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van Hierden, YM; Korte, SM; Ruesink, EW; van Reenen, CG; Engel, B; Koolhaas, JM; Blokhuis, HJ; Hierden, Yvonne M. van; Reenen, Cornelis G. van; Blokhuis, Harry J.

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The development of feather pecking behaviour and targeting of pecking in chicks from a high and low feather pecking line of laying hens

Yvonne M. van Hierden[a,b,*], S. Mechiel Korte[a], E. Wim Ruesink[a], Cornelis G. van Reenen[a], Bas Engel[a], Jaap M. Koolhaas[b], Harry J. Blokhuis[a]

[a]*Division of Animal Sciences, Institute for Animal Science and Health (ID-Lelystad), P.O. Box 65, NL-8200 AB Lelystad, The Netherlands*

[b]*Department of Animal Physiology, University of Groningen, P.O. Box 14, 9750 AA Haren, The Netherlands*

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Abstract

Large individual differences between adult laying hens in their propensity for feather pecking are known to exist. However, not much research has been carried out into the individual differences concerning the development of feather pecking behaviour. The purpose of this study was to investigate whether contrasting levels of feather pecking, observed among adult birds from two lines of laying hens, already occur at an early age. Furthermore, an important question to be discussed was whether different behavioural systems may be related to the occurrence of feather pecking. Therefore, this study consisted of studying and comparing the behaviour of White Leghorn laying hens from a high (HFP) and low feather pecking line (LFP) during the first 8 weeks of life. Chicks were reared in litter-floor pens and were kept in groups of five animals per line (12 groups per line).

HFP chicks showed significantly higher levels of gentle feather pecking (gentle FP) than LFP chicks at the age of 14 and 28 days. Furthermore, HFP chicks spent significantly more time preening than LFP chicks on days 14, 28 and 41. Duration of foraging behaviour and feeding behaviour was significantly higher in the LFP line compared to the HFP line on days 41 and 56 and days 28, 41 and 56, respectively. HFP chicks showed a significant negative correlation between gentle FP and preening on days 3 ($r = -0.49$) and 41 ($r = -0.86$). In the LFP line duration of feeding correlated negatively with gentle FP on day 3 ($r = -0.63$). A principal component analysis (PCA) revealed that in the HFP line, gentle FP and preening exhibited high and opposite loadings on the same component at all ages, whereas feeding consistently loaded on the other component. This outcome contrasted

* Corresponding author. Tel.: +31-320-238171; fax: +31-320-238094.
E-mail address: y.vanhierden@id.wag-ur.nl (Y.M. van Hierden).

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with that of the LFP line. In this line feeding predominantly loaded on the same principal component as gentle FP, with loadings opposite to those of gentle FP, whereas preening showed the same loadings as gentle FP, on days 3 and 41.

In conclusion, differences in feather pecking behaviour between HFP and LFP chicks can already be observed at a very early age during development. Furthermore, our results indicate that HFP and LFP chicks differ in the way pecking behaviour is targeted. This difference could be related to the existence of a difference in underlying motivational system controlling the development of feather pecking between the two lines.

Keywords: Feather pecking; Chicks; Domestic fowl; Development; Preening; Feeding; Motivational systems

1. Introduction

The occurrence of feather pecking behaviour is, despite years of studying this phenomenon, still rather unpredictable. Feather pecking, ranging from gentle feather pecking (resembling a stereotypy; Kjaer and Vestergaard, 1999) to pulling and removing feathers of conspecifics, causes deterioration of the plumage, injuries and ultimately leads to mortality (cannibalism). Hence, feather pecking negatively affects poultry welfare (Blokhuis and Wiepkema, 1998).

Research has revealed numerous factors contributing to the development of feather pecking (Hughes and Duncan, 1972). These include both animal related (e.g. hormones, genetics) (Hughes, 1973; Kjaer, 1999) and environment related factors, such as light intensity (Allen and Perry, 1975), diet (Hughes and Duncan, 1972), stocking density (Bilcík and Keeling, 2000; Simonsen et al., 1980; Kjaer and Vestergaard, 1999) and availability and quality of floor substrate (Blokhuis, 1986; Huber-Eicher and Wechsler, 1998).

