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# The role of loose feathers for the development of feather pecking in laying hens

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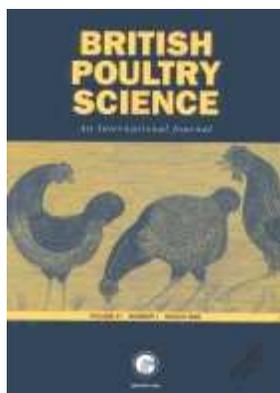
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**The role of loose feathers for the development of feather pecking in laying hens**

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4 **1 Role of loose feathers on the development of feather pecking in laying hens**  
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24 Short title: **Loose feathers and feather pecking**  
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19 Abstract. 1. The effect of the presence of loose feathers (on the floor) on the  
20 behaviour and plumage condition of laying hens (Lohmann Silver, LS) was  
21 studied during the rearing and laying periods.

22 2. From 1-d-old, 60 birds in each of 4 straw-bedded pens (n=240 in total) with 6.5  
23 birds/m<sup>2</sup> were either kept under conventional rearing and management conditions  
24 (CT: control group with feathers on the floor; n=120) or in pens from which the  
25 feathers were collected from the floor 4 times/week (FR: feathers removed;  
26 n=120). Fifty birds from each of these 4 groups (n=200 in total) were randomly  
27 selected at the age of 16 weeks and allocated to 4 identical pens in a poultry layer  
28 house (PH; with perches and 1/3 slatted floor) with access to an outside area  
29 (winter garden, WG) at a stocking density of 6 birds/m<sup>2</sup> in both PH and WG.

30 3. Observations on feather pecking and other behaviours (feeding, drinking,  
31 preening, standing, sitting, foraging, moving and dust bathing) were carried out at  
32 8 ages: 6, 10, 15 (rearing period), 20, 25, 30, 35 and 40 weeks (laying period).  
33 Feather scoring was carried out at 15, 32 and 39 weeks of age.

34 4. There were no differences in feather pecking rates, forms (gentle, severe and  
35 aggressive pecks) as well as in the plumage condition between groups at the end  
36 of the rearing period.

37 5. Birds in the **FR** group exhibited lower rates and less severe feather pecking  
38 during the laying period. Accordingly, birds in the control group had worse  
39 feather condition at 32 and 39 weeks of age. Feather pecking rates within groups  
40 were, in general, greater in the afternoon compared to the morning periods. Birds  
41 in the control group were more active in walking.

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5 42 6. Wings, rump, tail and back were the main targets for feather pecking. The  
6  
7 43 majority of feather pecking occurred on the floor (66 %) followed by feeding area  
8  
9 44 (26 %), perches (4 %) and slats (4 %).

10  
11  
12 45 7. Our results suggest that loose feathers on the floor may play an important role  
13  
14 46 in the development and severity of feather pecking behaviour in laying hens and  
15  
16 47 support the hypothesis (McKeegan and Savory 1999) that feather pecking can be  
17  
18 48 viewed as redirected foraging behaviour.  
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## 22 23 50 INTRODUCTION

24  
25  
26 51 Feather pecking is interpreted as an abnormal behaviour where laying hens peck  
27  
28 52 the feathers of conspecifics, damage the plumage or even injure the skin. It is  
29  
30 53 considered as one of the most widespread and serious problems of today's poultry  
31  
32 54 production when hens are kept under commercial conditions (Savory, 1995;  
33  
34 55 Blokhuis *et al.*, 2000). It reduces welfare in the recipient birds, because it has been  
35  
36 56 suggested that having feathers pulled out is perceived as painful (Gentle and  
37  
38 57 Hunter, 1990) and can lead to cannibalism (Allen and Perry, 1975). Moreover, it  
39  
40 58 increases economical losses due to increased mortality, reduction in egg  
41  
42 59 production (El-Lethy *et al.*, 2000), increased food consumption (Leeson and  
43  
44 60 Morrison, 1978), and is also associated with increased (chronic) fear (Hughes and  
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46 61 Duncan, 1972; Quart and Adams, 1982). Johnsen *et al.* (1998) emphasised the  
47  
48 62 importance of early rearing conditions (litter substrate) on the development of  
49  
50 63 feather pecking behaviour, of which the presence of loose feathers on the floor in  
51  
52 64 early life may affect subsequent pecking behaviour. Feather eating has been  
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54 65 observed in commercial layers (Savory and Mann, 1997; Harlander-Matauschek  
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5 66 and Bessei, 2005). Pullets prefer to eat shorter semiplumes (< 10 cm) rather than  
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7 67 longer ones, and once feather eating has become established, a shortage of loose  
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9 68 feathers on pen floors may cause a redirected pecking and eating of feathers from  
10  
11 69 other birds (McKeegan and Savory, 1999). Similarly, Forkman (2003) reported  
12  
13 70 that feather pecking can be viewed as foraging behaviour in which the birds first  
14  
15 71 learn to peck at loose feathers on the floor and then develop into proper feather  
16  
17 72 pecking when there are no more feathers available. The objective of this study  
18  
19 73 was to investigate the effect of feather presence or absence on the floor on various  
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21 74 behaviours of LS laying hens with emphasis on feather pecking and plumage  
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23 75 condition.  
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## 30 MATERIALS AND METHODS

