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Feather Pecking in Laying Hens

Social and developmental factors

Boris Bilčík

SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

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Abstract
The relationship between pecks received by individual birds and the feather and skin damage of those birds was examined. The social factor investigated was group size and the development of feather pecking and feather damage was followed. Laying hens were raised in floor pens in group sizes of 15, 30, 60 and 120 birds and at four different ages detailed feather scoring and behavioural observations were carried out. Feather condition was worse in larger group sizes, with the largest difference for the group of 120 birds. Severe feather pecks were found to be strongly related both to feather damage and skin injuries. The body parts that received most pecks were the tail, rump and back, but most quickly denuded body part was the belly. The number of received aggressive pecks (but not gentle or severe feather pecks) was negatively related to body weight.

The connection between pecking at feathers and pecking at the ground in individual birds was studied. The same experimental setup was used as in the first part of the thesis with the same four group sizes. The results showed that most feather pecking activity occurred in the largest group size (120 birds) and there was some evidence of an increasing frequency of aggressive pecks received with increasing group size. The parts of the body which were targets for feather pecking varied depending on the location of the bird giving the peck and the bird receiving it. When looking at the behaviour of individuals, birds doing a lot of feather pecking also showed more ground pecking supporting previous work that feather pecking individuals are generally more active.

The prediction that more feather pecking in larger groups together with increased competition between birds may be associated with greater fearfulness was investigated. Tonic immobility duration of laying hens kept in groups of different sizes and tested in both their home pen and in temporary isolation in a separate room was studied. Tonic immobility increased with group size, with a significant difference between group sizes 15 and 120, suggesting that larger group size is connected with increased fearfulness. Some methodological considerations are made concerning the testing in the home environment of the hen.

The possibility of using individual differences in dopaminergic sensitivity (estimated by the behavioural response to apomorphine in chicks shortly after hatching) to test for susceptibility to become a feather pecker as an adult was examined. Apomorphine treatment caused increased motor and pecking activities with large individual variation, however, there was no correlation between the behaviour of young chicks after the apomorphine challenge and their feather pecking behaviour as adult birds. Using quantitative autoradiography, the differences between feather peckers and non-peckers in dopamine D1 and D2 receptor densities in the basal forebrain were measured. There was no significant difference in D1 or D2 receptor densities in the whole lobus parolfactorius (LPO) or paleostriatum augmentatum (PA), however, there were minor alterations in densities in distinct sections in rostral (increased D1 in peckers in LPO), medial (increased D2 in peckers in PA) and caudal region (increased D2 in non-peckers in LPO).

Key words: laying hens, poultry behaviour, feather pecking, feather scoring, tonic immobility, apomorphine, dopamine, group size

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To my parents

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Key words: laying hens, poultry behaviour, feather pecking, feather scoring, tonic immobility, apomorphine, dopamine receptors, group size, plumage condition
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Contents

Appendix

Papers I-IV

The thesis is based on the following papers, which will be referred to in the text by their Roman numerals.

I. Bilčík B., Keeling L.J., 1999. Changes in feather condition in relation to feather pecking activity and aggressive behaviour in laying hens. *British Poultry Science* 40, 444-451.

II. Bilčík B., Keeling L.J., 2000. Relationship between feather pecking and ground pecking in laying hens and the effect of group size. *Applied Animal Behaviour Science* 68, 55-66.

III. Bilčík B., Keeling L.J., Newberry R., 1998. The effect of group size on tonic immobility in laying hens. *Behavioural Processes* 43, 53-59.

IV. Bilčík B., Košťál Ľ., Kubíková, Ľ., Výboh, P., Keeling L.J. Individual differences in behavioural responses of young domestic chicks to a single injection of apomorphine and its relation to feather pecking behaviour and dopamine receptors density in the basal forebrain of the same birds when adult. Submitted.

Introduction

If one asked people in the street about feather pecking in poultry, some perhaps wouldn't know what you were talking about. But the majority of people would respond saying: "Yes, it's simple, hens are aggressive because they are kept in cages and can't go outside". They would be wrong three times. Feather pecking is not a simple problem, it has nothing to do with aggression and it does not occur just because of cages.

Feather pecking has already been studied for a long time and if it was a simple problem, it would have been solved many years ago. In fact, the opposite is true. We know many factors influencing the occurrence of feather pecking and we have some ideas about the development of this behaviour, but feather pecking still remains highly unpredictable, causing welfare concerns and economic losses.

Feather pecking can occur both in cages and in floor housing systems. The actual frequency of feather pecking is higher in cages, compared to pens (Hughes and Duncan, 1972; Nørgaard-Nielsen, 1980), however, in the latter, the outbreak of feather pecking can easily spread and so affect more birds than in cages. Since many countries are considering a transition from traditional keeping of laying hens in battery cages to alternative housing systems, from modified (or "furnished") cages to free range, with different types of aviaries in between, feather pecking is receiving more attention.

Feather pecking

Feather pecking is an abnormal form of behaviour when the bird pecks at, and often pulls out feathers of other birds. Feather pecking is both a welfare and an economic problem (Blokhuis, 1989). Pulling out feathers causes pain (Gentle and Hunter, 1990), a higher risk of injuries and can trigger an outbreak of cannibalism (Allen and Perry, 1975). Extensive loss of feather cover is accompanied by increased heat loss and, hence, increased food consumption (Emmans and Charles, 1977; Tauson and Svensson, 1980).