A number of studies indicate that feather pecking can already be observed at a very early age (Hoffmeyer, 1969; Wennrich, 1975) and it is suggested that a relatively short sensitive period ''for getting the right pecking experience'' early in life (Johnsen et al., 1998) is important in the development of this behaviour (Johnsen et al., 1998; Vestergaard, 1994). In recent years, more interest has been directed to the onset of feather pecking and the role of early life experience (i.e. rearing conditions) in the causation and development of feather pecking in a group. For instance, the provision of suitable litter during the rearing phase, is found to substantially reduce feather pecking (e.g. Blokhuis and van der Haar, 1992; Huber-Eicher and Wechsler, 1998).

It has been postulated that feather pecking is a form of re- or misdirected pecking, related to the motivational system of either feeding and foraging (Blokhuis, 1989) or dustbathing (Vestergaard, 1994). According to these theories, exposing chicks to litter early in life would prevent them from perceiving feathers as a substrate for either foraging or dustbathing. However, feather pecking is not eliminated by providing suitable substrates (e.g. Nicol et al., 2001) and, therefore behavioural systems other than dustbathing or feeding may also be linked to the occurrence of feather pecking.

Large and consistent differences in feather pecking are observed between breeds and lines (Bessei, 1986; Hughes and Duncan, 1972; Kjaer and Sørensen, 1997), as well as

between individual birds within flocks of laying hens (Keeling, 1994). Blokhuis and Beutler (1992), reported two strains of White Leghorn layers showing contrasting levels of feather pecking damage. Birds at the age of 24 and 30 weeks (de Jong, unpublished results) and 38 and 41 weeks (Blokhuis and Beuving, 1993) showed significantly higher levels of (gentle) feather pecking behaviour in the so-called high feather pecking line (HFP) compared to the low feather pecking line (LFP).

It is still unclear at which developmental stage LFP and HFP chicks start to show differences in feather pecking. Furthermore, it remains unanswered which motivational systems are involved in the development of feather pecking in either line. It is essential to have a wide knowledge of these issues in order to further unravel the underlying causation of feather pecking. Thus, this study was designed to investigate the development of feather pecking and related behaviour of HFP and LFP chicks during the first 8 weeks of life.

2. Methods

2.1. Birds and housing

In this study, 120 White Leghorn chicks from two strains were obtained from a commercial supplier: 60 LFP and 60 HFP chicks. The two lines originate from different breeding lines and the difference in feather pecking is a coincidental result of a commercial selection program (Korte et al., 1997). All birds were female and non-beak trimmed. Chicks arrived on the day of hatching and were individually marked by a wingtag before housing. From the day of arrival chicks were kept in groups of five animals per line (12 groups per line) and housed in pens (0.75 m × 1.0 m) with wood shavings. Visual contact between chicks in adjacent pens was prevented by hardboard separations between the pens.

Pens were placed in a climate-controlled room. The environmental temperature was lowered from 34 °C on day 1 to 18 °C at 8 weeks of age. On days 1 and 2 of age the light regime was alternately 4 h light and 4 h dark. From 3 days to 8 weeks of age the light regime decreased from an 18 h light to a 10 h light period.

All groups had access to three drinking cups and one square feeding trough placed along one of the walls of the pen. Feeding regimes were those recommended by suppliers of commercial layers, i.e. starter feed (mash) from 0 to 6 weeks; grower feed (mash) from 6 to 8 weeks. Water and a commercial feed were provided ad libitum.

2.2. Behavioural measurements

The behaviour of the birds was studied at the age of 3, 14, 28, 41 and 56 days. On these days all pens were recorded on videotape between 13:00 and 17:00 h for a period of 30 min. At each age two focal birds were randomly chosen from each pen and their behaviour was scored continuously for 30 min per bird using The Observer® 3.0 software (Noldus, Wageningen, The Netherlands). Duration and frequency of the behavioural elements scored are described in Table 1.

