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Pecking behaviour of laying hens in single-tiered aviaries with and without outdoor area

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Abstract 1. The objective of the present study was to examine the behaviour of laying hens in single-tiered aviaries with and without outdoor areas with particular reference to the proportion of each behaviour and the ways it changed.
2. In all, 144 interbred cross layers (WL/RIR cross-breed) were used. At the age of 16 weeks, the hens were divided at random into two groups and moved to single-tiered aviary (SA) and free-range systems (FR, SA with in addition an outdoor range area covered with clover) with 18 hens per pen. Behavioural observations were conducted before, during and after access to the range.
3. All behaviours using the beak (eating, grazing, drinking, preening, aggressive pecking, feather pecking, litter pecking, object pecking and mate pecking) were recorded as pecking behaviour.
4. While most of the FR hens spent their time outside foraging, the proportion of hens eating, preening, litter pecking, object pecking, aggressive pecking and feather pecking was higher in SA than in FR hens.
5. The proportion of hens performing pecking behaviour of all types was very similar in SA ($61{\cdot}7 \pm 2{\cdot}0\%$) and in FR ($64{\cdot}0 \pm 0{\cdot}8\%$). The proportion of hens performing overall pecking behaviour increased as pre-laying sitting decreased.
6. The proportion of hens feather pecking decreased in FR during access to range and a similar tendency was found for aggressive pecking.
7. In conclusion, the total proportion of hens pecking was almost the same regardless of whether an outdoor area was provided or not, but the incidence of different types of pecking behaviour differed between SA and FR. The risk of feather pecking in FR may be lower when an outdoor grazing area is provided, although further testing on a larger scale would be essential.

INTRODUCTION

The use of non-cage systems as alternatives to conventional cages for laying hens is increasing, especially in the European Union, where they will be banned from 2012 (Blokhuis, 2004). Free-range systems are non-cage systems with an outdoor area. Eggs from free-range systems can usually be discriminated from eggs produced in other types of housing by labels such as the RSPCA-monitored 'Freedom Foods', and they command higher market prices. Consequently, the proportion of hens kept in free-range systems has increased in the European Union. In fact, the number of flocks of laying hens kept in housing systems with outdoor areas has increased within the European Union from 3228 (in 1991) to 16 942 (in 2001) (Windhorst, 2005). The use of this system has also increased in Japan because these eggs can be differentiated like those produced in the European Union. Therefore, free-range systems are increasing not only in the European Union but all over the world due to increased concern for animal welfare.

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However, scientific reports about the use of outdoor pasture are limited, and the behaviour patterns of hens in free-range systems have not been investigated in detail, though many problems have been suggested (see Tauson, 2005). Above all, feather pecking is one of the most critical problems for hen welfare (for example, Blokhuis *et al*., 2006). This abnormal pecking behaviour leads to cannibalism and is observed more frequently in large flocks, such as those in non-cage systems, than in small flocks, such as those in conventional cages (Blokhuis *et al*., 2006). However, it has been reported that feather condition was better if the hens in free-range systems spent more time outside (Mahboub *et al*., 2004). This suggests that the expression of abnormal pecking and other pecking behaviours were influenced by access to pasture, and so analysing its effect may help to improve hen welfare.

We therefore evaluated the effects of outdoor pasture on the pecking behaviour of laying hens. We equipped small-scale non-cage systems (single-tiered aviary) with and without an outdoor area for behavioural observation and compared the pecking behaviour in the two systems from the viewpoint of the proportions of behaviours displayed throughout the day.

MATERIALS AND METHODS

Animals and housing arrangement

In total, 144 hybrid layers (White Leghorn/Rhode Island Red cross-breed) were used. All birds had their beaks trimmed at one day old and were reared in pens with wood shavings on the floor. At the age of 16 weeks, the birds were randomly divided into two groups and moved to single-tiered aviary and free-range systems (4 replicate pens of each) with 18 birds per pen.

