Literature Featherpecking - Risk factors - bird related

Bestman, M., et al. (2009). "Influence of farm factors on the occurrence of feather pecking in organic reared hens and their predictability for feather pecking in the laying period." Applied Animal Behaviour Science **121**(2): 120-125.

Feather pecking is one of the most obvious welfare problems in laying hens. It is seen in all types of housing systems. Although banned in some countries, beak trimming is generally used to reduce the damage caused by this behaviour. In organic farming, where beak trimming is prohibited, the animals are being kept in a less intensive way than in conventional farming in order to improve their welfare. However, feather pecking is also seen in organic laying hens. Generally, rearing circumstances play an important role in the development of this behaviour. Therefore, rearing flocks were monitored for feather pecking and the relations between rearing factors and feather pecking at a young and at an adult age were analysed. Also the correlation between feather pecking during the rearing period and feather pecking during adult life was studied. Twenty-eight commercial flocks of rearing hens were monitored. These flocks split into 51 flocks of laying hens. Flocks were scored for signs of feather damage during rearing at the ages of 7, 12, and 16 weeks and on the laying farms at 30 weeks. On the rearing as well as the laying farm, data were collected on the housing system. Logistic regression was used to analyse our data. Feather damage was seen in 13 out of 24 (54%) of rearing flocks. Logistic regression showed that a higher number of pullets being kept per square meter in the first 4 weeks of life were associated with feather damage during the rearing period (Chi square = 8.49, df = 1, p = 0.004). Moreover, the combination of not having litter at the age of 1-4 weeks and the absence of daylight at the age of 7-17 weeks was a significant predictor of feather damage during the laying period (Chi square = 13.89, df = 4. p = 0.008). In 71% of the cases that pullets did not show feather pecking damage during rearing, they did not show feather pecking damage in the laying period either. When flocks of pullets did show feather damage, in 90% of the cases they did so during adult life. These results lead to suggestions on how to improve the rearing conditions of laying hens and increase their welfare not only during rearing but also during later life. Although the observations were done on organic farms, the results can be applied for other non-cage systems too.

Brunberg, E., et al. (2011). "Feather pecking behavior in laying hens: Hypothalamic gene expression in birds performing and receiving pecks." Poultry Science **90**(6): 1145-1152.

Feather pecking (FP) is a welfare and economic problem in the egg production sector. Beak trimming, the current method used to reduce FP, is also criticized. The present study used gene expression to explore the biological mechanisms underlying this behavior, which could lead to a greater understanding of the cause and a tool to mitigate the problem. White Leghorn hens performing and receiving FP, as well as neutral control birds, were identified on a commercial farm. Hypothalamic RNA from 11 peckers, 10 victims, and 10 controls was hybridized onto GeneChip Chicken Genome Arrays (Affymetrix Inc., Santa Clara, CA) to compare gene expression profiles in the different groups. Eleven transcripts corresponding to 10 genes differed significantly between the 3 groups (adjusted $P < 0.05$). Eight of these transcripts differed in the peckers compared with the controls, 1 was upregulated in the victims compared with the controls, and 6 differed significantly in the peckers compared with the victims. Additionally, 5 transcripts showed a trend (adjusted $P < 0.1$) to differ in the pecker-victim comparison. Some of the products of the differently expressed genes are involved in disorders, such as intestinal inflammation and insulin resistance, which fit well with the previously proposed hypothesis that FP is an abnormal foraging behavior. Other findings may also support the proposal that FP is linked to immune mechanisms and may serve as an animal model for obsessive compulsive disorder in humans. In conclusion, this study provides a gene list that may be useful in further research on the mechanisms behind FP.

Buitenhuis, A. J. and J. B. Kjaer (2008). "Long term selection for reduced or increased pecking behaviour in laying hens." Worlds Poultry Science Journal **64**(4): 477-487.

Feather pecking in laying hens is an important issue in animal welfare. Four studies in laying hens were selected which investigated increased or reduced pecking behaviour using direct or indirect measures of feather pecking behaviour. Direct comparison of the selected experiments is difficult, as the selection criteria and even the selection procedures varied. Keeping these differences in mind, the results of the experiments showed that a) It is possible to change pecking behaviour in the desired direction using selection, b) Aggressive pecking is not related to feather pecking, c) There is no clear consensus as to the relation between selection on pecking behaviour and laying performance and egg quality, d) Plasma serotonin level in the blood was reduced in the lines selected against pecking behaviour in both the individual selected lines and the group selected lines and there were indications that dopamine also plays a role in the regulation of pecking behaviour, and finally e) There are differences between the selected lines and their control lines with regard to the immune parameters both in the individual selected lines as the group selected lines, indicating that direct as well as indirect selection for reduced pecking behaviour changes the immune response.

Buitenhuis, A. J., et al. (2006). "Altered circulating levels of serotonin and immunological changes in laying hens divergently selected for feather pecking behavior." Poultry Science **85**(10): 1722-1728.

The aim of this study was to investigate the changes in immunological parameters as well as changes with respect to plasma levels of serotonin and tryptophan in lines selected for and against feather pecking (FP) behavior [high FP (HP) line and low FP (LP) line] for 5 generations. The hens from the HP line had a higher plasma serotonin level than those from the LP line (0.059 VS. 0.037 mu mol/L, F-2,F-27 = 0.031, P < 0.05). The plasma level of tryptophan was, on average, 67.30 mu mol/L and did not differ between the lines (68.3 vs. 66.3 mu mol/L, F-2,F-28 = 0.36, P > 0.05). The HP line had a higher response to infectious bursal disease virus vaccination after 1 wk post-vaccination compared with the control and LP lines. The number of white blood cells (P < 0.0001) and the expression of MHC class I molecules on CD4 (P < 0.02), CD8 beta (P < 0.006) and on B cells (P < 0.03) were highest in the LP line compared with the control and HP lines. Selection for or against FP, therefore, changes the number of white blood cells and the expression of MHC class I molecules on T and B cells, which may influence the health status of the birds.