Table 1
Ethogram showing the behavioural measurements (posture either standing or sitting)

Behaviour	Definition
Pecking frequencies	
Gentle feather pecking (gentle FP)	Mild pecking at the feathers of conspecific, generally performed in multiple bouts (every single peck is counted as one occurrence)
Severe feather pecking	Vigorous pecking/pulling/pinching at the feathers of conspecific
Aggressive pecking	Forceful and rapid singular pecks (mainly) at the head of conspecific (or other parts of the facial region)
Comb pecking	Pecking at the comb of a conspecific
Cage pecking	Pecking at the walls of the cage
Other frequency	
Ground scratching	Bird, alternately, makes backward strokes with both legs in the litter as part of foraging behaviour (every stroke is recorded as one occurrence)
Duration	
Feeding (FEED)	Pecking at food in trough
Foraging (FORAG)	Pecking at the litter and scratching (separately scored as ground scratching) or moving with the head in a lower position than the rump
Preening (PREEN)	Preening behaviour as described by Kruijt (1964): e.g. autopecking, nibbling, stroking, combing, head-rubbing
Walking (WALK)	Walking, running, jumping or flying (it may be accompanied by wing-flapping)
Dustbathing	Sitting and performing: vertical wing-shaking, body shaking, litter pecking and/or scratching, bill raking, side and head rubbing
Resting (REST)	Sitting or standing inactive (no movement of the legs)

2.3. Statistical analysis

For behaviour, initially, averages of the observations for the two randomly chosen birds per cage were analysed. First, separate analyses per age were performed. HFP and LFP lines were compared with Wilcoxon's two-sample test (Mann–Whitney test; Conover, 1980) applied to rank numbers of the data. Second, all ages were compared pairwise. For each pair, the difference between the means at the two ages was calculated for each cage. Wilcoxon's two-sample test was applied on these differences to compare HFP and LFP lines. A significant result indicates an interaction between lines and ages, i.e. age effects for the two lines differ. The test will show which line has the largest age effect. A non-significant result was taken as an indication that a main effects model would apply. In the first instance, as a follow-up, Wilcoxon's signed rank test (Wilcoxon's matched pairs test; Conover, 1980) was applied to the differences for the HFP and LFP lines separately. This way it can be checked whether age effects within lines differ from 0. In addition, parametric tests were performed per age with a generalised linear model, with a logit link for fractions and a logarithmic link for counts, and a multiplicative overdispersion parameter in the binomial and Poisson variance functions, respectively. The parameters were estimated by maximum quasi-likelihood, the overdispersion parameters were estimated from Pearson's chi-square statistic. Tests were performed with the maximum quasi-likelihood ratio statistic. Details may be found in McCullagh and Nelder (1989). Pairwise comparisons between ages were made with a generalised linear mixed model, including random effects

for cages, according to methodology presented in Engel and Keen (1994). Because of the complicated correlation structure between observations, no analysis was performed on all data with all ages in one model. The parametric and non-parametric analyses basically produced the same results and only results from the more simple rank tests will be discussed.

To study the relationship between pairs of variables individual observations per animal were used. At each age, two different, but related, approaches were followed. First, correlations were calculated between (Pearson) residuals saved from separate analyses of the variables with fixed cage effects. These correlations can be interpreted as pooled correlations within lines and cages. Second, one of the variables was added as a covariate to the generalised linear mixed model for the other variable. Tests where performed to see whether the coefficient of the additional covariable significantly depended on the lines and differed from zero.

To visualise the correlations structures per line and age between the behavioural parameters, separate principal component analysis (PCA) were performed. Variables were expressed in terms of the first two principal components in biplots. Each of these components is a linear combination of the variables gentle FP, foraging, feeding, preening, walking and resting. All statistical calculations were done in Genstat 5® (1993, 1997). Differences or correlations were considered significant if $P < 0.05$.