The house was ventilated with three ceiling fans. The average daytime temperature (±SD) during the observation period was 20·9 ± 7·6°C at the centre of the house. Lighting was provided by miniature ceiling bulbs, adjusted to give an intensity of 10 lux at the food troughs, with the light period from 05:00 to 19:00 h. The birds had *ad libitum* access to water and feed (Nosan, Yokohama, Japan). The feed contained more than 185 g CP and 11·88 MJ ME per kg. Feeding and other routine work were done from 08:00 to 08:30 and 15:00 to 15:30 h.

Housing systems

Single-tiered aviary (SA)

The area of the SA was 360 cm × 360 cm, providing a total floor area of 7200 cm^2 per hen (Figure 1). Each SA consisted of a litter area (180 cm × 360 cm) over one-half of the area and a raised slatted platform (180 cm × 360 cm) which allowed droppings to accumulate underneath over one-half of the area. Eight nest boxes (one nest/2·3 hens) were provided at a height of 100 cm from the slatted floor, two lined wood perches (27 cm/hen) were placed in front of the nest boxes, and feeders (20 cm/hen) and drinkers (20 cm/hen) were placed along the length of the slatted platform.

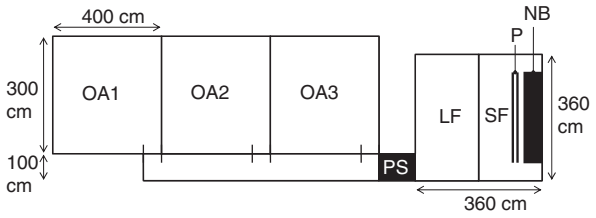

Figure 1. *Diagram of single-tiered aviary (only the right side area 360 cm × 360 cm from PS) and free-range systems. OA = outdoor area; PS = passage; LF = litter floor; SF = slat floor; P = perch; NB = nest box.*

Free-range system (FR)

The free-range system was a SA with an outdoor area (Figure 1). A passage hole (100 cm × 100 cm) was provided between the indoor and outdoor areas so that hens could readily go outside. The outdoor range area consisted of a passage (100 cm × 850 cm) and three areas (300 × 400 cm/area) separated by net barriers. Clover grew in these three areas, and hens were alternately pastured in one of the three areas in order to provide enough vegetation at any time. Hens were given access to the range area at 08:00 h and herded back into the indoor area at 16:00 h in order to protect them from predators.

Measurements

Behavioural observations were conducted at 22, 35, 38 and 47 weeks of age (3 d/week). Direct visual scans at 10 min intervals were conducted to record the locations and behaviour of hens in all pens at the same time for 8 h/d: 2 h before (06:00 to 08:00 h), during (10:00 to 12:00 and 13:00 to 15:00 h) and after (17:00 to 19:00 h) access to the range. Observation of FR hens was carried out at the same time, and one observer checked hens in the indoor area and the other in the range area. No observations were made on rainy days. Locations were recorded by functional position (nest, perch, slat floor, feeder, litter floor, passage hole and outdoor area). The location 'feeder' was recorded when a hen had her head in the feeder. Behaviours were recorded as pecking behaviours (eating, drinking, preening,

Table 1. *Mean proportion ± SD of hens at each location before (06:00 to 08:00 h), during (10:00 to 12:00, 13:00 to 15:00 h) and after (17:00 to 19:00 h) access to pasture in single-tiered aviary (SA) and free-range systems (FR)*