Buitenhuis, B., et al. (2009). "Differentially expressed genes for aggressive pecking behaviour in laying hens." Bmc Genomics **10**.

Background: Aggressive behaviour is an important aspect in the daily lives of animals living in groups. Aggressive animals have advantages, such as better access to food or territories, and they produce more offspring than low ranking animals. The social hierarchy in chickens is measured using the 'pecking order' concept, which counts the number of aggressive pecks given and received. To date, little is known about the underlying genetics of the 'pecking order'. Results: A total of 60 hens from a high feather pecking selection line were divided into three groups: only receivers (R), only peckers (P) and mixed peckers and receivers (P&R). In comparing the R and P groups, we observed that there were 40 differentially expressed genes [false discovery rate (FDR) P < 0.10]. It was not fully clear how the 40 genes regulated aggressive behaviour; however, gene set analysis detected a number of GO identifiers, which were potentially involved in aggressive behavioural processes. These genes code for synaptosomes (GO: 0019797), and proteins involved in the regulation of the excitatory postsynaptic membrane potential (GO: 0060079), the regulation of the membrane potential (GO: 0042391), and glutamate receptor binding (GO: 0035254). Conclusion: In conclusion, our study provides new insights into which genes are involved in aggressive behaviours in chickens. Pecking and receiving hens exhibited different gene expression profiles in their brains. Following confirmation, the identification of differentially expressed genes may elucidate how the pecking order forms in laying hens at a molecular level.

Cheng, H. W. and W. M. Muir (2007). "Mechanisms of aggression and production in chickens: genetic variations in the functions of serotonin, catecholamine, and corticosterone." Worlds Poultry Science Journal **63**(2): 233-254.

The neuroendocrine systems, such as dopamine (DA) and serotonin (5- HT) as well as corticosterone (CORT), are involved in regulating behavioural patterns and reproduction in humans and other mammals. Similar functions of neuroendocrine system may present in laying hens. To test the hypothesis, two divergent chicken lines were used in the study. Each line has distinct levels of aggressiveness and productivity at a group setting and exhibits differen susceptibility to various environmental stressors. We found that, at 21 wks of age, LGPS (Low Group Productivity and Survivability) birds had significantly higher blood concentrations of DA and epinephrine than the KGB birds (Kind Gentle Birds, also previously termed HGPS, birds with a High Group Productivity and Survivability) (P< 0.01, respectively). The blood concentration of norepinephrine was not significantly different between the lines but the ratio of epinephrine to norepinephrine was higher in LGPS birds (P< 0.01). The blood concentration of 5- HT was also significantly higher in LGPS birds compared to KGB birds (P< 0.01). In contrast, KGB birds tended to have a higher level of blood CORT (P= 0.1). The results suggest that genetic selection for productivity and survivability with domestic behaviours alters the birds' neuroendocrine homeostasis. The selection-associated plasticity of the neuroendocrine system in controlling animal aggression and productivity were discussed in the article.

Chow, A. and J. A. Hogan (2005). "The development of feather pecking in Burmese red junglefowl: the influence of early experience with exploratory-rich environments." Applied Animal Behaviour Science **93**(3-4): 283-294.

This study examines the development of feather pecking and its relationship to exploration in Burmese red junglefowl (Gallus gallus spadiceus). Ten groups of four chicks each were raised from hatching on wire mesh floors (home pen). Two of the four chicks in each group received experience in exploratory-rich environments four times a week for 5 weeks, and the other two chicks remained in the home pen. Observations conducted in the home pen revealed that chicks deprived of experience in exploratory-rich environments performed significantly more gentle feather pecking, and tended to show more severe feather pecking than the experienced birds. Experience in the exploratory-rich environments did not affect the frequency of environmental pecking or food pecking. These results suggest that chicks deprived of exploratory-rich environments may come to perceive pen mates as appropriate exploratory stimuli and subsequently direct exploratory behavior toward conspecifics. This tendency to peck pen mates may lead to the development of feather pecking. We suggest that forceful pecks may be reinforcing, and that the more likely pecks are directed to a conspecific, the more likely feather pecking will develop. (c) 2005 Elsevier B.V. All rights reserved.

de Haas, E. N., et al. (2014). "Parents and Early Life Environment Affect Behavioral Development of Laying Hen Chickens." Plos One **9**(3): e90577. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3948370/.

Severe feather pecking (SFP) in commercial laying hens is a maladaptive behavior which is associated with anxiety traits. Many experimental studies have shown that stress in the parents can affect anxiety in the offspring, but until now these effects have been neglected in addressing the problem of SFP in commercially kept laying hens. We therefore studied whether parental stock (PS) affected the development of SFP and anxiety in their offspring. We used flocks from a brown and white genetic hybrid because genetic background can affect SFP and anxiety. As SFP can also be influenced by housing conditions on the rearing farm, we included effects of housing system and litter availability in the analysis. Forty-seven rearing flocks, originating from ten PS flocks were followed. Behavioral and physiological parameters related to anxiety and SFP were studied in the PS at 40 weeks of age and in the rearing flocks at one, five, ten and fifteen weeks of age. We found that PS had an effect on SFP at one week of age and on anxiety at one and five weeks of age. In the white hybrid, but not in the brown hybrid, high levels of maternal corticosterone, maternal feather damage and maternal whole-blood serotonin levels showed positive relations with offsprings' SFP at one week and offsprings' anxiety at one and five weeks of age. Disruption and limitation of litter supply at an early age on the rearing farms increased SFP, feather damage and fearfulness. These effects were most prominent in the brown hybrid. It appeared that hens from a brown hybrid are more affected by environmental conditions, while hens from a white hybrid were more strongly affected by parental effects. These results are important for designing measures to prevent the development of SFP, which may require a different approach in brown and white flocks.

de Haas, E. N., et al. (2010). "Selection on feather pecking affects response to novelty and foraging behaviour in laying hens." Applied Animal Behaviour Science **124**(3-4): 90-96.