3. Results

3.1. Mean levels of behavioural elements

Significant age by line interactions ($P < 0.05$) were found for gentle FP, severe feather pecking, foraging, feeding, preening and walking (Fig. 1). Fig. 1A shows that HFP chicks displayed significantly more gentle FP than LFP chicks, at the age of 14 and 28 days. Levels of severe feather pecking (Fig. 1B), although quite low in either line, tended to be higher in HFP birds on 41 days of age. Duration (i.e. percentage of total observation time) of foraging behaviour (Fig. 1C) was significantly higher in the LFP line compared to the HFP line on days 41 and 56 of age.

Feeding behaviour (Fig. 1D) was significantly higher in the LFP line compared to the HFP line. The time spent feeding was higher on days 28, 41 and 56 of age. HFP chicks spent significantly more time preening (Fig. 1E) than LFP chicks on days 14, 28 and 41 and tended to on days 3 and 56 of age.

LFP spent more time walking than HFP birds (Fig. 1F), on days 28 ($P < 0.01$) and 41 ($P = 0.07$). LFP chicks showed significantly shorter duration of resting behaviour than HFP chicks, on days 28 ($28.18 \pm 2.52\%$ versus $46.86 \pm 4.34\%$; $P < 0.001$), 41 ($32.68 \pm 1.81\%$ versus $46.32 \pm 3.24\%$; $P < 0.001$) and 56 ($34.64 \pm 2.92\%$ versus $48.12 \pm 3.82\%$; $P < 0.01$) of age.

HFP birds pecked significantly ($P < 0.05$) more at the comb of a conspecific than LFP birds, on 14 days (2.25 ± 1.06 versus 0.12 ± 0.09) and 56 days of age (5.87 ± 1.94 versus 2.08 ± 0.71). No significant line or age differences were found for aggressive pecking (the overall level was 1.75 ± 0.211) and cage pecking (overall 8.22 ± 0.97). No significant line