Not all pecks directed at feathers of other birds cause damage and it is necessary to distinguish between different types of pecks. First of all, feather pecks are different from aggressive pecks, both in their character (Hoffmeyer, 1969) and underlying motivation (Vestergaard, 1994). Aggressive pecks are usually directed at the head, in the downward direction. These pecks are rapid, vigorous and result in escape of the pecked bird or in a fight. Feather pecks, on the other hand, are directed at the body, mainly to the rump, belly or tail feathers and are often repeated in bouts. The pecker approaches the victim with the head and tail in a low position, often when the peckee is involved in some kind of activity, such as dustbathing or eating (Keeling, 1995).

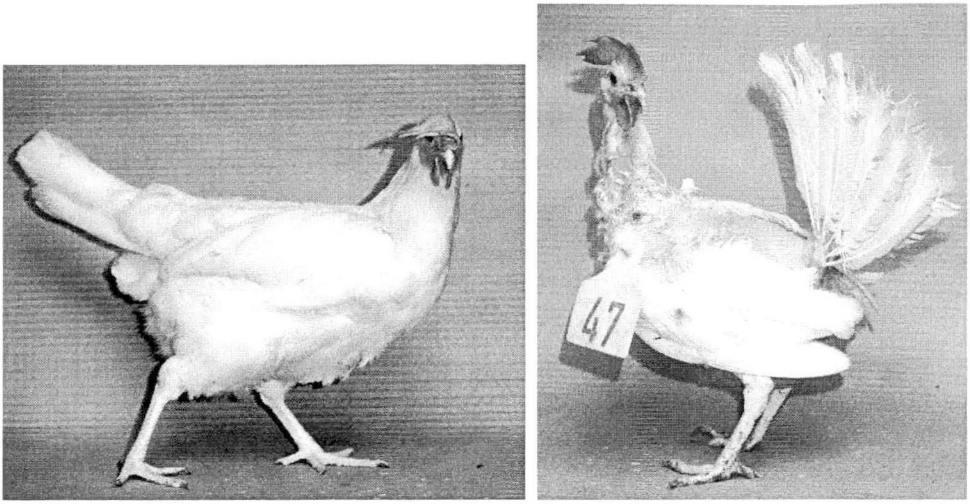

Figure 1. An example of a well feathered and poorly feathered bird.

Even within the term feather pecking, authors divide and define different forms of pecks. Some authors use a simple classification, like feather pecking, allopreening and allopecking (Vestergaard, 1994). Others use a more detailed division, by distinguishing between pecking, pulling, pinching and plucking feathers (Wechsler et al., 1998), or allopreening, light pecking, aggressive pecks, pulling and toe pecks (Leonard *et al.*, 1995). Keeling (1994) classified feather pecks as gentle (light pecks, often without any reaction of the pecked bird) and severe (more powerful pecks, pecked bird moves away) and several other authors have adopted this classification (e.g. Johnsen et al., 1998; Nørgaard-Nielsen, 1997).

Apart from direct behavioural observations, feather scoring is another valuable source of information about the level of feather pecking (Tauson et al., 1984). Methods of assessing plumage condition range from a very simple five point scale for the whole body (Hughes & Duncan, 1972), to very detailed three point scale given separately for eleven body parts (Gunnarsson *et al.*, 1995).

It is to be pointed out, that not only feather pecking has an impact on the plumage condition. Abrasion of feathers, mainly in cages, also contributes to feather damage (Tauson,1984).

Factors influencing the occurrence of feather pecking

Nutritional factors

Food composition and structure were probably the first known factors influencing feather pecking. A deficiency of amino acids (methionine, arginine), minerals (NaCl, Ca, Mg), protein and fibre, can increase its incidence (see Hughes and

Duncan, 1972 and Hughes, 1982 for a review). Higher levels of feather pecking have been reported when the birds have been fed pellets, compared to mash (Lindberg and Nicol, 1994; Savory et al., 1999).

Environmental factors

The influence of light is well known. Intensive light increased the frequency of feather pecking in laying hens housed in cages (Hughes and Duncan, 1972; Allen and Perry, 1975) and in pens (Kjaer and Vestergaard, 1999).

Another important environmental factor is the type of housing. Observing the junglefowl in semi-natural conditions, Dawkins (1989) found that hens spend 94% of their time budget by foraging and eating. The barren environment of conventional battery cages does not offer enough stimuli and as a result the incidence of feather pecking in cages is higher than in pens (Hughes and Duncan, 1972; Koelkebeck et al., 1987). Floor housing systems generally offer a more complex environment. Nevertheless, there are still large differences in the risk of feather pecking even between different types of aviaries (Hansen, 1994). The presence of litter suitable for scratching, pecking and dustbathing was found to decrease the incidence of feather pecking (Blokhuis, 1989). Also other forms of environmental enrichment have been shown to reduce feather pecking. In cages, birds provided with either perches or "key stimuli" (a dotted matrix fixed on the floor), showed better plumage condition (Braastad, 1990). Blokhuis and van der Haar (1992) reduced feather damage by scattering additional grain or straw on the floor during the rearing period. A similar feather pecking reducing effect was obtained by additional long-cut straw or polystyrene blocks, but not by shredded straw or wood shavings (Huber-Eicher and Wechsler, 1997) and by providing access to elevated perches (Huber-Eicher and Audigé, 1999). Also in turkeys, a lower incidence of injurious pecking (including feather pecking) was found in environmentally enriched pens (Sherwin et al., 1999). On the contrary, the use of operant feeders in hens housed on deep litter increased feather pecking (Linberg and Nicol, 1994).

The type of the litter together with the colour of feathers might play certain role as well, since contrasting particles on the feathers can attract the pecking (Savory and Mann, 1997). This hypothesis, however, was not proved by later experiments (Savory and Mann, 1999).