### 31 Birds and housing condition

32  
33 78 **Birds and housing condition**  
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35 79 A total of 240 1-d-old layer hen chicks (Lohmann Silver, LS) were either kept in  
36  
37 80 **two pens** under conventional rearing and management conditions (**CT; n=2 x 60**)  
38  
39 81 or in **two pens** from which the feathers were collected from the floor 4 times/week  
40  
41 82 (**FR; n=2 x 60**). Fifty birds from each of these 4 groups (n=200 in total) were  
42  
43 83 randomly selected at the age of 16 weeks and allocated to 4 identical pens in a  
44  
45 84 poultry layer house (PH; with perches and 1/3 slatted floor, the remaining part  
46  
47 85 was deep litter area with straw) with unrestricted access to an outside area (winter  
48  
49 86 garden, WG, littered with shredded tree bark) at a stocking density of 6 birds/m<sup>2</sup>  
50  
51 87 in both PH and WG. All selected hens remained in their original rearing group.  
52  
53 88 The treatment in the laying period (presence or absence of feathers on the floor in  
54  
55 89 the PH and WG) was the same for all birds as in the rearing period. Each group  
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4 90 had access to 4 nests (60 cm x 30 cm x 30 cm). Four perches were placed 50 cm  
5  
6 91 above the slats which allowed 15 cm space on the perch for each bird. Two round  
7  
8 92 feeders were fixed 20 cm above the floor and 5 nipple drinkers under the perches  
9  
10 93 allowed access to one nipple for 10 hens according to the EU-Council Directive  
11  
12 94 (1999/74/EC). Food and water were provided *ad libitum*. The light regimen in the  
13  
14 95 house was 14 h light: 10 h dark with a light intensity of 4-6 lux and temperatures  
15  
16 96 indoors were kept between 11°C and 28°C.

## 21 97 **Procedures**

### 23 98 *Behavioural observations*

25 99 Hens of each pen group were directly observed in two 3-h periods, once in the  
26  
27 100 morning (9.00-12.00 h) and the second in the afternoon (13.00-16.00 h). Each  
28  
29 101 group was directly observed for 15 min in each observation period by a person  
30  
31 102 who was sitting outside the pen on a high chair with a good view over the whole  
32  
33 103 pen. Because it was impossible to observe the entire pen at one time, each pen  
34  
35 104 was subdivided into two equal segments (Sanotra *et al.*, 2002) that were observed  
36  
37 105 separately. The birds were accustomed to the presence of the observer for 5 min  
38  
39 106 before initiation of behavioural recording.

### 44 107 *Feather pecking*

46 108 All occurrences (Altmann, 1974) of feather pecking interactions in a group were  
47  
48 109 recorded (5 periods of 3 min). Feather pecks that were successively directed at the  
49  
50 110 same receiver were recorded as one single interaction. An interaction ended when  
51  
52 111 there were no more pecks during a period of 4 s. Interactions were classified as:  
53  
54 112 A-“**Gentle**”: gentle pecks at feathers, not resulting in feathers being pulled out  
55  
56 113 and neither does the receiver show a reaction to the peck. B-“**Severe**”: forceful  
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4 114 pecks, sometimes feathers are pulled out and the receiver of the peck may move  
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6  
7 115 away. C-“**Aggressive**”: were always severe and fast, directed mainly at the head  
8  
9  
10 116 and given in a downward direction, occasionally when the attacked bird was  
11  
12 117 moving away; an aggressive peck could also be directed to other parts of the  
13  
14 118 body. The body parts to which pecks were directed (head, neck, back, rump, tail,  
15  
16 119 wing, belly, breast and leg) were recorded. All rates of feather pecking are given  
17  
18 120 as number of occurrences.