Feather pecking (FP) is a major welfare problem in laying hens, influenced by multiple factors. FP is thought to be redirected foraging behaviour, however fearful birds are also known to be more sensitive to develop FP. The relationship between fear-responses, foraging and FP is not well understood, therefore we studied the behaviour of 16 birds from a high feather pecking (HFP) line and 16 birds from a low feather pecking (LFP) line at 35 weeks of age inside a plus-maze. Birds were from the 10th generation of selection for either high or low FP. First exposure to the maze was used to measure birds' fear-responses to a novel barren environment. Hereafter, birds were trained three times in the maze with four different food-items that were offered in one of the four arms (i.e. regular food-pellets, feathers, grass, and mealworms hidden in wood-shavings). On the fifth day, birds were tested in the maze for 10 min during which they could choose to eat from all available food-items. When exposed for the first time in the maze HFP birds walked a longer distance, vocalized sooner and had more exploratory pecks compared to LFP birds who showed more wing-movements and defecations. When given a choice of food inside the maze both lines preferred eating worms, but HFP birds had more worm-eating bouts and ate faster than LFP birds. The results of this study indicate that HFP birds respond actively to fear-eliciting situations, which may originate from a proactive coping style. Instead of a clear preference for eating feathers, this study supports earlier findings that HFP birds have a stronger pecking motivation than LFP birds.

Drake, K. A., et al. (2010). "Influence of rearing and lay risk factors on propensity for feather damage in laying hens." British Poultry Science **51**(6): 725-733.

1. Feather pecking is one of the major problems facing the egg industry in non-cage systems and is set to become even more of an issue with the European Union ban on the keeping of laying hens in barren battery cages which comes into force in 2012 and the prospect of a ban on beak-trimming. Reducing feather pecking without resorting to beak treatment is an important goal for the poultry industry. 2. We report here a longitudinal study that included over 335 500 birds from 22 free range and organic laying farms. Accelerated failure time models and proportional hazards models were used to examine the effects of a wide range of factors (management, environment and bird) on development of substantial feather damage in lay. Particular emphasis was placed on risk factors during rear and on practices that could feasibly be changed or implemented. 3. The age at which a flock exhibits substantial feather damage could be predicted both by factors in the environment and by early symptoms in the birds themselves. Factors that were associated with earlier onset of severe feather damage included the presence of chain feeders, raised levels of carbon dioxide and ammonia, higher sound and light levels, particularly in younger birds. Increased feather damage (even very slight) in birds at 17-20 weeks of age was also highly predictive of the time of onset of severe feather damage during lay. Increased feed intake also indicated that a flock was at risk of early severe feather damage. 4. Birds that stayed on the same farm for rearing and lay showed later onset of serious feather damage than those that experienced a change in farm from rearing to lay. However, an increased number of changes between rearing and lay (feeder type, drinker type, light intensity etc) was not associated with earlier onset of serious feather damage. Further research needs to be done on the role of the transition from rearing to lay as a risk factor for FP in lay.

Flisikowski, K., et al. (2009). "Variation in neighbouring genes of the dopaminergic and serotonergic systems affects feather pecking behaviour of laying hens." Animal Genetics **40**(2): 192-199.

Feather pecking is a behavioural disorder of laying hens and has serious animal welfare and economic implications. One of the several aetiological hypotheses proposes that the disorder results from redirected exploratory behaviour. Variation in the gene encoding the dopamine D4 receptor (DRD4) has been shown to be associated with exploratory behaviour in several species, including in a passerine bird species. We therefore considered DRD4 as a candidate gene for feather pecking. We have annotated DRD4 in the chicken genome and have re-sequenced it in 140 animals belonging to: experimental layer lines divergently selected for high and low propensity to feather pecking; the

unselected founder population; and two commercial lines with low and high propensity to feather pecking. We have identified two sub-haplotypes of DRD4 that are highly significantly associated with feather pecking behaviour in the experimental (P = 7.30 x 10(-7)) as well as in the commercial lines (P = 2.78 x 10(-6)). Linkage disequilibrium (LD) extends into a neighbouring gene encoding deformed epidermal autoregulatory factor 1 (DEAF1). The product of DEAF1 regulates the transcription of the gene encoding the serotonin (5-hydroxytryptamine) 1A receptor. Thus, DEAF1 represents another candidate gene for feather pecking. Re-sequencing of five animals homozygous for the 'low-pecking' sub-haplotype and of six animals homozygous for the 'high-pecking' sub-haplotype delineated an LD block of 14 833 bases spanning the two genes. None of the variants in the LD block is obviously functional. However, the haplotype information will be useful to select against the propensity to feather pecking in chicken and to elucidate the functional implications of the variants.

Gilani, A.-M., et al. (2013). "The effect of rearing environment on feather pecking in young and adult laying hens." Applied Animal Behaviour Science **148**(1–2): 54-63.