Hormonal factors

Feather pecking can be triggered by hormonal changes bound to the onset of lay. Hughes (1973) supplied experimental evidence for this by implanting gonadal hormones in young birds. A combination of oestrogen and progesterone caused a significant increase of feather pecking. Cuthbertson (1978) also found a significant increase of feather pecking activity when testosterone was given in combination with oestrogen. Testosterone alone increased the feather damage in high doses, but decreased it in low doses.

Genetic background

Commercial breeds of laying hens differ in their propensity to feather peck. Hughes and Duncan (1972) found least feather pecking in the light hybrid strain Thornber 808 and significantly more pecking activity in Shavers and the medium hybrid Thornber 909. Abrahamsson et al. (1996) found significant differences in plumage condition of four hybrids housed under the same conditions. Savory and Mann (1997) observed more feather pecking in groups of Hisex hens, compared to White and Brown Leghorn hens. In addition to differences between strains, there are also differences within the strain. As a result of selection for other parameters, variation in propensity to feather peck may arise, as documented by Blokhuis and Beutler (1992) and Blokhuis and Beuving (1993). In genetic studies of feather pecking, heritability estimates range between h^2=0.07 (Bessei, 1984) and h^2=0.38 (Kjaer and Sørensen, 1997). This opens the possibility to apply genetic selection to decrease the incidence of feather pecking. Craig and Muir (1993) showed that selection for reduction of beak-inflicted injuries (as a result of feather pecking and cannibalism) can be effective already after the second generation.

Since breeding companies do not release much information about their selection programmes, it is hard to say whether selection against feather pecking has already been applied in a broader scale.

Social factors

Although density could be listed among environmental factors, having impact on physical milieu, it is also a social factor. Reports about the effect of stocking density on feather pecking differ. Hughes and Duncan (1972) did not find differences between high (10.9 birds/m^2) and low density pens (5.4 birds/m^2). Contrary to this, Allen and Perry (1975) found better plumage conditions in birds caged at 12.2 vs. 22.8 birds/m^2. This better plumage condition at lower densities for birds kept in pens is supported by results from Simonsen et al. (1980) and from Hansen and Braastad (1994). Similarly, Huber-Eicher and Audigé (1999) found that higher density contributes significantly to the occurrence of feather pecking behaviour.

The importance of group size has been showed by several authors. An increase in feather pecking frequency with increasing group size was documented in caged hens by Allen and Perry (1975) (group size 3-6 birds) and for hens kept in pens by Hughes and Duncan (1972) and Bilčík and Keeling (1999) with group sizes of 4-8 birds and 15-120 birds respectively.

Together with size of the group goes social structure of the flock. Hens in large groups may not recognise each other and form a clear social hierarchy which, in turn, could lead to long-term social stress (Anthony et al., 1988) and to increase in the risk of feather pecking. On the other hand, birds in very large groups may have a different strategy to establish relations in the group (Pagel and Dawkins, 1997). Attempts have been made to induce formation of subgroups by introducing cockerels and by these means decrease the level of aggression and feather pecking. Odén et al. (1999) studied flocks of 433 to 634 birds, with and without cockerels (one male per 20-27 females). They found a clear aggression reducing effect of the male presence, but no effect on feather pecking behaviour. This also underlines the different origin of feather pecking and aggressive behaviour.

Development of feather pecking

The factors listed in the previous section influence the amount of feather pecking, but they do not explain the reason why it starts and how it develops. First attempts to explain the origin of feather pecking behaviour were given by Hoffmeyer (1969) in pheasants and Wennrich (1975) in laying hens, who proposed that feather pecking evolves as misdirected ground pecking. This theory was later elaborated by Blokhuis (Blokhuis and Arkes, 1984; Blokhuis, 1986). According to Blokhuis (1986), feather pecking evolves as part of foraging behaviour and is under the control of the feeding system. The ground pecking redirection hypothesis is supported also by Huber-Eicher and Wechsler (1997; 1998), who found a strong relation between feather pecking and foraging activity.

An alternative hypothesis was proposed by Vestergaard et al. (1993). Pecking at the substrate is part of the normal dustbathing sequence, however the perceptual mechanism for dustbathing is not fully developed at hatching (Vestergaard et al., 1990). In the case where litter is absent or insuffitient, an inappropriate association between feathers and dustbathing substrate may result in pecks being redirected to the feathers of other birds (Vestergaard et al., 1993). The fact that in barren environments a dustbathing bird often pecks at feathers of other birds has been described for caged hens (Martin, 1975) and for Japanese quail (Bilcik and Bessei, 1993). Both hypotheses stress the importance of early experience on the development of feather pecking (Blokhuis, 1986; Vestergaard et al., 1993).

An explanation of the origin of feather pecking, different from the above mentioned two hypotheses, is offered by McKeegan and Savory (1999). They suggest that feather pecking develops as a consequence of feather eating. When availability of suitable size feathers on the floor become insufficient, feather eating and pecking might be redirected to other birds.

Ways of reducing/eliminating feather pecking

Ways of dealing with the problem of feather pecking in practice differ very much in their approach. Some of them can reduce feather pecking once it occurs, whereas others can reduce the risk of it occurring at all.

Changing the environment and routines

Beak trimming, routinely used in many countries, only prevents damage to the feathers, but does not affect feather pecking itself. Although this is quite an effective way of preventing feather damage, the procedure itself is painful for the birds (Grigor et.al, 1995) and can cause chronic pain (Gentle, 1986; Gentle et al., 1990).