21 121 *Other behavioural activities*

22  
23 122 The recording of feather pecking interactions was briefly interrupted every 3 min  
24  
25 123 for a scan sample of other activities. The number of birds engaged in 8 mutually-  
26  
27 124 exclusive activities were recorded for each scan (feeding, drinking, preening,  
28  
29 125 standing, sitting, foraging, moving and dust bathing). The percentage of birds  
30  
31 126 engaged in each behaviour was calculated during all scan samples for each pen.  
32  
33 127 Behavioural observations were carried out at 8 ages: 6, 10, 15 (rearing period),  
34  
35 128 and 20, 25, 30, 35 and 40 weeks (laying period in PH and WG). In addition, the  
36  
37 129 location (perch, floor, slats and feeding area) of the recipient bird during feather  
38  
39 130 pecking was recorded.

44 131 *Feather scoring*

45  
46 132 All birds from each pen were individually scored at 15, 32 and 39 weeks of age.  
47  
48 133 For inspection of feather condition, each bird was taken from the pen and 11  
49  
50 134 individual parts of the body (Gunnarson *et al.*, 1995), "head, neck, under the neck,  
51  
52 135 back, rump, tail, wings (wing-primary feathers and wing coverts), abdomen,  
53  
54 136 breast and legs" were carefully examined for damaged, broken, and missing  
55  
56 137 feathers and bald patches. Each body part was given a score from 0 (best) to 6  
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4 138 (worst), with special criteria used for scoring of flight feathers (the tail and the  
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7 139 primaries) compared to the feathers of the rest of the body that were differentiated  
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9  
10 140 for the types, number, length and damages (Table 1). The feathers under the neck  
11  
12 141 and breast were excluded because of the interfering effects of feeder edge and  
13  
14 142 brood patch on feather damage. A sum of all given values was taken as a total  
15  
16 143 body score.

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18  
19 144 (INSERT TABLE 1).

#### 20 21 145 **Statistical analysis**

22  
23 146 Data from behavioural observations, the number of feather pecking in different  
24  
25  
26 147 areas and locations as well as feather scores at different parts of the body were  
27  
28 148 analysed using generalised linear models (T-test: GLM- procedure, SAS Institute,  
29  
30 149 2001). Behavioural observations data from different ages were combined for the  
31  
32 150 analysis within the rearing and laying period. Residuals were tested for normal  
33  
34 151 distribution before analysis.

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37 152 The following model was used:

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39  
40 153  $Y_{ikl} = G_i + Per_k + \text{residual}_{ikl}$

41  
42 154 where

43  
44  
45 155  $Y$ = feather pecking or the type of behaviour observed (feeding, drinking,  
46  
47 156 foraging, preening, walking, standing and dust bathing), Feather score

48  
49  
50 157  $G_i$  = effect of group (feather treatment)

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52 158  $Per_k$  = effect of period (k= morning or afternoon)

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55 159 Residual= residual factors.  
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## 160 RESULTS

161 There were no differences in the rates of feather pecking, as well as feather  
162 pecking forms (gentle, severe and aggressive pecks) between the **CT** and **FR**  
163 groups in the rearing period, as shown in Table 2. In contrast, birds in the **CT**  
164 groups exhibited a higher rate of feather pecking ( $P=0.007$ ; see Table 3), and a  
165 more severe form of this behaviour ( $P<0.001$ ) in the laying period. Hens in the **FR**  
166 group exhibited more gentle FP ( $P<0.05$ ; see Figure 1).

167 (INSERT TABLES 2 and 3 and FIGURE 1)

168 Time of day had an effect on the rate of feather pecking, as feather pecking  
169 rates within the groups were in general greater in the afternoon compared to the  
170 morning periods ( $P < 0.001$ , **CT**;  $< 0.05$ , **FR**). However, the control group  
171 exhibited higher rates of afternoon feather pecking compared to the **FR** group  
172 ( $P=0.011$ ; see Table 3).

