Discussion

The results of experiment 1 confirm the inverse relationship between foraging behaviour and feather pecking found in a previous study (Huber-Eicher & Wechsler 1997). Chicks that were provided with long-cut straw or polystyrene blocks spent more time foraging at the trough and had lower rates of feather-pecking interactions than chicks that had access to shredded straw. The beneficial effect of long-cut straw on the incidence of feather pecking was due to its form but not due to its nutritive value: the rate of feather-pecking interactions was significantly increased when the chicks were offered the same straw but in shredded form. Moreover, there was no significant difference in the rate of feather-pecking interactions between chicks provided with long-cut straw and polystyrene blocks, which have no nutritive value.

EXPERIMENT 2

Foraging behaviour in poultry consists not only of behavioural elements performed with the beak (pecking, pulling, tearing, striking) but also movements of the feet (scratching). In experiment 1, we varied beak-related foraging behaviour by offering the chicks different foraging materials, but we prevented scratching by presenting the materials in troughs. In experiment 2, we aimed at varying the occurrence of scratching behaviour. Eight groups of chicks were provided with a scratching area containing a layer of wood-shavings ('scratching area open' condition) and eight groups with a scratching area in which the layer of wood-shavings was covered with a grid ('scratching area covered' condition). Based on the inverse relationship between foraging behaviour and feather pecking found in experiment 1, we expected that foraging behaviour would be increased and the rate of feather-pecking interactions reduced in chicks that could perform scratching in the wood-shavings.

As a second factor (2×2 factorial design) eight groups were each offered polystyrene in the form of a block ('polystyrene block' condition) or in the form of beads ('polystyrene beads' condition). We did this to test whether different forms of polystyrene provoke similar differences in foraging behaviour and feather pecking as

Table I. Mean rates of scratching events (per individual foraging on the scratching areas per 30 min) in weeks 1 and 2 and mean percentages of chicks recorded as foraging on the scratching areas or on the slats in weeks 4 and 5 (experiment 2)

Behaviour	Housing conditions			
	Block/open	Block/covered	Beads/open	Beads/covered
Scratching rate	24.1 (16.6–31.2)	0.3 (0.0–1.2)	12.8 (8.7–16.8)	4.2 (0.0–16.7)
Foraging on scratching area and at the trough (%)	26.7 (23.1–30.3)	31.3 (28.6–33.3)	22.7 (20.7–23.9)	24.0 (22.0–25.2)
Foraging on slats (%)	5.8 (4.6–7.5)	5.2 (4.8–6.5)	6.0 (4.7–7.1)	6.8 (5.3–8.9)

The chicks had access to polystyrene blocks or beads offered in troughs, and were provided with a scratching area containing wood-shavings that was either open or covered with a wire mesh. Maximum and minimum values are given in parentheses.

were found in experiment 1 with different forms of straw.

Methods

We offered the polystyrene blocks and beads (diameter 2–5 mm) in the same troughs as used in experiment 1. However, the troughs were shortened to 89 cm and placed across the pens, 100 cm away from the door at the edge of the plastic mat covering the slats during the first 10 days after hatching. In each pen there were two scratching areas made of plywood (89.0 × 9.5 cm, depth 3.5 cm) that were situated on both sides of the troughs. In the scratching area covered condition the layer of wood-shavings was covered with a wire mesh (openings 1.7 × 1.7 cm, wire 1.4 mm) to prevent the chicks from scratching in the substrate but not from pecking at the wood-shavings. The foraging material in the troughs and the wood-shavings in the scratching areas were regularly topped-up to guarantee that the chicks were continuously exposed to the treatments. Each of the four housing conditions was replicated in four pens.

In weeks 1 and 2 behavioural observation focused on the scratching activity of foraging chicks to check whether the occurrence of scratching was actually varied by the housing conditions. We observed each group four times per week for periods of 10 min, twice in the morning (0815–1055 hours) and twice in the afternoon (1230–1510 hours). During the observations we recorded 'all occurrences' of scratching events (i.e. a series of strokes with both legs followed by pecking) occurring on the scratching areas. In addition, we recorded at 1-min intervals the number of chicks engaged in foraging behaviour (for definition, see General Methods) that had at least one foot on a scratching area. In the analysis, we standardized the rate of scratching events by dividing the total number of such events observed in a given group by the average number of group members recorded as foraging on the scratching areas.