Another way is avoidance of known factors influencing the occurrence of feather pecking. In previous sections described methods, such as lower stocking density and smaller group size, lower light intensity, providing the birds with a balanced diet, providing with an appropriate substrate for scratching, pecking and dustbathing, enrichment of the barren cage or pen environment (e.g. perches in cages or pens, additional grain or straw) have been proved to decrease the risk of an outbreak of feather pecking. Risk of feather pecking occurrence can be reduced also by provision of an appropriate substrate for pecking from an early age, thus avoiding feathers becoming imprinted as pecking material instead of the substrate (Huber-Eicher and Wechsler, 1997; Johnsen, 1998).

None of the previously mentioned methods, however, can completely prevent feather pecking from appearing or to eliminate already developed feather pecking. On the other hand, when combined, they can help to keep feather pecking under control.

Changing the animals

An approach "from the other side" is the use of genetic selection. Although heritability of feather pecking seems to be rather low - between 0.07 and 0.1 (Bessei, 1984; Cuthbertson, 1980), several authors reported successful attempts to select against feather pecking behaviour (Craig and Muir, 1993; Keeling and Wilhelmsson, 1997; Kjaer and Sørensen, 1997).

The most effective, quick and least costly method would be to identify among young birds those who have higher propensity to feather peck and exclude them from further breeding. Jones et al. (1995) tried to link tonic immobility duration of young animals to later feather pecking but found no relation. Animals with undesirable characteristics can be identified through genetic markers linked to the unwanted trait, such as halotane sensitivity in stress-sensitive pigs (Sybesma and Eikelenboom, 1969), however, so far there is no known marker, which would allow us to use this approach in feather pecking.

Aims

The aim of this thesis was to contribute to the knowledge of feather pecking with the focus on social and developmental factors. More specific aims were:

- To describe and examine the relationship between pecks received by individual birds and the feather damage of those birds at different ages and in different group sizes.

- To study the relation between feather pecking and ground pecking in individual birds and the effect of group size on feather pecking behaviour.

- To examine the level of fear and fearfulness in groups of different sizes and tested in both their home pen and in temporary isolation in a separate room.

- To investigate whether individual differences between young chicks in dopaminergic sensitivity can be used for prediction of susceptibility to feather pecking.

Material and methods

Animals and husbandry

In papers I. II. and III., a White Leghorn type strain of laying hen (Hisex white) was used. From day 1, they were raised in floor pens on wood shaving litter, in groups of 15, 30, 60 and 120 birds (Figure 3). Each group size had four replicates, giving 16 pens in total, which were arranged in a randomised block design in one environmentally controlled building. The size of the pen varied according to the group size, keeping the same space allocation per bird (0.2 m^2). To restrict the differences just to the size of the group, the space at the perch, feeder, in the nest box and number of water nipples per bird were the same for all group sizes. Also the arrangement of these in the pen was as far as possible kept the same in all pens (Figure 4).

In the experiment described in paper IV., 160 Hisex brown chicks were used in the first part, from them 84 in the second and 18 in the third part. Chicks were kept from day old in rearing boxes with wire mesh floor, which for the first three days was covered with paper. From 12 weeks of age they were housed in pairs in cages with 0.088 m^2 per bird.

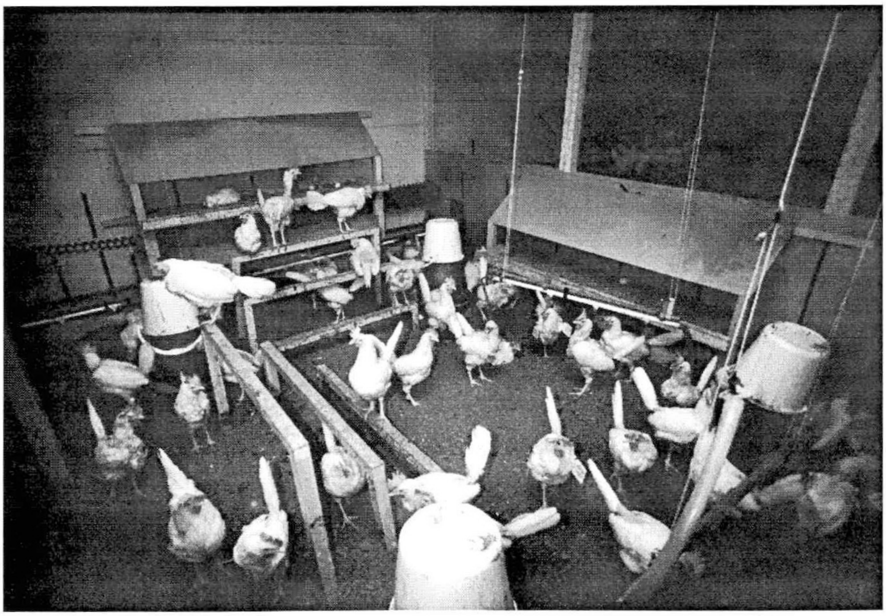

Figure 3. Pen with the group of 60 hens. Other experimental group sizes were 15, 30 and 120 birds.

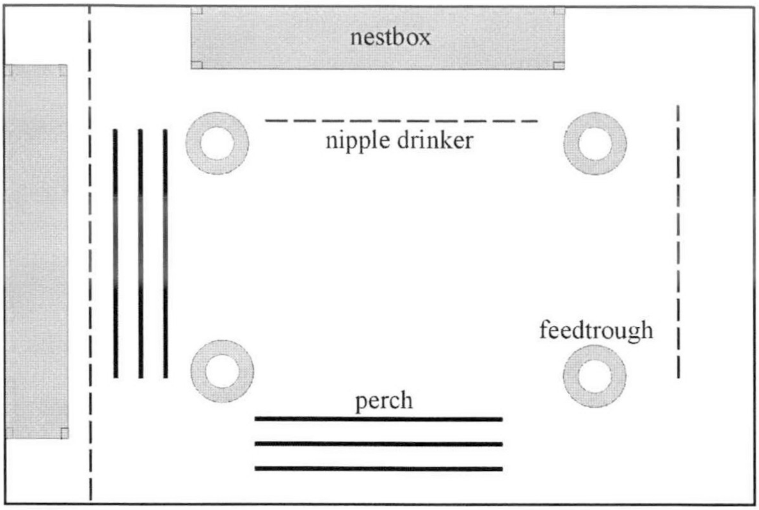

Figure 4. Scheme of the experimental pen, view from the top. Layout was kept the same for all group sizes. The number of nipple drinkers, space at feeder, perch and nest was proportionally changed to be constant per bird across group sizes.