Abstract Although the rearing period has an important influence on the development of feather pecking in laying hens, few studies have quantified the risk factors operating on commercial farms during this time and identified their long-term impact. Our aim was to conduct a longitudinal study to investigate the effect of rearing environment on feather pecking in young and adult laying hens. Thirty-four flocks from 29 rearing farms were recruited and visited at the beginning, middle and end of the rearing period and once at lay (35 weeks). Twelve flocks were beak trimmed. Information on rearing environment was used to create models predicting feather pecking and plumage damage during rear and lay, using the multilevel statistical software MLwiN 2.25. Across all flocks, gentle feather pecking (GFP) was observed during 94% of the visits at both rear and lay, at 1.3 and 1.0 bouts/bird/h respectively. Severe feather pecking (SFP) was observed during 27% of the visits during rear and during 65% of the visits at lay, with a mean rate of 0.4 pecks/bird/h during rear and 1.9 pecks/bird/h at lay, across all flocks. The mean percentage of the flock with missing feathers was 12% at 16 weeks and 49% at lay. The mean individual feather score at lay was 21 (range 6–24 (best)). The study confirmed that feather pecking and feather damage occur during the rearing period. Statistical modelling further showed that the percentage of the flock with missing feathers was significantly lower and individual feather scores significantly higher (better) at lay, in flocks where feather pecking had not started at the end of rear. The three models on the effect of rearing environment on GFP, SFP and the percentage of the flock with missing feathers during rear contained 21 significant variables. Approximately a third of those related to house climate (temperature, humidity, sound, light and dust levels), while another third related to foraging. Foraging itself appeared in all three models, confirming that good foraging is one of the major factors in reducing feather pecking. The four models on the effect of rearing environment on GFP, SFP, the percentage of the flock with missing feathers and individual feather scores at lay contained 17 significant variables and sound level was significant in three of the four. The analysis further indicated that experienced rearing staff was protective against feather pecking at both rear and lay and that feather pecking increased with an increasing number of diet changes during rear.

Gunnarsson, S., et al. (1999). "Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens." British Poultry Science **40**(1): 12-18.

1. Effects of rearing conditions on behavioural problems were investigated in a cohort study of commercial flocks of laying hens housed in 2 different loose housing systems. The sample population was 120 385 laying hens from 59 flocks of various hybrids at 21 different farms. 2. Logistic regression modelling was used to test the effects of selected factors on floor eggs, cloacal cannibalism and feather pecking. In addition to early access to perches or litter, models included hybrid, stocking density group size, housing system, age at delivery, identical housing system at the rearing farm and at the production farm and, in models for floor eggs and cloacal cannibalism, nest area per hen. Odds ratios were calculated from the results of the models to allow risk assessment. 3. No significant correlations were found between the prevalence of floor eggs, cloacal cannibalism and feather pecking. 4. Access to perches from not later than the 4th week of age decreased the prevalence of floor eggs during the period from start-of-lay until 35 weeks of age, odds ratio 0.30 (P<0.001). Furthermore. early access to perches decreased the prevalence of cloacal cannibalism during the production period, odds ratio 0.46 (P=0.03). 5. No other factor had a significant effect in these models. Although it was not significant, early access to litter had a non-significant tendency to reduce the prevalence of feather pecking.

Haas, E. N. d., et al. (2010). "Selection on feather pecking affects response to novelty and foraging behaviour in laying hens." Applied Animal Behaviour Science **124**(3/4): 90-96.

Feather pecking (FP) is a major welfare problem in laying hens, influenced by multiple factors. FP is thought to be redirected foraging behaviour, however fearful birds are also known to be more sensitive to develop FP. The relationship between fear-responses, foraging and FP is not well understood, therefore we studied the behaviour of 16 birds from a high feather pecking (HFP) line and 16 birds from a low feather pecking (LFP) line at 35 weeks of age inside a plus-maze. Birds were from the 10th generation of selection for either high or low FP. First exposure to the maze was used to measure birds' fear-responses to a novel barren environment. Hereafter, birds were trained three times in the maze with four different food-items that were offered in one of the four arms (i.e. regular food-pellets, feathers, grass, and mealworms hidden in wood-shavings). On the fifth day, birds were tested in the maze for 10 min during which they could choose to eat from all available food-items. When exposed for the first time in the maze HFP birds walked a longer distance, vocalized sooner and had more exploratory pecks compared to LFP birds who showed more wing-movements and defecations. When

given a choice of food inside the maze both lines preferred eating worms, but HFP birds had more worm-eating bouts and ate faster than LFP birds. The results of this study indicate that HFP birds respond actively to fear-eliciting situations, which may originate from a proactive coping style. Instead of a clear preference for eating feathers, this study supports earlier findings that HFP birds have a stronger pecking motivation than LFP birds.

Janczak, A. M. and A. B. Riber (2015). "Review of rearing-related factors affecting the welfare of laying hens." Poultry Science.

Laying hens may face a number of welfare problems including: acute and chronic pain caused by beak trimming; exaggerated fearfulness that may cause stress and suffocation; difficulties in locating resources, resulting potentially in emaciation and dehydration; frustration and boredom, caused by an environment that is barren; feather pecking; cannibalism; foot lesions; and bone fractures. In Europe, a greater proportion of laying hens are housed in non-cage systems compared to the rest of the world. The extent of the different welfare problems may therefore vary between countries as the type of housing system influences the risk of suffering. More generally, many of these welfare problems are influenced by the rearing environment of the pullets. This article therefore focuses on welfare problems in laying hens that can be traced back to rearing. Factors that have been studied in relation to their effects on bird welfare include beak trimming, housing type, furnishing, enrichment, feeding, stocking density, flock size, sound and light levels, concentration of gasses, age at transfer from rearing to production facilities, similarity between rearing and production facilities, competence of staff, and interactions between bird strain and environment. The present review aims to summarize rearing-related risk factors of poor welfare in adult laying hens housed according to European Union legislation. It aims to identify gaps in current knowledge, and suggests strategies for improving bird welfare by improving rearing conditions. Two main conclusions of this work are that attempts should be made to use appropriate genetic material and that beak trimming should be limited where possible. In addition to this, the rearing system should provide constant access to appropriate substrates, perches, and mashed feed, and should be as similar as possible to the housing system used for the adult birds. Finally, young birds (pullets) should be moved to the production facilities before 16 weeks of age. The measures outlined in this review may be useful for improving the welfare of pullets and adult laying hens.

Kjaer, J. B. (2011). "Neonate pecking preferences and feather pecking in domestic chickens: investigating the 'changed template' hypothesis." Archiv Fur Geflugelkunde **75**(4): 273-278.