		Time (h)				*F*-value[1]		
Location	System	06:00 to 08:00	10:00 to 12:00	13:00 to 15:00	17:00 to 19:00	System (S)	Time (T)	S × T
Nest	SA	19·5 ± 3·0	10·3 ± 1·2	2·0 ± 1·0	0·2 ± 0·4	2·0	228·9***	1·9
	FR	18·2 ± 1·4	7·7 ± 1·7	2·3 ± 0·7	0·9 ± 1·3			
Perch	SA	9·2 ± 2·2^{a}	4·2 ± 2·1^{b}	3·5 ± 2·5^{b}	1·8 ± 1·3^{b}	1·4	31·2***	3·3*
	FR	8·6 ± 0·9^{a}	1·5 ± 0·4^{b}	0·5 ± 0·2^{b}	3·4 ± 3·6^{b}			
Feeder	SA	15·9 ± 1·7^{b}	21·7 ± 1·1^{a}	20·4 ± 1·1^{a}	17·9 ± 2·6^{abc}	40·2***	2·7	20·2***
	FR	14·8 ± 0·8^{bc}	12·4 ± 0·6^{bc}	10·9 ± 0·5^{c}	15·0 ± 3·3^{b}			
Slat floor	SA	14·5 ± 4·9^{ab}	16·0 ± 3·2^{a}	16·6 ± 4·0^{a}	13·6 ± 3·7^{ab}	14·9**	8·3**	33·5***
	FR	11·2 ± 0·4^{b}	4·7 ± 0·5^{b}	4·3 ± 0·7^{b}	11·4 ± 1·7^{b}			
Litter floor	SA	40·8 ± 3·9^{b}	50·9 ± 8·3^{b}	57·6 ± 8·2^{ab}	66·5 ± 7·7^{ab}	28·0***	245·0***	166·7***
	FR	47·3 ± 1·4^{ab}	15·0 ± 3·0^{c}	12·1 ± 2·6^{c}	69·4 ± 2·8^{a}			
Passage hole	FR	0·0 ± 0·0^{b}	3·2 ± 1·4^{a}	2·1 ± 0·8^{a}	0·0 ± 0·0^{b}	–	19·3***	–
Outdoor area	FR	0·0 ± 0·0^{c}	55·4 ± 4·9^{b}	67·6 ± 4·1^{a}	0·0 ± 0·0^{c}	–	739·0***	–

*P < 0·05; **P < 0·01; ***P < 0·001.

[1]Degree of freedom of the effect of system (S) was 1, of time (T) was 3 and of S × T was 3 in each location. N = 32 in each location. Different superscript letters within the same location indicate significant difference (^{a-c}P < 0·05).

aggressive pecking, feather pecking, litter pecking, object pecking and mate pecking), resting, dust bathing, litter scratching, moving, pre-laying sitting and others. Aggressive pecking was pecking the head of the recipient, and excluded both severe feather pecking (forceful pecks, sometimes with feathers being pulled out and the recipient bird moving away) and gentle feather pecking (mate pecking and careful pecks, not resulting in feathers being pulled out and usually without reaction from the recipient bird). Pre-laying sitting was recorded when a hen was sitting in the nest box.

Statistical analysis

The proportions of birds found at each location and performing each behaviour were calculated in each pen for each observation period. The data was analysed by using the statistical software Statcel (Yanagii, 2007). There were 4 replicate pens of each system, giving 4 replications of each observation period. Because the data of each pen in a system were related, repeated measures ANOVA was used to evaluate the effects of system (SA, FR), observation time (06:00 to 08:00, 10:00 to 12:00, 13:00 to 15:00, 17:00 to 19:00 h) and interactions between these effects on the use of facilities and behaviour. Each measurement therefore involved 32 data units in the analysis (2 systems × 4 observation periods × 4 replications). The significance of individual effects was evaluated by a multiple comparison using the Tukey–Kramer test. When significant interactions between system and time were found, the dual data were unified and then compared using one-way ANOVA followed by the Tukey–Kramer test. The statistical significance was accepted at a probability level of less than 5%.

RESULTS

Location

The proportions of SA and FR hens at each location are shown in Table 1. The use of perch (P < 0·05), feeder (P < 0·001), slat floor (P < 0·001) and litter floor (P < 0·001) showed significant interactions between the effects of the system and observation time. While the proportion of FR hens in the passage hole and outdoor area increased during outside access periods (10:00 to 12:00 and 13:00 to 15:00 h), the proportion of hens on the litter floor decreased (P < 0·05) and a similar tendency was found in slat floor usage. About 20% of hens used the nest between 06:00 and 08:00 h initially, and the proportion decreased with time (P < 0·001).