173 The distribution of feather pecking to the various body regions are shown  
174 in Figures 2a and 2b. Birds in the control group pecked to a greater extent to most  
175 of the body parts in both the PH and WG, however, the difference did not reach  
176 significance. Wings, rump, tail and back were the main targets for feather  
177 pecking.

178 (INSERT FIGURES 2a, b)

179 Behavioural activities were similar for both groups except for walking (see  
180 Table 4). The percentage of hens walking was greater ( $P=0.004$ ) in birds of the  
181 control group.

182 (INSERT TABLE 4)

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5 183 Feather condition of the different body regions as well as the sum of total  
6  
7 184 feather score was similar between groups during the rearing period ( $P>0.05$ ). In  
8  
9 185 general there was little plumage deterioration at the end of the rearing period.  
10  
11 186 Results from feather scoring at different ages during the laying period are shown  
12  
13  
14 187 in Table 5.

15  
16 188 (INSERT TABLE 5)

17  
18  
19 189 Plumage damage increased with age during the laying period. At 32 weeks  
20  
21 190 of the age, feather condition on the back and wing-coverts of the birds in the **CT**  
22  
23 191 groups were worse than for the **FR** birds ( $p=0.043$ ,  $0.007$ , respectively).  
24  
25 192 Accordingly, birds in the **FR** group had less damaged feathers on the neck, back,  
26  
27 193 wing-coverts and leg ( $P=0.019$ ,  $0.044$ ,  $0.029$ ,  $0.001$ , respectively) at 39 weeks of  
28  
29 194 the age. In addition, the sum of feather scores for all body parts was better in  
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31 195 birds of the **FR** groups at 32 and 39 weeks of age ( $P=0.002$ ,  $0.007$ , respectively).  
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34  
35 196 In Figure 3 feather pecking (%) is compared at  
36  
37 197 different locations. Most feather pecking occurred on the floor, followed by the  
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39 198 feeding area, slats and perches in both groups.

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41  
42 199 (INSERT FIGURE 3)

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## 46 47 201 **DISCUSSION**

48  
49 202 The hypothesis that feather eating may be a precursor to subsequent damaging  
50  
51 203 pecks (Savory and Mann, 1997; McKeegan and Savory, 1999) is supported by our  
52  
53 204 results, which suggested that birds may have learnt to peck and to eat loose  
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55 205 feathers from the floor that were available during the rearing period, because  
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57 206 feather moulting occurs three times during this period (Appleby *et al.*, 1992).  
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4 207 When there is a shortage of loose feathers during the laying period, attention may  
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6 208 have been redirected towards the feathers of conspecifics and hence developed  
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9 209 into feather pecking. This is indicated by an increase in both total rate and severity  
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11 210 of feather pecking in the control group. Although highly significant, these  
12  
13 211 treatment differences were relatively small. Nevertheless, this result tends to be  
14  
15 212 consistent with McKeegan and Savory (1999), who reported that short feathers  
16  
17 213 were eaten preferentially and long feathers were partially eaten by pullets when  
18  
19 214 short feathers were no longer available from the litter; once feather eating has  
20  
21 215 become established, a low availability of suitable-sized feathers may cause feather  
22  
23 216 eating and pecking to be redirected towards other birds. Also, Forkman (2003)  
24  
25 217 found that birds that had previously loose feathers on the floor (during the rearing  
26  
27 218 period) displayed a more severe feather pecks at 20 weeks of age than those  
28  
29 219 deprived of loose feathers. Unfortunately his experiment was terminated after  
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31 220 three days of observations due to ethical reasons.  
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37 221 Feather pecking was observed with a higher frequency in the afternoon, in  
38  
39 222 accordance with a study of Preston (1987) who found feather pecking in general  
40  
41 223 to occur mostly in the afternoon. Birds showed increased activities in the  
42  
43 224 afternoon with more foraging, dust bathing, movement and feeding (Vestergaard,  
44  
45 225 1982; Appleby *et al.*, 1992; Channing *et al.*, 2001), which might be accompanied  
46  
47 226 by more feather pecking. This supports our results which showed that increased  
48  
49 227 walking activity was accompanied with a higher rate of feather pecking in the  
50  
51 228 control groups. Also, our results are in agreement with Newberry *et al.* (1988) and  
52  
53 229 Riber *et al.* (2007) who reported that an increase in general activity leads to  
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55 230 increases in feather pecking behaviour. Klein *et al.* (2000) reported that increased  
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4 231 moving is a sign of frustration. It can be interpreted as an attempt to increase the  
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6 232 chances of finding the stimuli which the birds need. Mahboub *et al.* (2002, 2004)  
7  
8  
9 233 found that walking and the frequency of short outdoor visits in free range laying  
10  
11  
12 234 hens was associated with a high probability of occurrence for being pecked.