Domestic chickens from lines selected for low (LFP) or high (HFP) levels of feather pecking (FP) were reared in 14 bird groups and pecking to various forms presented on a computer screen was recorded at 2 weeks of age. HFP chickens delivered significantly more pecks (combined for all forms: circle, ellipse, rod, rods in feather like pattern and feather in colours: red, yellow, green) than LPF chickens, whereas no significant effects were found for form, colour, hatch or interactions. Total FP (sum of gentle and severe FP) was significantly higher in HFP chickens and decreased significantly with increasing age from 6 over 9 to 21 days. According to the 'changed template'-hypothesis, pecking preferences of HFP chickens would differ to those of LFP chickens but data could not support this hypothesis. Rather, the HFP chickens pecked at any form and colour with a much higher intensity than the LFP chickens lending support to the hyperactivity model of feather pecking in that genetic selection for a higher level of FP is paralleled by a higher level of arousal leading to increased pecking to animate (FP) as well as inanimate (i.e. forms on a screen) stimuli.

Kjaer, J. B. and D. Guemene (2009). "Adrenal reactivity in lines of domestic fowl selected on feather pecking behavior." Physiology & Behavior **96**(2): 370-373.

Domestic chicken lines of the White Leghorn layer type differing in their level of feather pecking have been developed by divergent selection specifically on feather pecking behavior. This paper describes an investigation of basal level. reactivity to manual restraint and maximal adrenal response to 1-24 ACTH in breeder birds of the sixth generation of selection (S6) and their control line. Birds from the three lines had comparable basal levels of corticosterone (1.6 ng/ml, anova $F(2.101)=0.62$, ns), whereas males had higher basal levels than females, Ismean 1.9 vs. 1.5 ng/ml (anova $F(1.103)=6.03$. $P<0.05$). Reactivity to handling and restraint for 10 min differed with HFP birds showing higher reactivity than LFP birds, Ismean 11.0 vs. 7.9 ng/ml ($t=-2.00$, $P<0.05$), while control birds showed intermediate levels (10.2 ng/ml). Males had higher reactivity than females, Ismean 11.2 vs. 8.2 ng/ml (anova $F(1.103)=3.96$, $P<0.05$). Maximal response did not differ between lines (average 35.7 ng/ml. anova $F(2.101)=1.38$, $P>0.05$). Males had higher maximal response than females, Ismean 41.3 vs. 33.6 ng/ml (anova $F(1.103)=5.77$, $P<0.05$). The present study shows that selection against feather pecking behavior have resulted in lower levels of feather pecking as well as lower sensitivity to human handling and restraint in White Leghorn laying hen lines. From an animal welfare point of view this is a positive relationship. (C) 2008 Elsevier Inc. All rights reserved.

Kjaer, J. B. and P. M. Hocking (2004). The genetics of feather pecking and cannibalism. Cambridge, Cabi Publishing.

Feather pecking and cannibalism are important welfare issues in the battery cage system and even more of a problem in alternative systems of egg production. Interest in the genetics of feather pecking and cannibalism has grown in the last few decades and a genetic solution might be more sustainable, efficacious and cost-effective than environmental modifications. Strain differences in the plumage condition of laying hens and feather pecking behaviour have been reported. More recently within-line genetic components of feather pecking and cannibalism have been quantified. Estimates of the

heritability of plumage condition range from moderate (0.22) to high (0.54) and the heritability of observations of pecking behaviour from 0.06 to 0.38. Some selection experiments have produced little or no evidence of a response. However, in one experiment, group selection was very effective in reducing the incidence of beak-inflicted injuries in caged hens and realized family heritability was 0.65 +/- 0.13. Divergent selection for high and low feather pecking resulted in significant differences in feather pecking behaviour and plumage condition. There is uncertainty about the correlated responses to selection for low feather pecking and cannibalism, and this justifies more research. Molecular approaches may offer the opportunity for selection to decrease feather pecking and cannibalism without compromising the welfare of birds in the selected flock. However, the evidence so far is not encouraging, and future opportunities to change the propensity for damaging feather pecking and cannibalism in commercial laying hens will probably rely on conventional selection in appropriate environments.

Kjaer, J. B. and H. Jorgensen (2011). "Heart rate variability in domestic chicken lines genetically selected on feather pecking behavior." Genes Brain and Behavior **10**(7): 747-755.

Domestic chicken lines of the White Leghorn type differing in their level of feather pecking were developed by divergent genetic selection specifically on feather pecking behavior. We determined parameters of heart rate variability to elucidate the relative activation of the sympathetic and parasympathetic nervous systems during rest and stressful situations. A total of 48 hens were tested in 8 batches. Segments of 2 min were extracted from electrocardiograms recorded by radio-transmitter implants, before (basal undisturbed conditions) and during physical restraint and a social test. Under basal conditions mean distance between R-waves were shorter in the low and high lines compared to the control. During physical restraint, stress reactions [reduced root of the mean squares of successive differences (RMSSD), reduced high frequency (HF), high low frequency (LF/HF) and low vagal-sympathetic effect (VSE) compared to basal levels] were significant in all lines. During the physical restraint the high feather pecking (HFP) line reacted significantly stronger than control (CON) and low feather pecking (LFP) line. During social test the LFP line reacted different than the other two lines. Seemingly birds from LFP conceived the social test as less stressful than birds from the CON and HFP lines. From this it follows that (1) physical restraint generally induced higher stress reactions than the social test and (2) genetic selection for higher levels of feather pecking increased the autonomic nervous system reaction to physical restraint whereas selection against feather pecking has reduced the response to increased social contact.

Kjaer, J. B., et al. "Perseveration in a guessing task by laying hens selected for high or low levels of feather pecking does not support classification of feather pecking as a stereotypy." Applied Animal Behaviour Science(0).

