Research Note

The Effect of Feather Eating on Feed Passage in Laying Hens

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ABSTRACT

Previous work has demonstrated an association between feather pecking and feather eating in laying hens. This raised the question of the dietary effect of feathers. We hypothesized that feathers, as indigestible components, have similar effects as insoluble fiber, i.e., speeding up feed passage. Twenty-four adult laying hens each of a high (H) and a low (L) feather pecking line were kept in individual cages and fed a commercial pelleted diet ad libitum. One-half of each line was offered downy feathers (HF; LF) of the same genetic line. The other half of the birds were kept as control without access to feathers (H0; L0). After a 6-wk feeding period, 5 birds of each group were selected for determination of feed passage.

The HF birds with the highest number of feathers eaten and the LF birds with the lowest number of feathers eaten were used. Selection of L0 and H0 birds was carried out at random. Feed passage was determined over 48 h using titanium dioxide as a marker. The number of feathers eaten was significantly higher in HF birds than in LF birds before (P < 0.001) and during 48 h of marker excretion (P < 0.02). The time when 50% of the plateau level of excretion of the TiO2 was reached differed significantly among all groups; the shortest time was observed for the HF group (P < 0.05). The results clearly show that feathers increase the speed of feed passage and, in this regard, show similar effects as insoluble fiber. The dietary effect of feathers may be a crucial factor in the development of feather pecking and the related damages to the feather cover in laying hens.

Key words: feather pecking, feather eating, feed passage, cumulative excretion curve

INTRODUCTION

Feather pecking is abnormal behavior in laying hens. It is associated with cannibalism and severe welfare problems (Blokhuis and Wiepkema, 1998). There are various hypotheses on the causation of feather pecking. One of them is that feather pecking in laying hens could be a form of redirected behavior, developing either from feed pecking (Wennrich, 1974), ground pecking (Blokhuis, 1986), or pecking during dust bathing (Vestergaard and Lisborg, 1993). Recent studies have underlined the role of feather eating in the development of feather pecking in laying hens (Harlander-Matauschek and Bessei, 2004; McKeegan and Savory, 1999, 2001). The role of feathers as a feed component is not known. Feathers are considered a nonnutritive matter (McCasland and Richardson, 1966). We hypothesized that feathers may have a similar effect as insoluble fiber. Insoluble fiber stimulates peristaltic activity and hastens feed passage through the digestive tract (Krogdahl, 1986). It has also been found that increased fiber contents improved the feather cover of laying hens because of less feather pecking (Wahlström et al., 1998). This raises the question whether feathers may substitute fiber in low fiber diets conventionally fed to hens to stimulate feed passage. The aim of this experiment was to investigate the effect of self-selected feathers eaten by laying hens on feed passage.

MATERIALS AND METHODS

A total of 48 laying hens were used for this experiment: 24 high feather-pecking birds (H) and 24 low feather-pecking birds (L). These birds (Rhode Island Red) were divergently selected for high and low pulling at a bunch of feathers for 4 generations, which was positively correlated with visually observed feather pecking in the home pen (Bessei et al., 1999). The birds were kept in a deep litter system prior to the experimental situation and were transferred to individual cages, measuring 43 × 43 × 45 cm (length × width × height), at 58 wk of age. The feed trough was placed at the front of the cage and a nipple drinker was placed at the back of the cage. Each cage was supplemented with a perch of 20-cm length. The distance between each cage was 10 cm; therefore, the hens had visual contact, but no physical access, to their neighbors. The hens were kept in a ventilated windowless room at a constant temperature (20°C). Lights were on from 0400...
until 1800 h. Birds were given a commercial pelleted diet and water ad libitum. The experiment started after 2 wk of adaptation to the experimental situation.