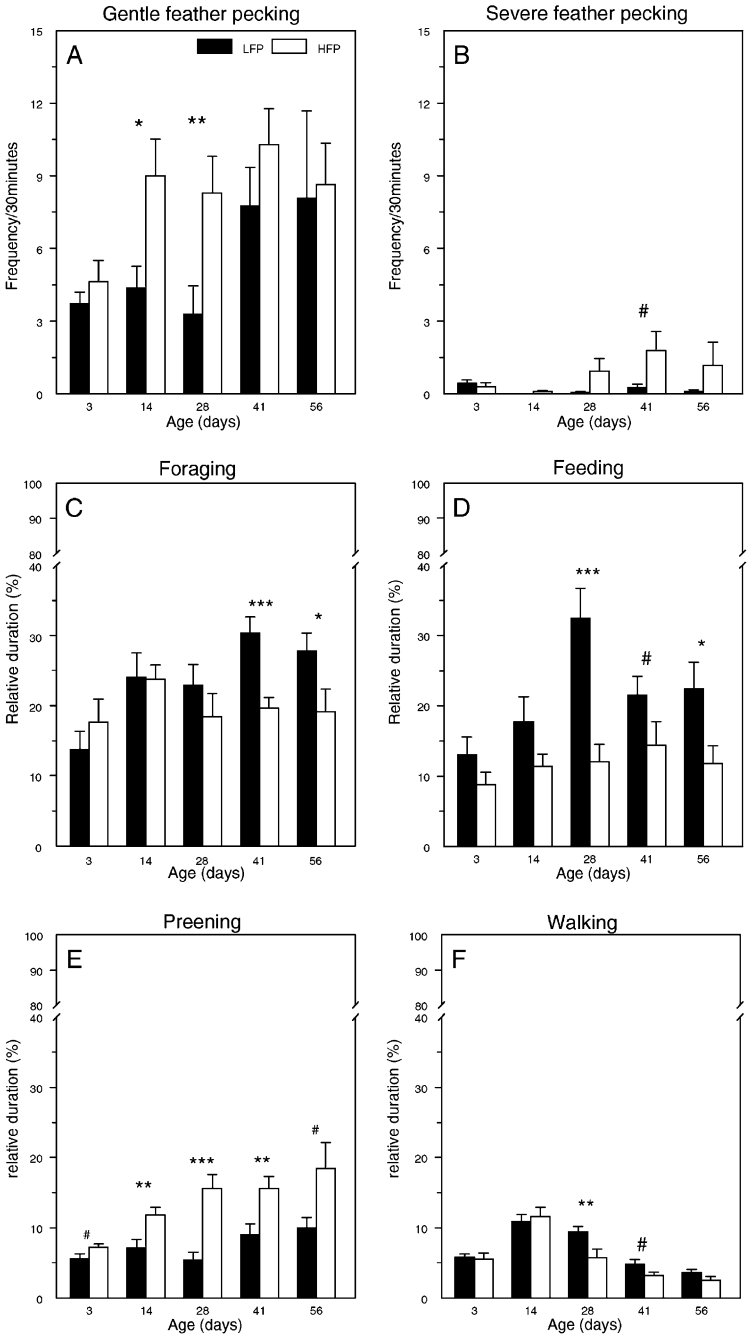

Fig. 1. Frequency or relative duration (percentage of the total observation time) of behaviour of LFP and HFP chicks on days 3, 14, 28, 41 and 56 of age (levels expressed as mean ± S.E.M.). $^{***}P < 0.001$, $^{**}P < 0.01$, $^{*}P < 0.05$, $^{\#}0.05 < P < 0.08$.

or age effects were found for ground scratching behaviour (overall 15.6 ± 1.95). Levels of dustbathing behaviour were close to zero in either lines, and no significant line or age differences were found.

3.2. Correlations and PCA

To examine whether the observed differences in the development of feather pecking behaviour between the two lines can be attributed to different underlying motivational systems, the frequency of gentle FP was correlated with the duration of several behavioural elements. In addition, using the same behavioural elements, a PCA was performed to summarise the correlation matrix and to further substantiate the possible existence of a common underlying factor.

Table 2
Pearson correlations (r) between gentle feather pecking and foraging, feeding, preening, walking and resting in LFP and HFP chicks on days 3, 14, 28, 41 and 56 of age

	Gentle feather pecking		
	Age (days)	LFP	HFP
Foraging	3	0.15	−0.34
	14	0.45*	0.26
	28	0.16	0.15
	41	0.02	0.34
	56	0.18	−0.32
Feeding	3	−0.63**	−0.06
	14	−0.24	−0.08
	28	−0.28	−0.18
	41	−0.35[a]	0.15
	56	−0.22	−0.11
Preening	3	0.27	−0.49***
	14	−0.01	−0.33
	28	0.02	−0.16
	41	0.16	−0.86**
	56	0.14	−0.30
Walking	3	−0.26	−0.36[a]
	14	0.26	0.59***
	28	0.35[a]	0.44*
	41	0.26	−0.32
	56	−0.28	−0.12
Resting	3	0.23	0.50*
	14	−0.26	−0.21
	28	0.32	0.18
	41	0.71**	0.54***
	56	0.42*	0.08

[a] $0.05 < P < 0.10$.
* $P < 0.05$.
** $P < 0.001$.
*** $P < 0.01$.