Behaviour

The proportions of SA and FR hens performing each behaviour are shown in Table 2. All behaviour observed in this study, except foraging, showed significant interaction between the effects of the system and the observation time. While the proportion of FR hens foraging increased when they were on the range (10:00 to 12:00 and 13:00 to 15:00 h), the proportions of FR hens eating, preening and litter pecking were lower during range periods than prior to outside access (6:00 to 8:00 h). As a result, the proportions of hens performing these behaviours were higher in SA than in FR hens (eating, P < 0·001; preening, P < 0·01; litter pecking, P < 0·05; object pecking, P < 0·05). The proportions of hens performing feather pecking were lower in FR than in SA during access to the range (feather pecking, P < 0·05) and similar tendency was found in aggressive pecking, though these behaviours in

Table 2. *Mean proportion ± standard error of hens performing each behaviour before (06:00 to 08:00 h), during (10:00 to 12:00, 13:00 to 15:00 h) and after (17:00 to 19:00 h) access to pasture in single-tiered aviary (SA) and free-range systems (FR)*

		Time (h)				*F*-value[1]		
Behaviour	System	06:00 to 08:00	10:00 to 12:00	13:00 to 15:00	17:00 to 19:00	System (S)	Time (T)	S × T
Foraging	FR	$0{\cdot}0 \pm 0{\cdot}0^{c}$	$31{\cdot}8 \pm 3{\cdot}6^{b}$	$41{\cdot}9 \pm 3{\cdot}3^{a}$	$0{\cdot}0 \pm 0{\cdot}0^{c}$	–	450·0***	–
	SA	$15{\cdot}9 \pm 1{\cdot}7^{b}$	$21{\cdot}2 \pm 1{\cdot}6^{a}$	$20{\cdot}4 \pm 1{\cdot}1^{a}$	$17{\cdot}9 \pm 2{\cdot}6^{ab}$	35·5***	2·4	19·3**
	FR	$14{\cdot}8 \pm 0{\cdot}8^{b}$	$12{\cdot}6 \pm 0{\cdot}4^{c}$	$10{\cdot}7 \pm 0{\cdot}4^{c}$	$15{\cdot}0 \pm 3{\cdot}3^{b}$			
Drinking	SA	$2{\cdot}5 \pm 0{\cdot}7^{b}$	$2{\cdot}9 \pm 0{\cdot}8^{b}$	$3{\cdot}3 \pm 0{\cdot}6^{b}$	$5{\cdot}0 \pm 0{\cdot}7^{a}$	1·5	37·6***	3·2*
	FR	$2{\cdot}7 \pm 0{\cdot}4^{b}$	$2{\cdot}2 \pm 0{\cdot}7^{b}$	$2{\cdot}0 \pm 0{\cdot}6^{b}$	$5{\cdot}0 \pm 1{\cdot}0^{a}$			
Resting	SA	$2{\cdot}6 \pm 1{\cdot}1$	$4{\cdot}1 \pm 1{\cdot}0$	$6{\cdot}3 \pm 2{\cdot}0$	$1{\cdot}8 \pm 1{\cdot}0$	0·0	11·2***	4·5*
	FR	$2{\cdot}5 \pm 0{\cdot}6$	$4{\cdot}3 \pm 1{\cdot}1$	$4{\cdot}4 \pm 1{\cdot}5$	$3{\cdot}8 \pm 1{\cdot}7$			
Comfort								
Dust bathing	SA	$0{\cdot}1 \pm 0{\cdot}1^{c}$	$2{\cdot}1 \pm 0{\cdot}8^{bc}$	$5{\cdot}3 \pm 1{\cdot}8^{a}$	$3{\cdot}6 \pm 0{\cdot}6^{ab}$	10·5*	15·1***	9·5***