In weeks 4 and 5, observations on feather-pecking interactions and foraging behaviour were made as described in the General Methods. We noted whether the chicks showed foraging behaviour on the scratching areas (including the trough) or on the slats.

Results

Giving the chicks access to a layer of wood-shavings effectively varied the occurrence of scratching behaviour. In weeks 1 and 2, chicks in the scratching area open condition showed significantly higher rates of scratching when foraging on the scratching area than chicks in the scratching area covered condition (two-way ANOVA: $F_{1,12}=40.12$, $P<0.001$; Table I). The quality of the foraging material in the troughs had no significant main effect on the rate of scratching ($F_{1,12}=0.38$, $P=0.55$), but there was an interaction close to significance between the two factors ($F_{1,12}=4.35$, $P=0.06$).

In weeks 4 and 5, the percentage of chicks recorded as foraging on the scratching area and at

the troughs was significantly influenced both by the quality of the foraging material and by the design of the scratching area (polystyrene block/beads: $F_{1,12}=23.54$, $P<0.001$; scratching area open/covered: $F_{1,12}=6.23$, $P=0.03$; Table I). Foraging behaviour was promoted by polystyrene blocks and a covered scratching area. No significant interaction between the two factors was detected ($F_{1,12}=1.87$, $P=0.2$). The chicks manipulated the polystyrene blocks by gently or vigorously pecking and tearing at them. When small pieces of the blocks were removed the chicks usually swallowed them immediately. With larger pieces, food-running (Kruijt 1964) was observed. In the polystyrene beads condition the chicks ingested the beads with a single peck. With respect to foraging on the slats there were no significant effects of the two factors varied in the experiment (polystyrene block/beads: $F_{1,12}=2.48$, $P=0.14$; scratching area open/covered: $F_{1,12}=0.03$, $P=0.86$; interaction: $F_{1,12}=1.18$, $P=0.3$; Table I).

The rate of feather-pecking interactions was significantly influenced by the form of the polystyrene offered in the troughs ($F_{1,12}=24.47$, $P<0.001$; Fig. 2). Groups with access to polystyrene blocks showed lower rates of feather-pecking interactions than groups provided with polystyrene beads. The design of the scratching area (open or covered) had no significant effect on the rate of feather-pecking interactions ($F_{1,12}=0.24$, $P=0.63$). No significant interaction was detected between the two factors ($F_{1,12}=0.002$, $P=0.97$).

Up to the end of week 5, bloody injuries caused by feather pecking were observed in three of the four housing conditions. There were no injuries in groups provided with a polystyrene block and an open scratching area. Most injuries were observed in groups with polystyrene beads and a covered scratching area (19 injuries). In the combinations polystyrene block∗scratching area covered and polystyrene beads∗scratching area open there were six and seven injuries, respectively.

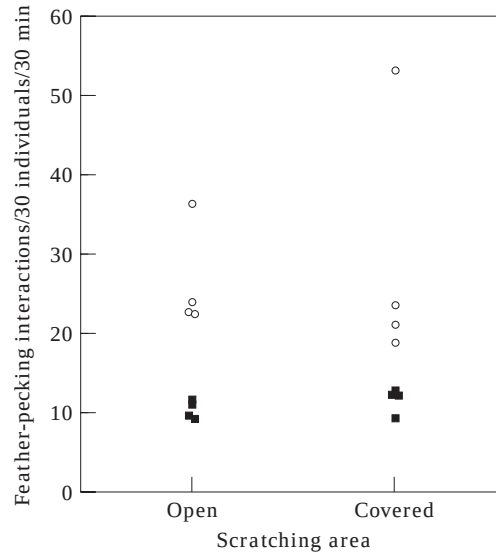

Figure 2. Rates of feather-pecking interactions in groups of chicks reared with access to polystyrene blocks (polystyrene block condition, ■) or polystyrene beads (polystyrene beads condition, ○). A scratching area filled with wood-shavings was open (scratching area open condition) or covered with wire mesh (scratching area covered condition).