13  
14 235 Hens located on the floor were reported to receive more feather pecks than  
15  
16 236 hens on the perches (Wechsler and Huber-Eicher, 1998). This supports our results  
17  
18 237 that the majority of feather pecks occurred on the floor during the laying period.  
19  
20 238 This may be attributed to many behaviours performed on the floor such as sitting  
21  
22  
23 239 or standing on the floor, and dust bathing behaviour which were found to be  
24  
25 240 associated with a high frequency of feather pecking (Vestergaard, 1994; Huber-  
26  
27  
28 241 Eicher and Wechsler, 1998). In addition, Bilčík and Keeling (2000) reported  
29  
30 242 increasing frequency of aggressive pecks with increasing group size.

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32  
33 243 Most feather pecks in the current study were directed to the wings, rump,  
34  
35 244 tail and back, in agreement with findings from other studies (for example,  
36  
37 245 Wechsler *et al.*, 1998). Savory and Mann (1999) reported that feather loss  
38  
39 246 typically commenced at the base of the back where litter particles tend to be  
40  
41 247 attached and where there are relatively short feathers, which may be both easily  
42  
43  
44 248 plucked and preferred for eating.

45  
46  
47 249 Feather scoring is often used as a convenient measure to assess feather  
48  
49 250 pecking in flocks of laying hens (Hughes and Duncan, 1972; Gunnarsson *et al.*,  
50  
51 251 1999). Our results demonstrated that there was little plumage deterioration at the  
52  
53 252 end of the rearing period. This may be attributed to a low rate of the severe form  
54  
55 253 of feather pecking observed in the current study during the rearing period which  
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58 254 usually causes most of the feather damage. Proctor and Lynch (1993) reported  
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4 255 that relatively minimal feather pecking combined with a rapid series of moults  
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6 256 during the first months of life may explain why pullets reared commercially often  
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9 257 appear to be fully feathered, however, feather pecking does take place during the  
10  
11 258 rearing period. Plumage deterioration increased with age during the laying period.  
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13  
14 259 A rise in the rate of feather pecking has been found to correspond with the rise in  
15  
16 260 gonadal hormones inducing egg laying (Hughes, 1982). Rodenburg and Koene  
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18 261 (2003) also reported that the intensity and severity of feather pecking seems to  
19  
20 262 depend on age. Gentle feather pecking is mostly observed in young chickens  
21  
22 263 (Kjaer and Sørensen, 1997; Wechsler *et al.* 1998) and severe feather pecking is  
23  
24 264 more often seen at a later age (Huber-Eicher and Sebö, 2001*b*). This may explain  
25  
26 265 the rapid changes in plumage condition of different body parts that were recorded  
27  
28 266 during the laying period. Hens in the control groups were rated with a worse  
29  
30 267 feather score than hens in the FR groups. This may be attributed to the difference  
31  
32 268 in the amount and severity of feather pecking behaviour among groups, which  
33  
34 269 was reflected in the plumage condition. Because birds in the control groups have  
35  
36 270 learnt to peck and eat feathers from the floor, and due to a lack of feathers from  
37  
38 271 the floor during the laying period, they have pecked, pulled out and eaten feathers  
39  
40 272 from pen mates. Therefore, feather pecking rates as well as the severe form of this  
41  
42 273 behaviour were highest in the control groups leading to a deterioration of feathers.  
43  
44 274 This is in agreement with Huber-Eicher and Sebö (2001*a,b*) who found that  
45  
46 275 individuals characterised by relatively high rates of feather pecking performed  
47  
48 276 more frequently the severe form of this behaviour. Also, Huber-Eicher and Sebö  
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50 277 (2001*a*) reported that feather scoring actually measures indirectly the amount of  
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4 278 severe feather pecks, but because of the proportionality it also indicates the total  
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7 279 amount of feather pecking.  
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9 280 The suggestion that feather damage is caused by severe feather pecks is  
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11 281 supported by the results from Vestergaard *et al.* (1993) and Bilčík and Keeling  
12  
13 282 (1999) who demonstrated that severe feather pecks and not gentle feather pecks or  
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15 283 aggressive pecks caused most of the feather damage on the body of the laying  
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18 284 hens. Moreover, McAdie and Keeling (2000) found that damaged or broken  
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20 285 feathers or even denuded areas due to feather loss may stimulate more feather  
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22 286 pecking.  
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26 287 In conclusion, our results suggest that the presence of loose feathers on the  
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28 288 floor may play an important role in the development and severity of feather  
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30 289 pecking behaviour in laying hens, and support the hypothesis that feather pecking  
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32 290 can be viewed as redirected foraging behaviour. However, these results need to be  
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34 291 verified on the basis of larger sample and group sizes.  
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4 417 **TABLE 1.** *Description of the scoring method used to evaluate feather condition*  
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6 418 *(modified from previous methods, BILČIK and KEELING 1999). A different scale*  
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8 419 *was used for flight feathers (wing primaries and tail) compared to feather*  
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12 420 *condition of the rest of the body*