	FR	$0{\cdot}2 \pm 0{\cdot}1^{c}$	$3{\cdot}8 \pm 0{\cdot}9^{ab}$	$1{\cdot}7 \pm 0{\cdot}7^{bc}$	$1{\cdot}6 \pm 1{\cdot}5^{bc}$			
Preening	SA	$14{\cdot}0 \pm 1{\cdot}9^{a}$	$14{\cdot}1 \pm 1{\cdot}7^{a}$	$14{\cdot}6 \pm 0{\cdot}2^{a}$	$9{\cdot}3 \pm 1{\cdot}3^{b}$	19·5**	9·1***	8·9***
	FR	$12{\cdot}7 \pm 2{\cdot}7^{a}$	$8{\cdot}1 \pm 0{\cdot}9^{b}$	$8{\cdot}5 \pm 0{\cdot}5^{b}$	$9{\cdot}5 \pm 2{\cdot}5^{b}$			
Exploring								
Litter pecking	SA	$10{\cdot}1 \pm 0{\cdot}9^{b}$	$15{\cdot}3 \pm 2{\cdot}0^{b}$	$17{\cdot}2 \pm 2{\cdot}6^{b}$	$31{\cdot}0 \pm 4{\cdot}6^{a}$	7·6*	274·6***	54·8***
	FR	$13{\cdot}9 \pm 2{\cdot}0^{b}$	$3{\cdot}4 \pm 1{\cdot}7^{c}$	$3{\cdot}0 \pm 0{\cdot}7^{c}$	$37{\cdot}7 \pm 4{\cdot}1^{a}$			
Litter scratching	SA	$0{\cdot}5 \pm 0{\cdot}1^{b}$	$0{\cdot}9 \pm 0{\cdot}4^{ab}$	$1{\cdot}0 \pm 0{\cdot}3^{ab}$	$2{\cdot}0 \pm 0{\cdot}6^{a}$	0·8	18·0***	7·5**
	FR	$0{\cdot}5 \pm 0{\cdot}1^{b}$	$1{\cdot}5 \pm 0{\cdot}6^{ab}$	$2{\cdot}0 \pm 0{\cdot}9^{a}$	$1{\cdot}4 \pm 0{\cdot}4^{ab}$			
Object pecking	SA	$3{\cdot}6 \pm 1{\cdot}7^{b}$	$5{\cdot}0 \pm 2{\cdot}3^{ab}$	$5{\cdot}4 \pm 2{\cdot}4^{ab}$	$8{\cdot}2 \pm 2{\cdot}9^{a}$	6·4*	9·7***	5·7**
	FR	$2{\cdot}9 \pm 1{\cdot}5^{b}$	$2{\cdot}3 \pm 1{\cdot}0^{b}$	$2{\cdot}1 \pm 1{\cdot}0^{b}$	$3{\cdot}3 \pm 0{\cdot}8^{b}$			
Mate pecking	SA	$0{\cdot}3 \pm 0{\cdot}3^{b}$	$0{\cdot}7 \pm 0{\cdot}3^{b}$	$0{\cdot}9 \pm 0{\cdot}5^{b}$	$0{\cdot}4 \pm 0{\cdot}3^{b}$	11·2*	29·4***	10·4***
	FR	$0{\cdot}3 \pm 0{\cdot}2^{b}$	$2{\cdot}2 \pm 0{\cdot}1^{a}$	$1{\cdot}7 \pm 0{\cdot}7^{a}$	$0{\cdot}6 \pm 0{\cdot}1^{b}$			
Aggressive pecking	SA	$0{\cdot}5 \pm 0{\cdot}2^{ab}$	$0{\cdot}8 \pm 0{\cdot}1^{a}$	$0{\cdot}7 \pm 0{\cdot}3^{ab}$	$0{\cdot}5 \pm 0{\cdot}2^{ab}$	14·7**	0·9	0·9*
	FR	$0{\cdot}4 \pm 0{\cdot}2^{b}$	$0{\cdot}3 \pm 0{\cdot}1^{b}$	$0{\cdot}2 \pm 0{\cdot}1^{b}$	$0{\cdot}5 \pm 0{\cdot}2^{ab}$			
Feather pecking	SA	$0{\cdot}3 \pm 0{\cdot}1^{b}$	$1{\cdot}5 \pm 0{\cdot}5^{a}$	$2{\cdot}1 \pm 0{\cdot}7^{a}$	$1{\cdot}4 \pm 0{\cdot}4^{ab}$	15·1**	10·5***	8·0**
	FR	$0{\cdot}6 \pm 0{\cdot}2^{b}$	$0{\cdot}8 \pm 0{\cdot}1^{b}$	$0{\cdot}6 \pm 0{\cdot}3^{b}$	$1{\cdot}6 \pm 0{\cdot}4^{ab}$			
Moving	SA	$10{\cdot}3 \pm 1{\cdot}3^{a}$	$8{\cdot}2 \pm 1{\cdot}0^{ab}$	$7{\cdot}4 \pm 1{\cdot}1^{b}$	$7{\cdot}3 \pm 0{\cdot}5^{b}$	9·2*	8·7***	5·5**
	FR	$10{\cdot}0 \pm 1{\cdot}4^{ab}$	$10{\cdot}9 \pm 0{\cdot}8^{a}$	$10{\cdot}9 \pm 1{\cdot}8^{a}$	$7{\cdot}7 \pm 1{\cdot}3^{b}$			