Discussion

The results obtained by rearing chicks with access to polystyrene in the form of blocks or beads confirm that there is an inverse relationship between foraging behaviour and feather pecking in laying hen chicks. Groups that were provided with polystyrene blocks showed significantly more foraging behaviour and had significantly lower rates of feather-pecking interactions than chicks provided with polystyrene beads. As with experiment 1, where we found a significantly lower rate of feather-pecking interactions in chicks reared with access to long-cut straw compared with shredded straw, polystyrene blocks and beads differed only in their form. Polystyrene blocks, which elicit elements of foraging behaviour that are not possible with polystyrene beads, were effective in reducing the rate of feather-pecking interactions.

Covering the scratching area with a wire mesh effectively prevented the chicks from scratching in the layer of wood-shavings, but the experimental variation of this type of foraging behaviour had no significant effect on the rate of feather-pecking interactions. This suggests that scratching is not related to feather pecking. However, contrary to our expectation, the chicks showed more foraging behaviour on the covered than on the open scratching areas. This may have masked an effect of scratching behaviour on the incidence of feather pecking.

EXPERIMENT 3

In experiments 1 and 2 the provision of foraging materials that elicited not only pecking but also other beak-related behavioural elements (pulling, tearing, striking) resulted in an increase in foraging behaviour and a decrease in the rate of feather-pecking interactions. Based on the results of these experiments, however, we could not tell whether the beneficial effect of the long-cut straw and the polystyrene blocks on the incidence of feather pecking was due to the quality of the behaviour the chicks directed at these materials or to an increase in time the chicks spent on foraging. In experiment 3 we therefore varied the time the chicks had access to foraging materials. There were eight groups with continuous access to foraging material ('access whole day' condition) and eight groups in which the troughs containing the foraging materials were available only in the morning ('access half day' condition). As a second factor, eight groups were each provided with polystyrene blocks or beads in the troughs (2×2 factorial design). Data were analysed to check whether both the quality and the availability of the foraging materials had an inverse effect on foraging behaviour and feather pecking. In addition, we tested wehther the removal of the foraging materials in the afternoon in the access half day condition resulted in a short-term increase in feather pecking. Finally, we analysed the behaviour of focal animals foraging at the trough to identify differences in the quality of behaviour directed at the polystyrene blocks and beads.

Methods

The troughs in which the polystyrene blocks and beads were provided were fixed at the same place in the pens as in experiment 2 but without the scratching areas used in the previous experiment. In the access half day condition the troughs were removed daily from 1130 to 1800 hours whereas in the access whole day condition the chicks had continuous access to the foraging materials. We regularly refilled the troughs with polystyrene blocks and beads. Observations on feather pecking and foraging behaviour were made in weeks 4 and 5 as described in the General Methods.

Both on day 26 and on day 28 after hatching we observed four focal animals in every pen between 0830 and 1200 hours. Focal animals were randomly chosen among animals engaged in foraging behaviour at the trough. A focal animal sample was terminated after 2 min or when the chick went away from the trough, sat down or started preening (Kruijt 1964). We ignored samples lasting less than 10 s. During the focal animal samples we recorded all occurrences of tearing (i.e. the chick takes hold of the material with its beak and tears at it with a vigorous backward movement of the head) and pecking (i.e. the chick's beak briefly touches the material without tearing) directed at the material in the trough. In the results rates of pecking events are given in pecks per individual per min.

Results

The removal of the troughs with the foraging materials in the access half day condition had the intended effect on the percentage of chicks engaged in foraging behaviour. Compared with data collected in the morning, foraging behaviour was significantly decreased in the afternoon when the troughs were removed from the pens (exact permutation test for paired replicates; $N=8$; mean values for morning and afternoon are 19.6 and 10.7, respectively, $P=0.008$). No such difference was found for chicks in the access whole day condition ($N=8$; mean values for morning and afternoon are 22.7 and 22.6, respectively, $P=0.94$).