Twenty-four H and 24 L were divided into 4 groups: Group HF = 12 H with access to feathers, Group H0 = 12 H without access to feathers, Group LF = 12 L with access to feathers, and Group L0 = 12 L without access to feathers. Thus, the treatment structure was a $2 \times 2$ factorial; factors were feather pecking (H and L) and access to feathers (F and 0). Over a period of 6 wk, we tested the response of each bird to the presentation of downy breast or belly feathers (~4 to 5 cm in length) plucked from dead birds of the same genetic line. Ten feathers were put into a transparent plastic lid (10 x 8 cm), which was fixed next to the feed once every morning (0900 h), 5 times/wk over a period of 3 wk. Subsequently, the number of presented feathers was increased to 20 feathers/d and was given 5 times/wk over a period of 3 wk. Five birds from each group, representing those with the highest feather consumption in the HF group and the lowest feather consumption in the LF group, were used for determining feed passage time with TiO$_2$ (Catalog No. 10080, Merck KG, Darmstadt, Germany) as a marker in the bird’s digesta samples. The birds were deprived of feed for 15 h, and thereafter, 3 gelatin capsules, containing 150 mg of TiO$_2$ each, were given to each hen of the 4 groups. After that, the same pelleted diet as before was fed (ad libitum), and 20 feathers in the transparent plastic lid were offered.

Feces from each cage were collected hourly for the first 8 h and after 10, 24, and 48 h. Feed consumption and the number of feathers eaten were measured 48 h after TiO$_2$ treatment.

**Chemical Analysis**

Feces were pooled per experimental group (H0, HF, L0, LF). Pooling was necessary because of the costly chemical analysis of feces. A valid estimate of error for the pooled samples was obtained based on the deviations from a nonlinear regression described subsequently.

Dry matter of the digesta was determined after drying 1.5 h at 60°C. Twenty-five milliliters of H$_2$SO$_4$ (96%; Catalog No. 109981, Merck KG), 2 mL CuSO$_4$ · 5 H$_2$O (25%; Catalog No. 102784, Merck KG) and 6 g of K$_2$SO$_4$ (Catalog No. 105153, Merck KG) were added to aliquots (0.5 g) of the dried samples. After the solution became clear, the samples were boiled for 3 h. The solutions were poured into 100-mL volumetric flasks through filter paper (Filter Paper No. 594, Merck KG). Two-tenths milliliter of 2 N H$_2$SO$_4$ and 0.2 mL H$_2$O$_2$ (30%; Catalog No. 822287, Merck KG) were added to 1 mL of the filtered solution from each flask. After 30 min, aliquots from the resulting solutions were measured on a spectrophotometer (Model PM 2DL, Zeiss, Oberkirchen, Germany) at 405 nm according to the method described by Brandt and Allam (1987). The average of 2 aliquots of each pooled sample at each time point and for each group was used.

**Statistical Analysis**

Data were subjected to ANOVA using the GLM procedure of SPSS. Means were separated using Student’s t-test, and significance was based on a 5% probability level. Data of TiO$_2$ content from each group were calculated as cumulative fractions of the total amount of TiO$_2$ determined during the 48-h collection.

We fitted the Richards model:

$$y_i = \alpha [1 - \exp(\beta t_i)]^{\gamma} + \epsilon_i$$

where $t_i$ is point in time $i$ (in days), $y_i$ is the response at time $t_i$, and $\alpha$, $\beta$, and $\gamma$ are parameters (Schabenberger and Pierce, 2002). The response curve reaches a plateau value $\alpha$; therefore, this parameter has a direct interpretation. The rate with which this plateau is reached, depends on the parameters $\beta$ and $\gamma$. For inference, it is useful to determine the point in time at which one-half of the plateau value $\alpha$ is reached. This point may be denoted by $\theta_{50}$ and is given by $2^{-1} \alpha = \alpha [1 - \exp(\beta \theta_{50})]^{\gamma}$, which may be rearranged to yield