Scores	Body feather	Flight feather
0	Intact feathers.	Intact feathers.
1	Some feathers scruffy and/or up to 5 damaged feathers.	Few separated feathers up to 5, but none damaged, broken or missing.
2	> 5 damaged feathers and/or up to 5 broken feathers.	> 5 feathers separated and/or up to 5 damaged feathers.
3	> 5 broken feathers and/or up to 5 missing feathers.	All feathers separated, or > 5 feathers damaged or up to 3 broken.
4	Bald patch < 50 % of area.	All feathers damaged and/or > 3 feathers broken or up to 3 feathers missing.
5	Bald patch > 50 % of area.	All feathers broken or > 3 feathers missing.
6	Completely denuded area.	Almost all feathers missing.

421 **TABLE 2.** *Least squares means ( $\pm$  standard error) and P-value for feather*  
422 *pecking (FP) rate and feather pecking forms during the rearing period*

Items	Control	Feather Removal	P-value
Total FP (n)	9.77 ( $\pm$ 1.13)	8.53 ( $\pm$ 0.76)	NS
Gentle FP	6.50 ( $\pm$ 1.07)	5.70 ( $\pm$ 0.72)	NS
Severe FP	2.63 ( $\pm$ 0.39)	2.27 ( $\pm$ 0.32)	NS
Aggressive FP	0.63 ( $\pm$ 0.11)	0.57 ( $\pm$ 2.11)	NS

423 **TABLE 3.** *Least squares means ( $\pm$  standard error) and P-value for feather*  
 424 *pecking rate and effect of day time (laying period)*

Items	Control	Feather removal	I-value
Total feather pecking	12.60 <sup>a</sup> ( $\pm$ 0.53)	11.01 <sup>b</sup> ( $\pm$ 0.40)	0.007
Time of day			
am	11.22 ( $\pm$ 0.56)	10.16 ( $\pm$ 0.44)	NS
pm	13.98*** ( $\pm$ 0.86)	11.86* ( $\pm$ 0.65)	0.011

425 Statistically significant at \* $P < 0.05$ , \*\*\*  $P < 0.001$  (within the group).

426 **TABLE 4.** *Least squares means ( $\pm$  standard error) and P-value for total number*  
 427 *of hens (%) observed performing various behaviours*

Behaviour	Control	Feather removal	P-value
Feeding	10.84 ( $\pm$ 1.18)	11.87 ( $\pm$ 1.35)	NS
Drinking	8.11 ( $\pm$ 0.92)	7.99 ( $\pm$ 0.89)	NS
Foraging	30.93 ( $\pm$ 1.89)	32.86 ( $\pm$ 1.83)	NS
Preening	16.50 ( $\pm$ 1.09)	14.07 ( $\pm$ 0.88)	NS
Walking	8.39 <sup>a</sup> ( $\pm$ 0.39)	6.13 <sup>b</sup> ( $\pm$ 0.50)	0.004
Standing	10.71 ( $\pm$ 1.00)	10.47 ( $\pm$ 0.78)	NS
Sitting	7.51 ( $\pm$ 0.56)	7.69 ( $\pm$ 0.72)	NS
Dustbathing	3.94 ( $\pm$ 0.90)	5.93 ( $\pm$ 0.98)	NS