The influence of the quality and the availability of the foraging materials on the incidence of foraging behaviour was analysed separately for observations made in the morning (when all pens contained foraging material) and for observations made in the afternoon (when there was no foraging material in half of the pens). The percentage of chicks engaged in foraging behaviour was significantly influenced by the quality of the foraging material both in the morning (two-way ANOVA, $F_{1,12}=36.10$, $P<0.001$; Table II) and in the afternoon ($F_{1,12}=10.32$, $P=0.007$). Chicks provided with polystyrene blocks showed more foraging behaviour than chicks that had access to polystyrene beads. With respect to data collected in the morning the percentage of chicks recorded as foraging did not differ significantly between groups with continuous and groups with temporally restricted access to the foraging materials ($F_{1,12}=2.36$, $P=0.15$). As expected, however, the

Table II. Mean percentages of chicks engaged in foraging behaviour in the morning and in the afternoon, mean numbers of bloody injuries caused by feather pecking and mean rates of pecking events (per min and per individual) directed at foraging materials in pens with different housing conditions (experiment 3)

	Housing conditions			
	Block/whole	Block/half	Beads/whole	Beads/half
Foraging in the morning	28.9 (22.4–33.3)	24.8 (20.8–28.5)	16.5 (11.0–21.3)	14.5 (13.6–16.3)
Foraging in the afternoon	28.7 (21.9–33.8)	11.2 (8.3–18.0)	16.4 (13.7–21.5)	10.2 (9.4–10.9)
Bloody injuries	2.7 (0–5)	7.0 (4–13)	11.7 (3–20)	24.0 (20–32)
Pecking events	4.4 (3.7–5.3)	4.3 (3.4–5.0)	2.9 (2.0–3.5)	3.5 (3.1–4.4)

The chicks had access to polystyrene blocks or beads during the whole day (whole) or only during the morning (half). Maximum and minimum values are given in parentheses.

chicks spent less time on foraging behaviour in the afternoon in the access half day condition than in the access whole day condition ($F_{1,12}=40.31$, $P<0.001$). The interaction between the quality and the availability of the foraging materials was significant in the afternoon ($F_{1,12}=7.33$, $P=0.02$), but not in the morning ($F_{1,12}=0.19$, $P=0.67$). This interaction reflects the fact that in the afternoon the effect of the quality of the foraging material was much more pronounced in pens where the material was present (access whole day condition) than in pens without foraging material (access half day condition).

Data on feather pecking were also analysed separately for observations made in the morning and in the afternoon. The rate of feather-pecking interactions in the morning was significantly reduced by polystyrene blocks compared with polystyrene beads (two-way ANOVA: $F_{1,12}=41.68$, $P<0.001$; Fig. 3). This effect was also significant in the afternoon ($F_{1,12}=32.01$, $P<0.001$). The availability of the foraging materials had a significant influence on the rate of feather-pecking interactions both in the morning ($F_{1,12}=14.80$, $P=0.002$) and in the afternoon ($F_{1,12}=22.31$, $P<0.001$). The chicks showed more feather-pecking interactions in pens where the troughs were removed in the afternoon (access half day condition) than in pens where the troughs were continuously present (access whole day condition). No significant interactions between the quality and the availability of the foraging materials were detected, either in the morning ($F_{1,12}=0.001$, $P=0.98$) or in the afternoon ($F_{1,12}=0.002$, $P=0.96$).