$$\theta_{50} = \beta^{-1}[\log(1 - 2^{-1/\gamma})].$$

The model was initially fitted by nonlinear least squares using the NLIN procedure of the SAS System (SAS Institute, 1999). We then fitted the same model by Maximum Likelihood using the NL MIXED procedure with parameter estimates of the least squares fit as starting values. This allows estimating parameter contrasts, approximate standard errors, and Wald tests. We specifically estimated contrasts for all pairwise comparisons as well as contrasts for main effects and the interaction pertaining to the 2-factorial structure of the experiment. The standard error for $\theta_{50}$ was computed by the delta method. The model was fitted to all 4 groups simultaneously to obtain a pooled estimate of error and to be able to compare parameter values of different groups. The residuals did not suggest heterogeneity of variance or departure from normality; therefore, a homogeneous variance was assumed. We checked the data (measurements per group and day) for serial correlation of repeated measurements over testing days in the same group (subject) by fitting various spatial covariance structures using the NL MIX macro (Littell et al., 1996). Comparison of Akaike information criterion values suggested a lack of serial correlation, supporting the assumption of independent errors.

**RESULTS AND DISCUSSION**

The HF birds ate a significantly higher number of feathers per day than did the LF birds in the 6-wk period before the TiO$_2$ treatment (9.3 ± 1.5 and 2.3 ± 1.9; $P < 0.001$, respectively) and during the 48 h of marker excretion (9.3 ± 2.2 and 4.5 ± 3.3; $P < 0.02$, respectively). This is in agreement with the results of McKeegan and Savory (2001) according to which feather peckers ate, picked up, and manipulated feathers significantly more frequently than nonpeckers.
The question arises whether testing the highest feather eaters from the H line and the lowest eaters from the L line biases the results when compared with a random sample of birds in the L and H lines. Although the birds from the H line have been shown to differ significantly from the low line in feather eating, there was a considerable overlap among birds of these 2 treatment groups. Not enough birds could be tested to detect significant differences in feed passage time when random samples from each line were taken. Therefore, it was decided to choose the extremes of both lines. This design is expected to yield somewhat larger differences among treatments than in random samples of birds, but the direction of the differences is expected to remain unaltered, thus yielding valid inferences regarding the relative ranking of different treatments. It should be stressed that the diverging selection of 5 extreme birds in different groups (H and L) is just a continuation of the selection that has been exercised from the low line in feather eating, there was a considerable overlap among birds of these 2 treatment groups. Not enough birds could be tested to detect significant differences in feed passage time when random samples from each line were taken. Therefore, it was decided to choose the extremes of both lines. This design is expected to yield somewhat larger differences among treatments than in random samples of birds, but the direction of the differences is expected to remain unaltered, thus yielding valid inferences regarding the relative ranking of different treatments.

The time of 50% Ti excretion ($\tilde{\theta}_{50}$) differed significantly (Table 1) among all groups; the shortest time was observed for the HF birds, followed by H0, L0, and LF birds. For time to 50% of the plateau ($\tilde{\theta}_{50}$), there is both a strong interaction and a pronounced main effect (Table 2) for H vs. L groups. Specifically, high feather-pecking birds are quicker in reaching 50% of the plateau than are low feather-pecking birds. The interaction indicates that the difference in $\theta_{50}$ is significantly higher for birds with access to feathers. Contrasts for the shape parameters ($\beta, \gamma$) are not significant, just reaching significance; therefore, differences for these parameters are less important.

The more rapid feed passage in HF birds could be caused by the physical structure of the feathers eaten. Results by Hetland and Svihus (2001) indicated that physical structure increased grinding activity of the gizzard. It is known that the peristaltic movements throughout the intestine are affected by gizzard activity (Duke, 1986), which could increase digesta flow (Svihus et al., 2002). Increased grinding activity of the gizzard could also explain the rapid feed passage in H0 birds. It has been shown that individually caged H0 birds had a bulk of feathers in their gizzard. This was not found in L0 birds, which indicates that H0 birds eat their own feathers (unpublished data).

Van der Klis and Van Voorst (1993) assumed a more pronounced separation between the solid and liquid phase in the chyme as a consequence of high gizzard activity. They found Cr as a marker in the ceca when indigestible material was added to the diets. The occurrence of the marker in the ceca indicates that Cr in the solid phase was kept for a longer time in the ceca.