*$P<0{\cdot}05$; **$P<0{\cdot}01$; ***$P<0{\cdot}001$.

[1]Degree of freedom of the effect of system (S) was 1, of time (T) was 3 and of S × T was 3 in each behaviour. $N=32$ in each behaviour. Different superscript letters within the same behaviour indicate significant difference ($^{a-d}P<0{\cdot}05$).

FR had tendencies to increase after the range period (17:00 to 19:00 h, $P<0{\cdot}01$). Pre-laying sitting, as well as use of nest, tended to decrease with time in both systems ($P<0{\cdot}01$).

The total proportion (±SD) of hens performing all forms of pecking behaviour was almost the same in both systems over all times ($61{\cdot}7 \pm 2{\cdot}0\%$ in SA and $64{\cdot}0 \pm 0{\cdot}8\%$ in FR). The changes in the total proportion of pecking behaviour with time also increased similarly in SA and FR (Figure 2). The change in the total proportion of hens performing all forms of pecking behaviour had the greatest negative correlation with pre-laying sitting ($r=-0{\cdot}94$, $P<0{\cdot}001$). The total proportion of hens performing pecking behaviour was increased as pre-laying sitting decreased (Figure 2).

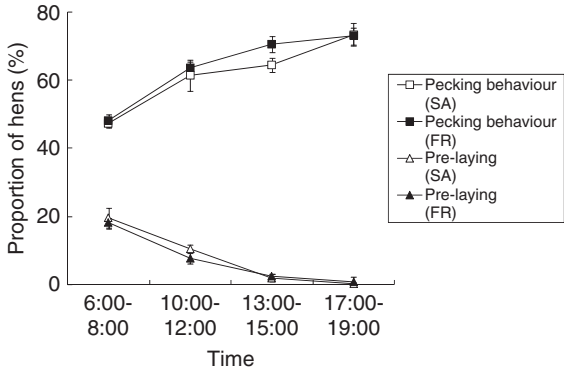

Figure 2. *The changes of total mean proportion (±SD) of hens performing all forms of pecking behaviour and pre-laying before (06:00 to 08:00 h), during (10:00 to 12:00, 13:00 to 15:00 h) and after (17:00 to 19:00 h) access to pasture in single-tiered aviary (SA) and free-range systems (FR).*