In all experiments food and water were provided ad libitum. The light schedule followed the recommendations of the breeders.

Feather scoring

To evaluate feather condition in different group sizes and to examine the relationship between feather pecking and feather condition, detailed feather scoring was used in paper I. Each scoring was done individually, outside the pen. The bird was placed on an elevated platform and the entire feather cover was carefully examined. The division of the body into eleven parts was adopted from Gunnarsson et al. (1995), however, we have used a more sensitive six level scoring scale. Feathers on the tail and wing primaries were scored with a different criteria, as well as skin injuries. Such detailed scoring allowed us to discover feather damage which would not be recorded otherwise, since missing feathers were often covered under a layer of other feathers. Feather scoring was repeated at the age of 18, 23, 28 and 33 weeks.

Feather pecking observations

Behavioural observations in papers I and II were recorded directly on a portable computer, using The Observer (Noldus Information Technology, 1990). At 4 different ages, all 192 focal birds were observed within four days, combining group size, replicate and time of day in a balanced way. Each bird was observed for 5 minutes, using the focal animal sampling method. Recorded was the behaviour of the bird with the lowest tag number, then the bird with the next highest tag number was observed, and so on, until all 12 focal birds had been observed. Recorded were also the location of the bird in the pen and all pecking related behaviours - number of gentle and severe feather pecks given and received to 11 body parts, aggressive pecks given and received, pecks at feeder, drinker, floor and other objects.

When recording feather pecks and aggressive pecks, the identity of the bird receiving the peck from the observed bird or giving the peck to the observed bird was not recorded, since only 12 focal birds in each group were wingtagged. This is also the reason why the number of feather pecks received was much higher than the number of pecks given – pecks from all group members were included, whereas pecks given are only those given by the 12 focal birds in the group. Following the feather pecking behaviour at different ages and recording the pecks on the same parts of the body that were feather scored, allowed us to study the development of feather pecking and feather damage over a longer period of time.

During the observations in the second part of paper IV, numbers of gentle and severe feather pecks (given and received) and aggressive pecks (given and received) were recorded, as well as pecks at the feeder, drinker and floor or walls of the cage.

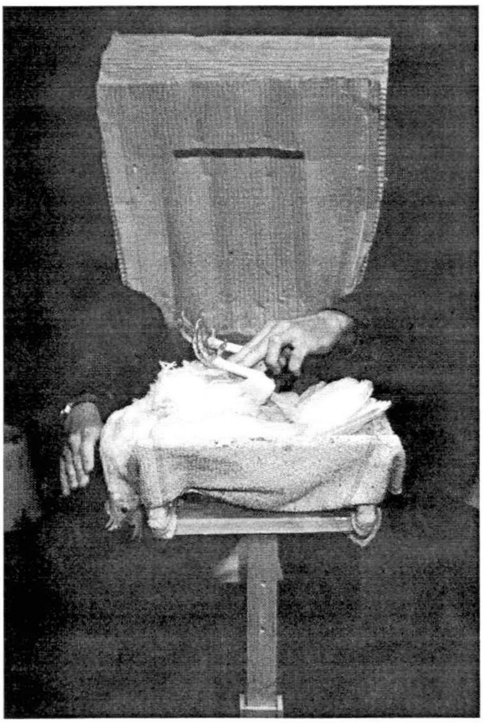

Figure 5. During the tonic immobility test, the experimenter was behind a cardboard blind, to reduce the effect of human presence.

Tonic immobility test

The duration of tonic immobility (TI) is considered to be a useful measure of the fear and underlying fearfulness of a bird. It can be induced by a brief period of physical restraint, in our experiment by placing the bird on its back and restraining it in a V-shaped cradle. For a detailed description of the procedure see Jones and Faure (1981). The TI testing was done under two conditions - directly in the pen or in a separate room.

During the manipulation and testing of the bird, the handler had a cardboard blind fixed on the upper part of the body (Figure 5). This was done to reduce possible effects of human presence during the test and to control for the difference in habituation to human proximity (since pens varied in size the possibility to avoid the person entering the pens varied).

Apomorphine test

To investigate differences in dopaminergic sensitivity, chicks shortly after hatching (2-6 days old) were injected into the breast muscle with dopamine receptor agonist apomorphine (0.5 mg/kg). Chicks were then placed in a test box (Figure 6) and their behaviour was video recorded during a 30 min test period. In order to test all 160 animals in the shortest possible time, our experimental setup consisted of four parallel test boxes recorded with two video cameras (Figure 7).