Abstract Feather pecking is a behaviour by which birds damage or destroy the feathers of themselves (self-pecking) or other birds (allo feather pecking), in some cases even plucking out feathers and eating these. The self-pecking is rarely seen in domestic laying hens but is not uncommon in parrots. Feather pecking in laying hens has been described as being stereotypic, i.e. a repetitive invariant motor pattern without an obvious function, and indeed the amount of self-pecking in parrots was found to correlate positively with the amount of recurrent perseveration (RP), the tendency to repeat responses inappropriately, which in humans and other animals was found to correlate with stereotypic behaviour. In the present experiment we set out to investigate the correlation between allo feather pecking and RP in laying hens. We used birds (N = 92) from the 10th and 11th generation (G10 and G11) of lines selectively bred for high feather pecking (HFP) and low feather pecking (LFP), and from an unselected control line (CON) with intermediate levels of feather pecking. We hypothesised that levels of RP would be higher, and the time taken (standardised latency) to repeat a response lower, in HFP compared to LFP hens, with CON hens in between. Using a two-choice guessing task, we found that lines differed significantly in their levels of RP, with HFP unexpectedly showing lower levels of RP than CON and LFP. Latency to make a repeat did not differ between lines. Latency to make a switch differed between lines with a shorter latency in HFP compared to LFP (in G10), or CON (in G11). Latency to peck for repeats versus latency to peck for switches did not differ between lines. Total time to complete the test was significantly shorter in HFP compared to CON and LFP. Thus, our hypotheses were not supported by the data. In contrast, selection for feather pecking seems to induce the opposite effects than would be expected from stereotyping animals: pecking was less sequenced and reaction to make a switch and to complete the test was lower in HFP. This supports the hyperactivity-model of feather pecking, suggesting that feather pecking is related to a higher general activity, possibly due to changes in the dopaminergic system.

Natt, D., et al. (2007). "Plumage color and feather pecking - Behavioral differences associated with PMEL17 genotypes in chicken (Gallus gallus)." Behavior Genetics **37**(2): 399-407.

An F(5) generation of an advanced inter-cross between red junglefowl (wild- type) and White Leghorn (domesticated) was used to investigate earlier findings suggesting that a mutation in the plumage color gene PMEL17 protects against victimization to feather pecking (FP). F(4) parents were selected according to genotype to produce PMEL17 homozygous offspring (i/i and I/I respectively). Birds were raised and their behavior recorded in groups of either two wild-type i/i (dark colored) and one white I/I, or two I/I and one i/i. In addition each bird was tested for feather preference, reaction to novelty, open-field activity, fear for humans, and tonic-immobility. In the home-pens, i/i birds were more feather pecked and had poorer feather condition than I/I birds. No pecking preference for immobile dark colored feathers was observed. In the open-field test i/i birds vocalized more and earlier than I/I birds, and in the fear-for-human test I/I birds had higher activity at 21 weeks of age. No other

behavior differences were observed, but clearly, genotypes of PMEL17 affected some aspects of behavior. Such behavioral differences might be important aspects of the mechanism which predispose i/i individuals for being victims of FP.

Newberry, R. C., et al. (2007). "Behaviour when young as a predictor of severe feather pecking in adult laying hens: The redirected foraging hypothesis revisited." Applied Animal Behaviour Science **107**(3-4): 262-274.

It has been suggested that feather pecking in poultry results when foraging behaviour is redirected to feathers in the absence of adequate foraging incentives and that gentle feather pecking is a precursor of severe feather pecking. Associations have also been proposed between feather pecking and other behaviours including dust bathing and preening. Here, we present the results of a longitudinal study on the development of severe feather pecking in individual domestic fowl. We hypothesised that behaviour, and especially foraging and gentle feather pecking behaviour, of individual birds when young predicts severe feather pecking behaviour by the same birds when adult. To test this hypothesis, we used behavioural data collected from 192 individual White Leghorn hens (12 focal birds/group) housed continuously from hatch in 16 floor pens. Data on 34 behaviour variables recorded when the birds were young (3-15 weeks of age) were subjected to factor analysis. The resulting factors were entered as independent variables in a generalised linear model to determine their relationship with severe feather pecking by the same birds as adults (1737 weeks of age). We found a positive association between a factor describing foraging when young and severe feather pecking when adult, and a negative association between a factor describing dust bathing when young and severe feather pecking when adult ($P < 0.05$). Levels of severe feather pecking increased following the onset of lay and we found no significant. association between factors describing feather pecking when young and severe feather pecking by the same individuals when adult. Most of the birds were observed to perform exploratory gentle feather pecks when young. No evidence was found that exploratory or stereotyped gentle feather pecks consistently became more severe over time but factor analysis indicated that severe feather pecking by young birds was more closely correlated with exploratory, than stereotyped, gentle feather pecking, signalling utility in distinguishing between exploratory and stereotyped gentle feather pecking in future studies. We conclude that severe feather pecking did not substitute for foraging behaviour but, rather, was more likely to emerge in adult hens that had performed relatively more foraging, and less resting and dust bathing, when young. However, none of the individual behaviour variables recorded when young could be used to identify precisely which individuals would exhibit severe feather pecking when adult.

Rodenburg, T. B., et al. (2010a). "Breeding amiable animals? Improving farm animal welfare by including social effects in breeding programmes." Animal Welfare **19**(Supplement): 77-82.

Social interactions between individuals, such as co-operation and competition, are key factors in evolution by natural selection. As a consequence, evolutionary biologists have developed extensive theories to understand the consequences of social interactions for response to natural selection. Current genetic improvement programmes in animal husbandry, in contrast, largely ignore the implications of social interactions for the design of breeding programmes. Recently, we have developed theoretical and empirical tools to quantify the magnitude of heritable social effects, ie the heritable effects that animals have on their group mates' traits, in livestock populations, and to utilise those effects in genetic improvement programmes. Results in commercial populations of pigs and laying hens indicate large heritable social effects, and the potential to substantially increase responses to selection in traits affected by social interactions. In pigs, including social effects into the breeding programme affected aggressive behaviour, both at mixing and in stable groups, indicating changes in the way dominance relationships are established and in aggressiveness. In laying hens, we applied selection between kin-groups to reduce mortality due to cannibalistic pecking. This resulted in a considerable difference in mortality between the low mortality line and the unselected control line in the first generation (20 vs 30%). Furthermore, changes in behavioural and neurobiological responses to stress were detected in the low mortality line, pointing to reduced fearfulness and stress sensitivity. These first results indicate that including social effects into breeding programmes is a promising way to reduce negative social interactions in farm animals, and possibly to also increase positive social interactions, by breeding animals with better social skills.