428 **TABLE 5.** *Least squares means ( $\pm$  standard error) and P-value for feather scoring at 32 and 39 weeks of age*

Items	Control	Feather removal	P-value	Control	Feather removal	P-value
<b>Body parts</b>	<b>32 weeks</b>			<b>39 weeks</b>		
Head	1.84 ( $\pm$ 0.08)	1.76 ( $\pm$ 0.06)	NS	2.71 ( $\pm$ 0.10)	2.68 ( $\pm$ 0.12)	NS
Neck	2.50 ( $\pm$ 0.07)	2.41 ( $\pm$ 0.07)	NS	3.84 <sup>a</sup> ( $\pm$ 0.06)	3.62 <sup>b</sup> ( $\pm$ 0.08)	0.019
Back	1.88 <sup>a</sup> ( $\pm$ 0.05)	1.73 <sup>b</sup> ( $\pm$ 0.07)	0.043	3.04 <sup>a</sup> ( $\pm$ 0.11)	2.74 <sup>b</sup> ( $\pm$ 0.10)	0.044
Rump	1.74 ( $\pm$ 0.09)	1.53 ( $\pm$ 0.07)	NS	2.51 ( $\pm$ 0.08)	2.66 ( $\pm$ 0.09)	NS
Tail	2.54 ( $\pm$ 0.07)	2.41 ( $\pm$ 0.09)	NS	2.71 ( $\pm$ 0.09)	2.55 ( $\pm$ 0.08)	NS
Wing-coverts	2.02 <sup>a</sup> ( $\pm$ 0.05)	1.73 <sup>b</sup> ( $\pm$ 0.09)	0.007	2.96 <sup>a</sup> ( $\pm$ 0.06)	2.72 <sup>b</sup> ( $\pm$ 0.07)	0.029
Wing primaries	3.18 ( $\pm$ 0.07)	3.10 ( $\pm$ 0.07)	NS	3.38 ( $\pm$ 0.05)	3.68 ( $\pm$ 0.08)	NS
Belly	1.26 ( $\pm$ 0.07)	1.12 ( $\pm$ 0.04)	NS	2.45 ( $\pm$ 0.08)	2.36 ( $\pm$ 0.08)	NS
Leg	2.22 ( $\pm$ 0.06)	2.22 ( $\pm$ 0.06)	NS	3.78 <sup>a</sup> ( $\pm$ 0.06)	3.40 <sup>b</sup> ( $\pm$ 0.10)	0.001
Total body parts	19.18 <sup>a</sup> ( $\pm$ 0.24)	18.02 <sup>b</sup> ( $\pm$ 0.28)	0.002	27.84 <sup>a</sup> ( $\pm$ 0.34)	26.43 <sup>b</sup> ( $\pm$ 0.45)	0.007

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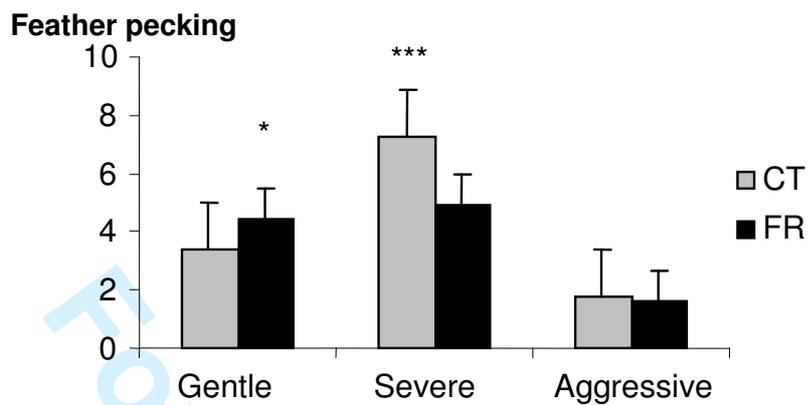
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**FIGURE 1.** Least squares means ( $\pm$  standard error) for feather pecking forms

during the laying period (\*\* $P < 0.001$ , \*  $P < 0.05$ ).