DISCUSSION

Feather pecking is a behaviour seen in laying hens, pheasants and turkeys. This behaviour is well known to lead to cannibalism, and many studies have described factors that affect feather pecking, for example, group size (Hughes and Wood-Gush, 1977; Hughes *et al.*, 1997) and light intensity (Hughes and Duncan, 1972). More recently, the effect of access to range on feather condition has been reported. In a study that compared two genotypes of laying hens in a free-range system, the hens that had a higher fear response and used the pasture less had more severe feather damage (Mahboub *et al.*, 2004). Green *et al.* (2000) reported that the risk of feather pecking increased if less than 50% of the

flock utilised the outdoor area. In our study, the proportions of hens using the outdoor area (61·5%) and foraging (36·9%) were high, which was associated with a lower proportion of hens performing feather pecking in FR hens during access to the range. This observation is consistent with a report (Tanaka *et al*., 2007) that feather condition was worse in aviaries with no outdoor area than in those which had one. These observations support the hypothesis that feather pecking would be decreased by outdoor pasturage. On the other hand, in large commercial flocks, the free range often remains unused by many hens. Hegelund *et al*. (2005) investigated the effect of flock size on use of the range area, and reported the low percentage of hens outside: the predicted percentage of hens at outdoor area was about 15% in large flocks (>30 000) and less than 40% even in small flocks (1 to 1000). Also, in some studies most hens tended to stay in the free-range area near the house (Keeling *et al*., 1988; Hegelund *et al*., 2005). In the present study, the flock size was very small (18 hens) thereby their greater use of free-range area was not unexpected. In view of the desirability to reduce feather pecking in commercial flocks, there is an urgent need for the development of a type of outdoor area that would be used by large flocks.

Pecking is a behaviour peculiar to birds, and much avian behaviour is performed using the beak, such as eating, preening, litter pecking and aggressive pecking. Lee and Craig (1990) reported that intact birds performed more litter pecking and that beak-trimmed birds did less litter pecking and more preening. We reported a similar result (Shimmura *et al*., 2006). In our previous study investigating the effects of beak trimming, preening increased while aggressive behaviour and eating decreased after beak trimming. In a study comparing the behaviour after some moulting methods, it was observed that exploration by pecking increased sharply after feed withdrawal (Shimmura *et al*., 2008).

Furthermore, many studies of environmental enrichment show that feather pecking decreased when pecking was redirected to enrichment materials such as straw or wood shavings (Huber-Eicher and Wechsler, 1997; Huber-Eicher and Sebo, 2001) and string (Jones *et al*., 2002). These studies suggest that hens might have strong pecking motivation, and if one outlet is not available and motivation cannot be fulfilled, hens may compensate by pecking another object. In fact, such compensatory behaviour has been reported. Blokhuis and van der Haar (1989) found that feather pecking decreased while ground pecking increased, in birds reared on litter and that the total frequency of observed pecking behaviour was similar in pens with and without litter. Furthermore, Appleby *et al*. (1989), observing behaviours of laying hens in a deep litter house, found different activities occurred in the litter area and slated area in the house but the total proportion of time spent by hens on pecking something was almost the same.

Strong motivation for pecking material was also observed in semi-wild Red Junglefowl, the ancestor of the domestic fowl (Dawkins, 1989); the percentage of time spent on pecking was about 60%, which was similar to that found in the domestic fowl (Appleby *et al*., 1989). In the current study, the total proportion of hens performing pecking behaviour overall was about 62·9% and almost the same in SA and FR, although the proportions of hens performing different types of pecking behaviours differed between the systems. The changes in total pecking behaviour with time also increased similarly in SA and FR. Therefore, if FR is the best environment for satisfying a set of pecking motivations of hens, SA hens might compensate for a portion of the foraging that they are not able to perform in SA by eating, preening, litter pecking and object pecking. The incidence of these compensatory behaviours seemed adequate to compensate for the lack of foraging. This study also confirmed that the total proportion of hens performing pecking behaviour increased correspondingly as the pre-laying sitting decreased. Further studies comparing various housing types including cage systems are needed in order to identify the compensatory behaviour more clearly.

In conclusion, it was confirmed that the total frequency of pecking behaviour was almost the same regardless of whether an outdoor area was provided or not, although the incidence of different types of pecking behaviour varied between SA and FR. The risk of feather pecking in FR may be lower when an outdoor range area is provided, although larger trials would be needed to test this in commercial scale flocks.

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