Rodenburg, T. B., et al. (2009a). "Maternal care and selection for low mortality affect post-stress corticosterone and peripheral serotonin in laying hens." Physiology & Behavior **98**(5): 519-523.

The aim of the present study was to investigate the effect of brooding and group selection for low mortality on post-stress corticosterone and peripheral serotonin in laying hens. Birds in the experiment originated from the same population and were either group-selected for low mortality (low mortality line) or randomly selected (control line) for two generations. Twelve groups of seven birds from each line were used. Within each line, six groups were brooded by a foster mother and six groups were non-brooded. At 33 weeks of age, birds (n = 42/treatment) were manually restrained for 5 min, during which their behavioral response (number of struggles) was studied. Fifteen minutes after the start of the manual restraint, blood samples were drawn for assessment of plasma corticosterone and whole blood serotonin (5-HT) concentration. In the low mortality line, 80% of the birds struggled and vocalized vs. 72% in the control line (non significant). Birds from the control line had a higher plasma corticosterone concentration after manual restraint than birds from the low mortality line (7.7 vs. 6.0 nmol ml(-1)). Furthermore, birds from the control line that were reared without a mother had a lower whole-blood 5-HT concentration than birds from the other treatments (45 vs. 48 nmol ml(-1)). These results indicate that both brooding and selection for low mortality affect post-stress corticosterone and

peripheral serotonin concentration, which may result in a reduced propensity to develop feather pecking. (C) 2009 Elsevier Inc. All rights reserved.

Rodenburg, T. B., et al. (2004a). "Genetic and phenotypic correlations between feather pecking and open-field response in laying hens at two different ages." Behavior Genetics **34**(4): 407-415.

The object of this research was to study the relationship between feather pecking and open-field activity in laying hens at two different ages. A population of 550 birds of a laying hen cross was subjected to an open-field test at 5 and 29 weeks of age and to a social feather pecking test at 6 and 30 weeks of age. Factor analysis was used to identify underlying factors for each test: pecking behavior (social test) and open-field activity (open-field test). In young birds, a positive phenotypic correlation of 0.24 was found between high open-field activity and high levels of pecking behavior (ground pecking, preening, gentle feather pecking, and wall pecking). In adults, a similar genetic correlation of 0.62 was found. At adult age, the factor pecking behavior consisted mainly of gentle and severe feather pecking. Between ages, a strong, negative genetic correlation of -0.65 was found between open-field activity at young age and pecking behavior at adult age, indicating that open-field activity levels in young birds may predict pecking behavior in adult hens.

Rodenburg, T. B., et al. (2010b). "Fearfulness and feather damage in laying hens divergently selected for high and low feather pecking." Applied Animal Behaviour Science **128**(1/4): 91-96.

Feather pecking (FP) remains a major welfare and economic problem in laying hens. FP has been found to be related to other behavioural characteristics, such as fearfulness. There are indications that fearful birds are more likely to develop FP. Furthermore, FP can lead to increased fearfulness in the victims. To investigate further the relationship between FP and fearfulness, feather damage and behavioural fear responses were recorded in three White Leghorn lines of laying hens: a line selected for high FP (HFP line), a line selected for low FP (LFP line) and an unselected control line (10th generation of selection). We used 64 birds per line housed in 16 four-bird cages (cage was the experimental unit). At 25 weeks of age, birds were subjected to a tonic immobility (TI) test and a combined human approach (HA) and novel object (NO) test, and plumage condition was recorded. Line differences in fear responses between the HFP and LFP lines were not found, neither in the TI-test, nor in the HA or NO test. As expected, birds from the HFP line had considerably more feather damage than birds from the LFP line and birds from the unselected control line were intermediate. Cages that withdrew from the NO 30 s after placement had more feather damage on the back compared with cages that did not show a withdrawal response. These results suggest that although relationships were found between feather damage and fear response at cage level, lines divergently selected on feather pecking behaviour do not differ in their fear responses. Divergent selection on feather pecking may have altered pecking motivation rather than fearfulness.

Rodenburg, T. B., et al. (2008a). "Selection method and early-life history affect behavioural development, feather pecking and cannibalism in laying hens: a review." Applied Animal Behaviour Science **110**(3/4): 217-228.

The aim of this review is to discuss the effects of selection method and early-life history on the behavioural development of laying hens. Especially in larger groups, laying hens often develop damaging behaviours, such as feather pecking and cannibalism, leading to impaired animal welfare. We hypothesise that the propensity to develop feather pecking and cannibalism is affected by a bird's genetic background and by its early-life history. The genetic background can be influenced by genetic selection. Laying hens are traditionally selected on individual performance, which may lead to co-selection of feather pecking and cannibalism. For hens kept in small groups, it has recently been demonstrated that a novel group selection method, focusing on group performance, can help to reduce cannibalism. However, the biological background behind the success of group selection is unknown. It is also not known whether these results from small groups can be translated to larger groups of laying hens. Regarding early-life history, laying, brooding and rearing conditions have been shown to have major effects on behavioural development and on feather pecking and cannibalism. The presence of a hen during rearing has been shown to improve foraging- and social behaviour, to decrease feather pecking and to decrease fearfulness in chicks. Applying group selection and rearing laying hens in a more natural environment may be key factors in solving the problems caused by feather pecking and cannibalism, especially if the promising results of group selection from small groups in experimental settings can be translated to large-group housing systems.

Rodenburg, T. B., et al. (2009b). "The effects of selection on low mortality and brooding by a mother hen on open-field response, feather pecking and cannibalism in laying hens." Animal Welfare **18**(4): 427-432.