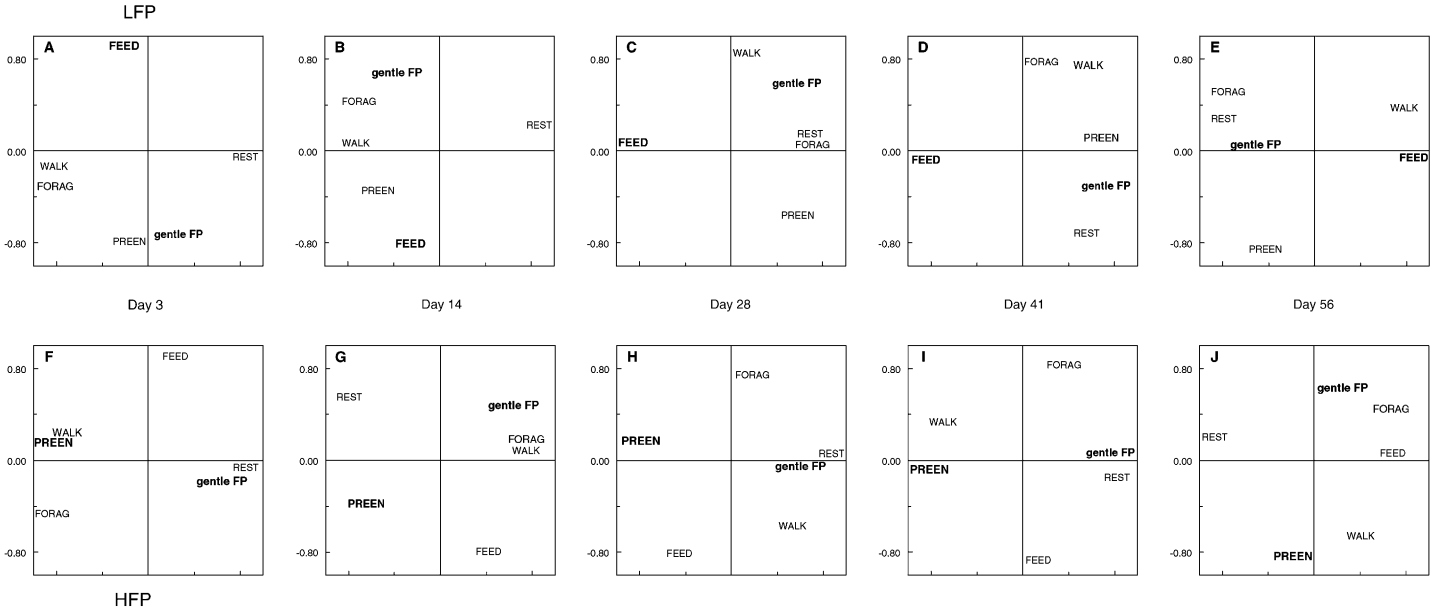

Fig. 2. Distribution of behavioural parameters in relation to the first two components of a principal component analysis achieved from behavioural observations of LFP and HFP chicks on days 3, 14, 28, 41 and 56 of age. Each abbreviation of a behavioural parameter indicates the mean position of this behavioural parameter in relation to the first two components. Each behavioural parameter (see for description Table 1) has a specific loading on both the *X*- and *Y*-axis.

Table 2 presents Pearson correlations between gentle FP and foraging, feeding, preening, walking and resting. No correlations are shown for severe feather pecking and dustbathing behaviour because of the very low levels for these behavioural elements.

Foraging behaviour showed no clear correlation with gentle FP. Only on day 14 a significant positive correlation was found in the LFP line. In the LFP line duration of feeding correlated negatively with gentle FP on days 3 and 41 of age. Resting behaviour correlated positively on days 41 and 56 in the LFP line and also positively in the HFP line on days 3 and 41. In HFP chicks a significant negative correlation was found between gentle FP and preening on days 3 and 41. Walking correlated negatively on day 3 but positively on days 14 and 28 in this line.

The first two principal components explained 77, 67, 65 and 72% of the variation for ages 3, 14, 28, 41 and 56, respectively for the LFP line and 78, 65, 64, 75 and 63% for the HFP line. In Fig. 2, for each line and age, the five behavioural parameters are expressed in terms of the first two components and presented in a biplot. These plots are a visualisation of the correlation structure. For instance, the high and opposite loadings for gentle FP and preening (PREEN) for the HFP line were consistent with the moderate to high negative correlations between these variables in Table 2. The fact that gentle FP hardly correlated with feeding (FEED) for HFP chicks is consistent with the latter parameter always loading on the other component (Fig. 2F–J). In contrast to the HFP line, for LFP chicks, FEED predominantly loaded on the same component as gentle FP, with opposite loadings, while PREEN had similar loadings as gentle FP at 3 and 41 days of age (Fig. 2A and D). Thus, at each age, the principal component with a high loading for gentle FP was differently associated with PREEN and FEED in HFP and LFP chicks, respectively.