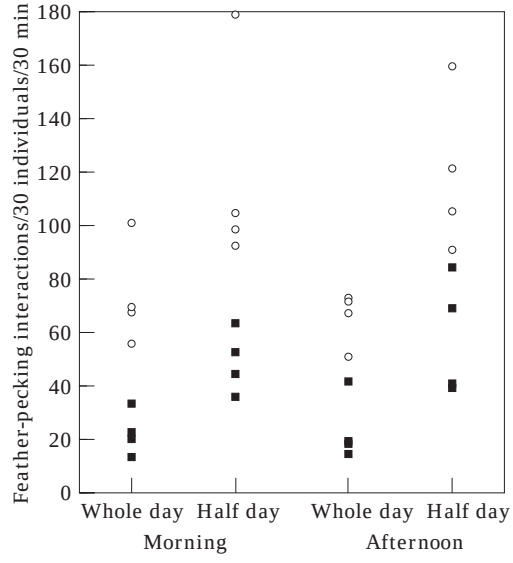

Figure 3. Rates of feather-pecking interactions in the morning and in the afternoon in groups of chicks reared with access to foraging materials during the whole day (access whole day condition) or only in the morning (access half day condition). The foraging materials were polystyrene blocks (polystyrene block condition, ■) or polystyrene beads (polystyrene beads condition, ○).

The rate of feather-pecking interactions in a given pen did not differ between data collected in the morning and in the afternoon either for

chicks in the access whole day condition (exact permutation test for paired replicates; $N=8$; mean values for morning and afternoon are 48.1 and 45.0, respectively, $P=0.71$) or for chicks in the access half day condition ($N=8$; mean values for morning and afternoon are 84.2 and 89.5, respectively, $P=0.52$).

Up to the end of week 5, bloody injuries caused by feather pecking occurred in 15 of the 16 pens (Table II). Both the quality and the availability of the foraging materials had a significant effect on the number of such injuries (two-way ANOVA: polystyrene block/beads, $F_{1,12}=23.51$, $P<0.001$, access whole/half day, $F_{1,12}=9.92$, $P=0.008$). Injuries were more frequent in pens with polystyrene beads and in pens in which the chicks had temporally restricted access to the foraging materials. No significant interaction between the two factors was detected ($F_{1,12}=0.44$, $P=0.52$).

In the focal animal observations, 2818 and 1620 beak-related events directed at the foraging materials were recorded in the polystyrene blocks condition and the polystyrene beads condition, respectively. With polystyrene beads all events were necessarily classified as 'pecking' whereas with polystyrene blocks 9.7% of the events were classified as 'tearing'. The rate of pecking events was significantly influenced by the quality of the foraging material (two-way ANOVA: $F_{1,12}=10.61$, $P=0.007$; Table II). Chicks pecked at a higher rate at polystyrene blocks than at polystyrene beads. Whether the chicks had access to the troughs during the whole day or only in the morning had no significant effect on the rate of pecking at the material (whole/half day condition, $F_{1,12}=0.78$, $P=0.39$). No significant interaction was found between the two factors ($F_{1,12}=1.42$, $P=0.26$).

Discussion

In accordance with the results of experiment 2, chicks provided with polystyrene blocks showed more foraging behaviour and less feather pecking than chicks that had access to polystyrene beads. With respect to the availability of the foraging materials there was also an inverse relationship between foraging behaviour and feather pecking for data collected in the afternoon. In pens where the foraging materials were removed, the percentage of chicks engaged in foraging behaviour was significantly reduced, and the rate of feather-pecking interactions was significantly increased. However, chicks in the access half day condition also showed more feather pecking than chicks in the access whole day condition in the morning when all groups had access to foraging materials even though there was no significant difference in foraging behaviour between the two housing conditions in the morning. The temporal restriction of the access to the foraging materials thus induced a persistent rise in the chicks' tendency to peck at the feathers of conspecifics. In fact, the rate of feather-pecking interactions did not differ between data collected in the morning and in the afternoon in the access half day condition.

In a previous study with laying hen chicks (Wechsler et al., in press) we observed that group members characterized by high rates of feather-pecking interactions showed more severe forms of this behaviour. It is therefore not surprising that the quality and the availability of the foraging materials had significant effects not only on the rate of feather-pecking interactions but also on the incidence of bloody injuries. More injuries were found in housing conditions with higher rates of feather-pecking interactions. The occurrence of bloody injuries in the experimental housing conditions also shows that the chicks developed levels of feather pecking that are of relevance for behavioural problems observed in commercial housing systems.