The aim of the present study was to investigate the effects of selection on low mortality in combination with brooding by a mother hen on open-field response at 5-6 weeks of age and on plumage and body condition at 42 weeks of age. Birds in the experiment were either selected for low mortality in group housing (low mortality line) or randomly selected (control line) for two generations. These lines originated from the same population. Twenty groups of 10 female birds from each line were used. Within each line, ten groups were brooded by a foster mother and ten groups were non-brooded. At 5-6 weeks of age, the chicks were tested in an open-field test for five minutes. At 42 weeks of age, plumage condition and incidence of comb lesions and toe wounds of all birds was recorded. It was found that both brooded chicks and chicks from the low mortality line were more active in the open-field test at 5-6 weeks of age, indicating that they were less fearful or had a stronger exploratory motivation. No interactions were found between selection on low mortality and brooding. Birds from the low mortality line also had a lower incidence of comb and toe wounds compared with the control

line at 42 weeks of age. No effect of brooding on plumage condition or incidence of wounds was found. This study indicates that selection on low mortality is a promising way forward to reduce maladaptive behaviour in laying hens, especially if such an approach is combined with improved rearing conditions.

Uitdchaag, K. (2008). Effects of genetic background and social environment on feather pecking and related behavioural characteristics in laying hens. Wageningen, Wageningen Universiteit (Wageningen University).
To gain further insight in risk factors related to feather pecking, this thesis investigated the effects of genetic background and social environment on feather pecking and related behavioural characteristics in laying hens. In several experiments, behaviour, performance and physiology of cage-housed birds from purebred genetic lines was studied in different social environments at different ages. It was shown that birds from different purebred lines differed in feather damage due to severe feather pecking (an indicator for feather pecking) and in responses towards a novel object. This indicates that it is possible to select against high levels of both feather pecking and fear related behaviour. The tendency to develop feather pecking was also related to the response towards a novel object, although this relation differed between birds from different backgrounds and from different ages. Other results showed that the response in the novel object test was also related to performance, which should be taken into account if such a test would to be used in a breeding programme. Feather pecking and fear related behaviour were also affected by group mates (social environment): non-fearful birds became more fearful in presence of fearful birds. This effect could only be established at 18, but not at 5-6 weeks of age. At adult age, fearful birds showed more feather damage in presence of non-fearful birds, whereas the social environment during rearing had no effect on the occurrence of feather pecking. This indicates that fearful behaviour predisposes adult birds both to more easily develop and to be targeted by feather pecking. The changes in social environment were, however, not accompanied by physiological changes in brain serotonin or dopamine activity. These neurotransmission systems have been related to feather pecking. Results did indicate that the role of serotonin uptake does require further attention. According to the results from this thesis, laying hens should be kept in behavioural uniform groups to minimize the damage due to feather pecking. Additionally, reducing the expression of feather pecking could be achieved by breeding against expression of fearful behaviour, but possible correlated changes in performance should be accounted for. It remains to be investigated how the results with respect to social environment can be translated towards more extensive systems, such as floor-housing.

Uitdehaag, K. A., et al. (2009). "Mixed housing of different genetic lines of laying hens negatively affects feather pecking and fear related behaviour." Applied Animal Behaviour Science **116**(1): 58-66.
Adult laying hens from Rhode Island Red (RIR) origin both express lower levels of feather pecking and lower fear responses towards a novel object than laying hens from White Leghorn (WL) origin. The present study investigated whether mixed housing of RIR and WL laying hens would affect their behaviour in both an open field (at 17-18 weeks of age) and manual restraint test (at 24 weeks of age) and their feather damage due to severe feather pecking. In experiment A. 'pure' groups contained birds from one line only throughout the rearing and laying period. 'Mixed' groups contained an equal number of RIR and WL birds. Pure and mixed groups contained four birds, which were housed in battery cages. It was found that RIR birds were more active in the open field and manual restraint test than WL birds, although RIR birds from mixed groups became less active in the open field test than RIR birds from pure groups. This would indicate that RIR birds were less fearful than WL birds, but that they became more fearful in presence of these WL birds. In experiment B, RIR and WL birds were only housed together during the laying period, in varying ratios. It was found that WL birds from mixed groups had more feather damage due to severe feather pecking than WL birds from pure groups, whereas no effect of mixing was found in RIR birds. RIR birds from mixed groups therefore appeared to have developed relatively high levels of feather pecking, targeted at WL birds. This would indicate that, together with results from experiment A, fearful RIR birds from mixed groups were at higher risk to develop feather pecking than less fearful RIR birds from pure groups. This study clearly demonstrates that social factors have a strong influence on the development of feather pecking and related behavioural characteristics. (C) 2008 Elsevier B.V. All rights reserved.

van Hierden, Y. M., et al. (2005). "Chicks from a high and low feather pecking line of laying hens differ in apomorphine sensitivity." Physiology & Behavior **84**(3): 471-477.
Proactive rodents show a larger behavioral response to apomorphine (APO) than reactive copers, suggesting a more sensitive DA system in proactive individuals. Previously, chicks from a high feather pecking (HFP) and low feather pecking line (LFP) have been suggested to display a proactive and reactive cooing strategy, respectively. therefore, at approximately 4 weeks of age, the behavior of 48 LFP and 48 HFP chicks in response to an APO injection Was studied using an open field. Another objective of the present study was to determine whether behavioral variation (in an open field) between HFP and UP birds, after APO injection, is also reflected by variation of D, and D, receptor densities in the brain. Receptor binding capacities were assessed by measuring specific binding of tritiated D-1 and D-2 receptor ligands in different regions of the brain of control HFP and UP chicks. In the present study, it is shown that indeed HFP chicks display a more enhanced behavioral response to acute APO treatment (0.5 mg/kg BW) than LFP birds an open field. This difference was not reflected by variation of D-1 and D-2 receptor densities in the brain between both lines. (c) 2005 Elsevier Inc. All rights reserved.