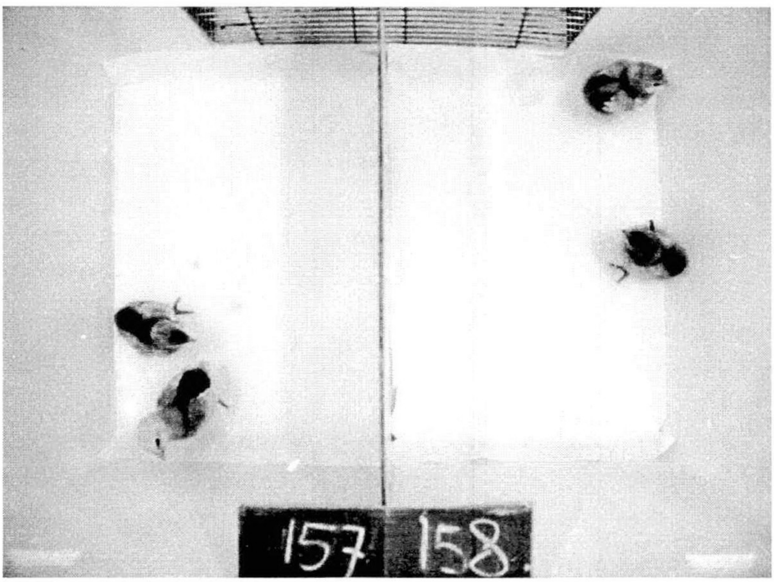

Figure 6. View of the testing box, with tested chick and non-treated opponent.

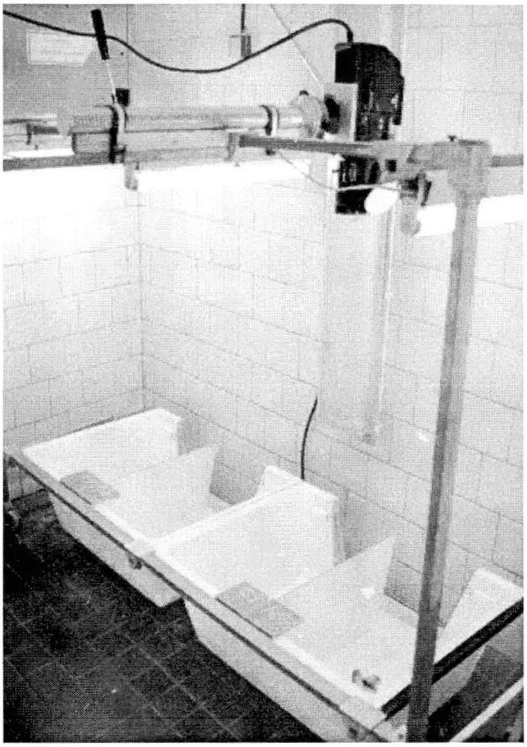

Figure 7. Experimental setup. On the photo, only one of the two video cameras is mounted.

Chicks respond very intensively to an apomorphine injections, even at relatively low doses (Osuide and Adejoh, 1973), therefore we had to use the dose which would elicit enough pecking activity while still enabling us to follow the behaviour and count the number of pecks at different targets. After some preliminary experiments and comparisons with Osuide and Adejoh (1973), who tested a wide range of doses (0.125-70 mg/kg), we found the dose of 0.5 mg/kg to be optimal.

Quantitative autoradiography

In order to investigate individual differences between feather peckers and non-peckers, densities of dopamine D1 and D2 receptors were compared using quantitative autoradiography. Eighteen birds (9 peckers + 9 non peckers) were decapitated, brains were quickly removed, frozen and stored at -70 °C. The frontal parts of the brains were cut on a cryostat and 20 μm thick sections from every 0.52 mm were mounted on gelatine-coated slides. Afterwards, a receptor binding assay was performed. The slides were then exposed to the tritium-sensitive Hyperfilm for 4-6 weeks. Films after processing were digitised and densitometric analysis of autoradiograms was performed.

Statistics

In paper I, the data from feather scoring were on an ordinal scale, therefore differences in the feather condition between groups at different ages were tested using nonparametric Kruskal-Wallis ANOVA on ranks.

Differences between the four group sizes in papers II and III were analysed using ANOVA with Tukey HSD tests for post-hoc comparisons. Data had to be logtransformed in both papers.

In the first experiment of paper IV, individual differences between birds were analysed using a factor analysis with principal component as extraction method and a cluster analysis with complete linkage. The measure of distance was Pearson r.

For the comparison of dopamine receptor densities in the brains of pecker and non-pecker birds, a nested design ANOVA was used, since several autoradiograms from different parts of the brain of each bird were used.

Results

The results from paper I present a comparison of the plumage condition in the groups of 15, 30, 60 and 120 hens at different ages and the correlation of the plumage condition with the feather pecks received. The changes in feather condition were age dependent, with a rapid deterioration after 18 weeks of age, especially in the largest group. Scoring on separate body parts showed a different (more linear and less rapid) pattern of deterioration of wing and flight feathers, which can be attributed either to abrasion or to the fact that these feathers are less vulnerable to pecking damage. Body parts with the most excessive feather damage were the belly and rump, followed by the back. These parts also had most skin injuries (mainly in group 120). The distribution of feather pecks (including both gentle and severe pecks) was uneven and most pecks were aimed at the tail (18.5%), rump (17.6%) and back (12.9%). A regression analysis of data from feather scorings and behavioural observations showed a significant relation between feather damage and both group size ($p<0.001$ at all ages) and the number of severe feather pecks received ($p<0.05$ at all ages). Aggressive pecks were aimed mainly towards the head, hence they had little effect on the damage of the rest of the body. An interesting finding was the negative correlation ($p<0.01$ at the age of 27 and 32 weeks) between number of aggressive pecks received and body weight. No relation of received either gentle or severe feather pecks to body weight was found.