4. Discussion

4.1. The development of behaviour and targeting of pecking

In the present study, we investigated the development of feather pecking and related behaviour in chicks of the LFP and HFP line. HFP chicks appear to have a higher ''drive'' in performing feather directed behaviour than LFP chicks, as shown by the higher levels of gentle FP and preening behaviour in HFP chicks at several points in time during the first 8 weeks of development. LFP chicks showed more interest in exploring and pecking the environment, i.e. were more engaged in pecking feed and litter. Thus, the essential difference in pecking behaviour between the two lines may not be a difference in the propensity to peck per se, but in the way pecking is targeted.

Interesting in this regard is a study by Braastad (1990), which shows that targeting of pecking behaviour can be influenced during early development. In that study, chicks were exposed to blue-dyed food during the first 6 days post-hatching (i.e. the sensitive period for food imprinting according to Hess, 1964), and then provided with blue key-stimuli on the floor as adult birds. These hens pecked more at the floor and showed significantly less preening and a better plumage (possibly indicating less feather pecking) than other birds.

4.2. Gentle feather pecking and preening behaviour in HFP chicks

On the individual level preening behaviour was inversely related to gentle FP in the HFP line but not in the LFP line. Preening behaviour appears to be influenced by the same environmental factors as feather pecking (Aerni et al., 2000; Blokhuis, 1986). Aerni et al. (2000) recorded preening significantly more often in pens without straw than with straw and more often in hens fed on pellets than in hens fed on mash. Savory and Mann (1997) found that in several strains of laying hens, an increase in feather pecking on a group level coincided with an increase in preening during development. They suggested that there may be an element of allopreening in feather pecking and that increased attention towards a bird's own plumage may be associated with increased attention towards other birds' plumage as well. Blokhuis (1986) suggested that a certain basal level of pecking at conspecifics exists that is not controlled by the ground pecking system, and that this feather pecking may therefore be considered exploratory behaviour or allopreening (Harrison, 1965).

Roden and Wechsler (1998) observed that preening chicks sometimes started to peck at the feathers of neighbouring birds, possibly not differentiating between their own and the feathers of other birds. Unfortunately, their studies did not provide information about a correlation between feather pecking and preening.

We hypothesise here that HFP chicks that spent less time pecking and manipulating their own feathers (i.e. preening), may have redirected these pecks towards the feathers of penmates.

4.3. Gentle feather pecking and feeding behaviour in LFP chicks

In the LFP line gentle FP was not related to preening. LFP chicks showed higher levels of foraging and feeding behaviour. This finding seems in agreement with the hypothesis of Blokhuis (1989), that feather pecking is a form of re- or misdirected pecking, under the control of the feeding system. However, in the LFP line, on the individual level, gentle FP was inversely related to feeding but not to foraging. An explanation could lie in the ethogram used in this study, in which the scoring of feeding was restricted to the feeding trough and the scoring of foraging and scratching was restricted to the litter. However, the feeding trough was large enough for very young chicks to get into completely (and most of them did during feeding), and we observed a lot of scratching in the food during feeding, a behaviour associated with foraging. Therefore, it is likely that part of the behaviour scored as feeding, did not actually involve feed intake, but was in fact foraging or exploratory pecking behaviour, intended to gather information about the food and not primarily to ingest it. Chicks do spend a considerable amount of time pecking at their food without eating (Fujita, 1973).

The feeding system of chicks is not fully developed at the time of hatching and during the first days of life pecking at food is not motivated by hunger as the presence of yolk sac reserves makes food ingestion totally unnecessary (Goodwin and Hess, 1969). Most pecks made in that period of time are of an exploratory nature (Vestergaard, 1994), serving no other immediate function than information gathering.

Hence, we argue that young LFP chicks that spent less time pecking exploratively at the food (scored as feeding) may have redirected these exploratory pecks to the feathers of conspecifics.