Table 1. Maximum likelihood parameter estimates of Richard’s model for 4 groups of laying hens

<table>
<thead>
<tr>
<th>Group</th>
<th>$\alpha^1$ Estimate (SE)</th>
<th>$\beta^2$ Estimate (SE)</th>
<th>$\gamma^3$ Estimate (SE)</th>
<th>$\theta_{50}^3$ Estimate (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF</td>
<td>2.094 (0.045)</td>
<td>-0.920 (0.129)</td>
<td>15.71 (6.76)</td>
<td>3.415 (0.108)</td>
</tr>
<tr>
<td>H0</td>
<td>1.742 (0.053)</td>
<td>-0.673 (0.102)</td>
<td>11.34 (4.75)</td>
<td>1.948 (0.162)</td>
</tr>
<tr>
<td>LF</td>
<td>2.323 (0.062)</td>
<td>-0.456 (0.045)</td>
<td>10.54 (2.79)</td>
<td>6.044 (0.163)</td>
</tr>
<tr>
<td>L0</td>
<td>2.271 (0.058)</td>
<td>-0.630 (0.078)</td>
<td>18.26 (7.30)</td>
<td>5.223 (0.132)</td>
</tr>
</tbody>
</table>

Parameters in a column followed by the same letter are not statistically different at the 5% level according to an approximate Wald test. Letter display was obtained using the method described in Piepho (2004).

$^1$ $\alpha$ = response curve reaches a plateau value (g).

$^2$ $\beta$, $\gamma$ = shape parameters.

$^3$ $\theta_{50}$ = point in time (h) at which one-half of the plateau value $\alpha$ is reached.

$^4$ H = high feather-pecking birds, L = low feather-pecking birds, F = access to feathers, and 0 = no access to feathers.

* Contrast estimates with an asterisk are significant at the 5% level according to a Wald test.

Table 2. Contrasts for parameter estimates of Richards model for 4 groups of laying hens (H = high feather-pecking birds, L = low feather-pecking birds, F = access to feathers, and 0 = no access to feathers)

<table>
<thead>
<tr>
<th>Contrast</th>
<th>$\alpha^1$ Estimate (SE)</th>
<th>$\beta^2$ Estimate (SE)</th>
<th>$\gamma^3$ Estimate (SE)</th>
<th>$\theta_{50}^3$ Estimate (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F vs. 0$^a$</td>
<td>0.202* (0.055)</td>
<td>0.036 (0.094)</td>
<td>-1.68 (5.69)</td>
<td>0.019 (0.143)</td>
</tr>
<tr>
<td>H vs. L$^b$</td>
<td>-0.379* (0.055)</td>
<td>-0.254* (0.094)</td>
<td>-0.88 (5.69)</td>
<td>-1.827* (0.143)</td>
</tr>
<tr>
<td>Interaction$^c$</td>
<td>0.300* (0.110)</td>
<td>-0.422* (0.187)</td>
<td>12.09 (11.37)</td>
<td>-1.604* (0.286)</td>
</tr>
</tbody>
</table>

$^a$ $\alpha$ = response curve reaches a plateau value (g).

$^b$ $\beta$, $\gamma$ = shape parameters.

$^c$ $\theta_{50}$ = point in time (h) at which one-half of the plateau value $\alpha$ is reached.

$^d$ $\theta_{50}$ = point in time (h) at which one-half of the plateau value $\alpha$ is reached.

$^e$ (HF + LF)/2 − (H0 + L0)/2, b: (HF + H0)/2 − (LF + L0)/2, c: HF − H0 − LF + L0.

* Contrast estimates with an asterisk are significant at the 5% level according to a Wald test.
Figure 1. The fitted Richards model for the cumulative excretion curves of TiO$_2$ (g) over a period of 48 h in 4 groups of birds: $H =$ high feather-pecking birds, $L =$ low feather-pecking birds, $F =$ access to feathers, and $O =$ no access to feathers.

The dietary effect of feathers may be a crucial factor in the development of feather pecking and the related damages to the feather cover in laying hens. The results underline the importance of structural insoluble fiber components from feed or environment in high feather-pecking birds.

REFERENCES