In paper II, the connection between pecking at the feathers of another bird and pecking at the ground in individual birds was studied. The same experimental setup was used as in paper I, with the same four group sizes. There were no significant differences between group sizes in the number of gentle feather pecks given, however, in the number of severe pecks given, groups of 120 differed from groups of 15 and 30 ($p<0.05$). Groups of 120 differed from all other groups also in the number of gentle ($p<0.05$) and severe ($p<0.001$) feather pecks received. We found no significant differences in the number of aggressive pecks given, however, the number of aggressive pecks received gradually increased as group size increased, though only the differences between groups 15 and 30 ($p=0.019$) and groups 15 and 120 ($p<0.001$) were significant. Groups did not differ in the amount of pecks to the ground, food, drinker and other objects. Concerning the location, hens spent on average 70 % of the time on the floor, 26 % on the perch and 4 % in the nest and other locations. The parts of the body which were targets for feather pecking varied depending on the location of the bird giving the peck and the bird receiving it. When the pecker was on the perch, it gave most pecks to the rump and neck of other birds. However, when the pecker was on the floor, pecks were given mainly to the belly. When the pecked bird was perching, it was most likely that it was pecked on its breast, wing-coverts, rump and belly, whereas when the bird was on the floor, most pecks were received on its tail, rump and back. Correlation analysis between feather pecking and pecks at the ground, did not reveal the expected negative correlation that would have supported the hypothesis that feather pecking is redirected ground pecking. On the contrary, in the groups of 120 we found a significant positive correlation between severe pecks given and the number of pecks to the floor ($r=0.41$; $p=0.004$), which supports previous work that feather pecking individuals are generally more active.

In paper III, the prediction that more feather pecking in larger groups (as was found in papers I and II), together with increased competition and aggression between birds may be associated with greater fearfulness, was investigated. Since tonic immobility is primarily an antipredator behaviour, the more birds there are around the tested individual, the better chances it has to escape the predator (Roberts, 1995). Hence, the alternative hypothesis was that the TI should be shorter in larger groups. In the test performed directly in the home pen ("in"), duration of tonic immobility increased with group size, with a significant difference between group sizes 15 and 120 ($p=0.012$). When the birds were tested in the separate room ("out"), there was a trend for tonic immobility to be longer in larger groups ($p=0.11$). Tonic immobility duration in all groups was significantly longer when birds were tested "out" (mean, 95 % CI; 199.3 s, 164.1, 242.1) than when they were tested "in" (58.6 s, 49.1, 69.9) ($p<0.001$). Under both testing conditions, group size had no effect on the number of TI inductions, however, more inductions were needed "in" than "out" ($p<0.001$). The results of this study suggest that larger group size is connected with increased fearfulness. The clearer effect of group size when the birds were tested directly in their home pen, rather than in a separate room, suggests that this may be a more appropriate method than the testing in isolation, which is the usual way.

The last part of the thesis, paper IV, examines individual differences in dopaminergic sensitivity and the possibility of using this to predict an individual's predisposition to develop feather pecking behaviour. An apomorphine injection caused increased motor and pecking activities in chicks. There was large individual variation and chicks could be divided into three groups, according to behaviours prevailing in their response: (1) pecking and pulling of own and opponent's toes, backward pacing, (2) pecking on head and body of the other bird, and (3) object pecking, forward pacing, head shaking. Nevertheless, there was no correlation between the behaviour of young chicks after the apomorphine challenge and their later feather pecking behaviour as adult birds. Despite this, dopamine does seem to be involved in this behaviour. Differences in dopamine receptor densities in adult feather peckers and non peckers were investigated. Using quantitative autoradiography, densities of dopamine D1 and D2 receptors in basal forebrain - lobus parolfactorius (LPO) and paleostriatum augmentatum (PA) were measured. There were no significant effects of group (peckers vs. non-peckers) on either D1 or D2 receptor densities in both studied structures as a whole. The effect of the cutting plane was highly significant ($p<0.001$), indicating differences in receptor densities in rostral, medial and caudal parts of the LPO and

PA respectively, both LPO and PA having higher densities in the rostro-medial parts. Post-hoc tests shown higher density of D1 receptors in rostral part of the LPO of peckers ($p<0.05$), while the density of D2 receptors in caudal part was lower ($p<0.05$). There were significantly higher densities of D2 receptors in the intermediate part of the PA of peckers ($p<0.01$), while in case of the D1 there was only a trend towards increased levels in PA of peckers. Our results indicate possible involvement of dopaminergic neurotransmission in the expression of feather pecking in laying hens.

General discussion

Feather pecking and feather condition

Feather scoring is an easy and, compared to behavioural observations, relatively quick method of assessing the level of feather pecking. Some authors use the whole body score to assess the degree of pecking damage (Hughes and Duncan, 1972; Adams et al., 1978), however, for proper evaluation a more detailed examination of different body parts is necessary (Tauson et al., 1984; Gunnarsson et al., 1995). The scoring method used in paper I (6-point scale and scoring on 11 parts of the body) detected feather pecking even at early stages, when the birds seemed at first glance to have no feather damage.

The correlation between severe feather pecking and feather damage (paper I) was significant at all ages, however, no such correlation was found for gentle feather pecks. McKeegan and Savory (1999) also correlated feather pecking with feather damage, but found no significant correlation. However, as the authors conclude, most of the pecks were non-damaging gentle pecks. Also their observations were on young animals (5-14 weeks of age) and as we report in paper I, a major increases in feather pecking activity was observed after 18 weeks of age. An interesting finding of McKeegan and Savory (1999) was the negative correlation between feather damage and numbers of short feathers on the floor. This led the authors to the hypothesis that low availability of feathers on the floor may lead to redirection of pecking to other birds.