4.4. Gentle feather pecking and severe feather pecking

The present observation of feather pecking behaviour from the age of 3 days post-hatching in both lines, agrees with findings of, e.g. Hoffmeyer (1969) and Wennrich (1975).

HFP and LFP chicks only differed in gentle FP on days 14 and 28 of age. Previous studies (Blokhuis and Beuving, 1993; de Jong, unpublished results) on adult birds from the same experimental lines report consistent higher levels of gentle FP in the HFP line compared to the LFP line, suggesting that the difference between chicks in the present study is not merely reflecting a difference in developmental rate.

In the present experiment, the nature of the observed feather pecking was primarily gentle. Levels of severe feather pecking were generally low, possibly due to experimental conditions of low stocking density and availability of litter. A question of particular relevance for practical husbandry is whether birds showing high levels of gentle FP at an early age, may be more predisposed to becoming severe feather peckers later on. Further research is needed in which individual chicks are monitored from day 1 post-hatching to adulthood.

The associations between gentle FP and other behavioural elements demonstrated in the present study may not be of any relevance to the development of severe feather pecking. It has been suggested that gentle and severe feather pecking originate from different motivational systems (Kjaer and Vestergaard, 1999). The motor pattern of gentle FP resembles that of stereotypic pecking (Kjaer and Vestergaard, 1999) and is quite different from the motor pattern of severe feather pecking. However, in this study, severe feather pecks were always embedded within bouts of gentle FP (data not shown), providing support for the recent suggestion by Kim-Madslien (2000) that ‘‘gentle and severe feather pecking represent different extremes of the same behavioural continuum’’, rather than two separate behaviours. Unfortunately, in the present study levels of severe feather pecking were too low to allow a reliable estimation of correlations between severe feather pecking and other behavioural elements, as was done for gentle FP.

4.5. Summary and conclusions

In summary, this study indicates that in HFP birds preening and gentle FP are negatively associated, with chicks either performing a relatively high level of preening together with a relatively low level of gentle FP, or vice versa. In LFP chicks gentle FP is negatively associated to feeding. Results from the PCA substantiate differences between lines concerning the way various behavioural elements relate, in particular gentle FP, preening and feeding. The correlations of feeding and preening with those principal components with high loadings for gentle FP were profoundly different for the HFP and LFP line, respectively. From the assumption that a principal component with a high loading for gentle FP reflects an underlying factor related to the propensity to engage in (gentle) feather pecking, we suggest that the motivational system controlling the

performance of (gentle) feather pecking may differ as to the genetical background (HFP versus LFP).

Hence, we argue that young HFP chicks are more predisposed to direct (exploratory) pecks at animate stimuli, whereas LFP chicks are more predisposed to direct (exploratory) pecks at inanimate environmental stimuli. We hypothesise that due to this difference, feather pecking, starting off as ''normal'' exploratory pecking, may turn out to be controlled by different motivational systems in both lines. Further research is necessary to test this hypothesis.

This supposition might be an explanation as to how feather pecking develops in both lines. However, it does not account for the difference in the frequency of gentle FP between the two lines. Korte et al. (1997, 1999) showed that the behavioural and physiological characteristics of adult HFP and LFP birds resemble those of the so-called proactive and reactive coping strategy, respectively. Proactive individuals are more intrinsically driven and more prone to develop behavioural routines, whereas reactive individuals react more to environmental stimuli (Koolhaas, 1999). Feather pecking may well be an example of such a routine-like behaviour. In future experiments, we will investigate whether differences in behavioural, physiological and neurobiological (coping) characteristics between chicks may account for the differences in the frequency of feather pecking, not only in these experimental lines but also in commercial lines.

In conclusion, differences in feather pecking behaviour between HFP and LFP chicks can already be observed at a very early age during development. Furthermore, our results indicate that HFP and LFP chicks differ in the way pecking behaviour is targeted. This difference could be related to the existence of a difference in underlying motivational system controlling the development of feather pecking between the two lines.

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