The rate of feather-pecking interactions was lower in chicks provided with polystyrene blocks than with beads. The results of the focal animal samples suggest that this may be caused by differences in the quality of behaviour directed at the two foraging materials. First, the rate of pecking at the material was significantly higher with polystyrene blocks than with beads. Second, 9.7% of the beak-related events directed at the blocks were classified as tearing, a behavioural element that could not be shown with the beads. As a third difference, the blocks may have elicited more severe pecks than the beads. More experiments with different types of foraging material are necessary to assess the relative importance of these qualitative differences in foraging behaviour for the development of feather pecking.

There was no difference in foraging behaviour recorded in the morning between chicks in the access whole day and the access half day conditions, either in the percentage of chicks

engaged in foraging behaviour (scan samples) or in the rate of pecks directed at the foraging materials (focal animal samples). This shows that chicks in the access half day condition did not compensate for the reduction in foraging behaviour in the afternoon by showing more such behaviour in the morning. Given the inverse relationship between foraging behaviour and feather pecking, temporal restrictions of the access to foraging material should therefore be avoided to prevent the development of feather pecking.

GENERAL DISCUSSION

From a previous experimental study on feather pecking (Huber-Eicher & Wechsler 1997), we had hypothesized that feather pecking is inversely related to foraging behaviour. Our present results confirm our hypothesis. In all three experiments we were able to induce differences in the amount of time the chicks spent on exploratory and manipulative foraging behaviour away from the feeder, which were inversely related to the rate of feather-pecking interactions. We therefore conclude that feather pecking should be considered as redirected foraging behaviour. By using the term 'redirected' we mean that foraging behaviour is directed at a substitute stimulus (the feathers of conspecifics) as a consequence of the lack of more adequate stimuli.

There are other examples of redirected behaviour in farm animals. Fattening pigs, *Sus scrofa*, kept in barren pens without straw direct rooting and chewing at pen-mates (Fraser et al. 1991). Sows housed in farrowing crates without straw direct nest-building behaviour at the floor and the fixtures during the last hours before farrowing (Lawrence et al. 1994). Calves, *Bos taurus*, reared without cows direct cross-sucking towards the mouth and ears of other calves (Lidfors 1993). In all these examples the animals direct their behaviour at inappropriate stimuli, as they are deprived of an adequate stimulus.

In accordance with our results, Blokhuis (1986) and Blokhuis & Arkes (1984) found that laying hen chicks kept on litter floor (wood-shavings) showed more ground pecking and less feather pecking than chicks housed on slats. Our results indicate, however, that there are foraging materials that are more effective in reducing feather pecking than a layer of loose material. Chicks with access to bundles of straw or polystyrene blocks spent significantly more time engaged in foraging behaviour and showed significantly lower rates of feather pecking than chicks with access to shredded straw or polystyrene beads, respectively. We therefore suggest that chicks should be provided not only with litter but also with materials that elicit a variety of elements of foraging behaviour. Given the fact that the chicks' ability to act on foraging material changes during their development it may also be necessary to alter the quality of the materials offered during the rearing period.

There are different ways to promote foraging behaviour in laying hen chicks. In the present study both the quality and the availability of the foraging materials had a significant effect on foraging behaviour and feather pecking. In a previous study, chicks that could forage on sand from day 1 on showed more foraging behaviour on this substrate and less feather pecking in weeks 4 and 5 than chicks that had access to sand only from day 10 on (Huber-Eicher & Wechsler 1997). For a comprehensive understanding of the development of feather pecking it would thus be important to test whether different factors found to be related to feather pecking (light intensity: Hughes & Duncan 1972; stocking density: Hoffmeyer 1969; Ouart & Adams 1982; group size: Hughes & Duncan 1972; fear: Craig et al. 1983; Vestergaard et al. 1993; food composition: Schaible et al. 1947) have an effect on the amount of time the chicks spend on foraging behaviour. The timing of these factors may also be important. Moreover, differences in feather pecking found between laying hen strains (Cuthbertson 1980; Ouart & Adams 1982; Craig & Lee 1990; Blokhuis & Beuving 1993) may be paralleled by differences in the birds' tendency to perform foraging behaviour.

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