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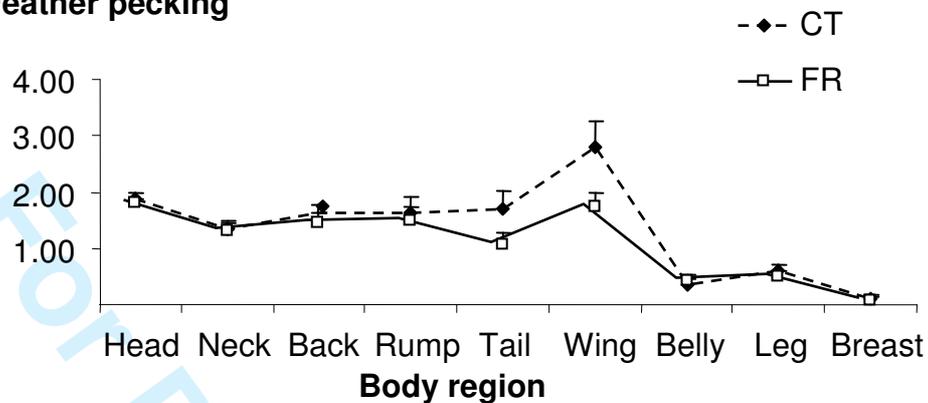
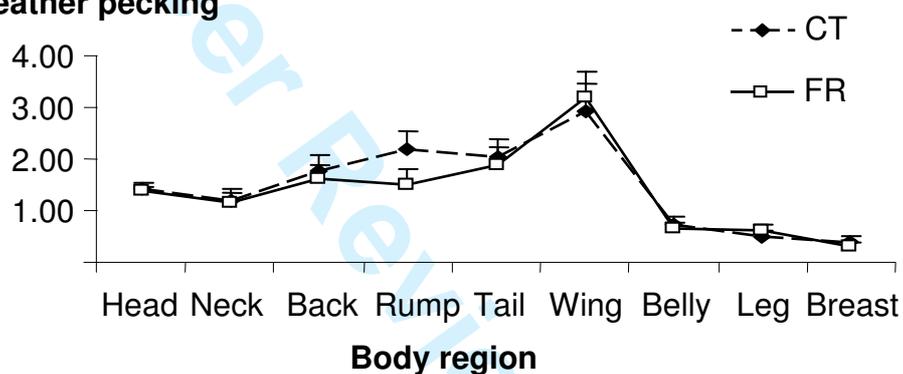
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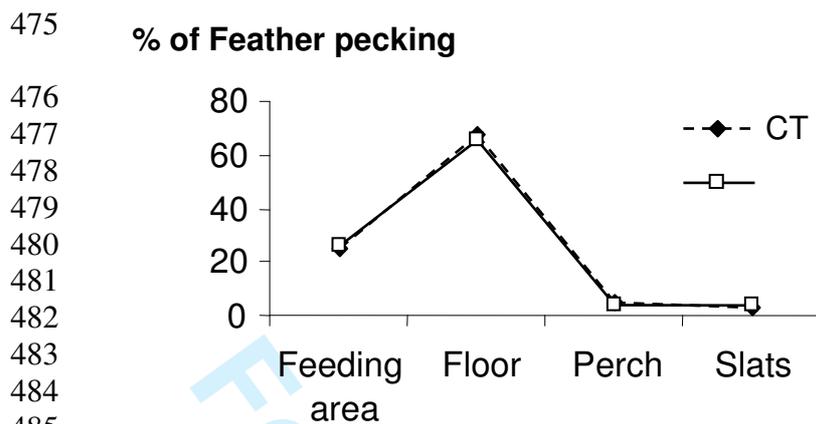
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**a. Poultry house****Feather pecking****b. Winter garden****Feather pecking**

**FIGURE 2.** Least squares means ( $\pm$  standard error) for the feather pecking directed to various body parts in the Poultry house (a) and Winter garden (b).



**Feather pecking locations**

**FIGURE 3.** Feather pecking locations of occurrence.