Not all body parts are equally "attractive" for feather pecking. Nørgaard-Nielsen et al. (1993) observed most feather pecks delivered on the breast and back and Savory and Mann (1997) found most pronounced feather pecking on the back and on the thigh. In our experiment (paper I), the body parts that received most pecks were the tail, rump and back, but the most quickly denuded body parts were the belly, rump and back. This may reflect the ease with which feathers are pulled out from different regions. It also raises the question of whether individual birds specialise in pecking on some parts of the body. Wechsler et al. (1998) found no evidence of certain birds specialised in pecking at specific areas, however, in paper II we found that the parts of the body which become targets for feather pecking varied depending on the location of the bird giving the peck and the bird receiving it.

Although feather damage in our experiment (paper I) correlated very well with the number of received severe feather pecks, it is necessary to also consider other factors. Abrasion of feathers on certain body parts can be influenced by the type of housing. In cages, with usually high stocking densities, abrasion of feathers from other birds or from cage walls and the feeder (especially underneck) can contribute to bad plumage condition (Tauson, 1984). In pens, attempts to fly or escape can result in damage on the wing and tail feathers. In paper I we had to exclude from the analysis the wing coverts and breast regions, because it was difficult to distinguish pecking damage from the abrasion caused by the wing tag on the coverts and from the brood patch on the breast.

The risk is, that damaged feathers, as a result of abrasion, may attract other birds and trigger an outbreak of feather pecking (Hughes, 1978). This has been experimentally confirmed by McAdie and Keeling (2000) who manipulated the feathers on the rump, tail or belly and found that these damaged feathers received significantly more severe feather pecks than undamaged feathers.

Considering that the back, rump and belly frequently receive severe feather pecks and that these regions also get quickly denuded (together with smaller probability of abrasion), feather condition on these three parts is probably most suitable indicator of feather pecking compared to other parts of the body.

Early rearing conditions and development of feather pecking

Development and causation of feather pecking has been studied by several authors and the currently two main hypotheses were already described in more detail in the introductory part of this thesis (Vestergaard et al., 1993 and Blokhuis, 1986).

According to both the "groundpecking" and "dustbathing" hypothesis, redirection of pecks from substrate to feathers of other birds occurs as a result of misimprinting of proper substrate. This happens during early life and several authors have tried to determine sensitive period for the correct perception. Johnsen et al. (1998) reared hens on either wire, sand or straw during their first four weeks of life. Although all birds had access to sand or straw after four weeks, birds initially reared on wire showed significantly higher feather pecking activity later in life (19, 33 and 45 weeks). Huber-Eicher and Wechsler (1997) narrowed the knowledge of the sensitive period by showing that chicks given access to sand from 1 day of age have a lower incidence of feather pecking than those having access from 10 days of age. That the association between pecking and substrate (in this case for dustbathing) can be established as early as on day 3 of life, was showed by Vestergaard and Baranyiová (1996).

Even early provision of litter does not guarantee that feather pecking will not develop. In our experiments (papers I and II), chicks were kept on wood shaving litter from 1 day old and considerable feather pecking, especially in larger groups, was still observed. This raises the question about the suitable type of substrate. Since the association between substrate and pecking seems to be established rather early, it is important that the litter on which the chicks are reared during their first days of life suits their needs. Substrates like wood shavings or straw might have high explorative value for adult birds, but it might not have suitable properties for young. Nørgaard-Nielsen et al. (1993) reared chicks from day 1 either on cut straw or on a mixture of dark sand and peat and found a feather pecking reducing effect of the latter, although feather pecking developed in both treatments. Thus the use of different substrates during the rearing period (e.g. first peat and later wood shavings or straw) might be useful in decreasing feather pecking in adult birds.

Another factor, which probably plays a role in the process of learning to use appropriate substrate, is light. If the area for foraging and dustbathing is small, crowding of animals on these places might result in misimprinting on the feathers of other animals instead of the substrate (Johnsen et al., 1998). Avoiding crowding, especially under heat sources (e.g. by using darkened chicken brooders), can, according to Johnsen et al. (1998), help to reduce the chance of erroneous imprinting of feathers. On the other hand, Roden and Wechsler (1998) found that the presence of a hen does not prevent the chicks from redirecting pecks at other penmates and from developing feather pecking.

Whether feather pecks are redirected ground pecks was also one of the questions addressed in paper II. That a higher feather pecking rate is associated with a lower rate of ground pecking, was showed by Blokhuis and van der Haar (1992) and by Savory and Mann (1997). The opposite results, however, can also be found - Hansen (1994) reported a positive correlation between feather pecking and ground pecking. In our study we found no evidence of a negative correlation between the number of feather pecks and the number of pecks on the ground, as might be expected if feather pecking is redirected ground pecking. Contrary, in the largest group size we found a positive correlation. This can probably be explained by the age of the animals. Redirection occurs in young birds and in adult animals observed in our study it might already have been overlapped by higher activity of feather pecking birds.

Group size and the relation to feather pecking and aggression

Natural group sizes in the domestic hen ancestors, the red jungle fowl, vary between 6 and 30 birds of various sexes, ages and level of relatedness (Collias and Collias, 1996). It is obvious that the way of keeping laying hens nowadays, in unisex groups of birds of the same age and with group sizes in floor housing systems of several thousand birds is far from natural conditions. Group size is one of the parameters, studied also in this thesis.

The effect of group size on feather pecking and aggression has already been studied by several authors. Most of these studies, however, were on caged birds and on rather small groups. Allen and Perry (1975) found more feather pecking in groups of 6 caged hens than in groups of 3. Also in pen-housed hens (groups of

10, 20 and 40 hens) Hughes and Duncan (1972) found most pecking damage in the largest group. Comparing the groups of 3 or 6 hens, housed either in cages or pens, Hughes and Wood-Gush (1977) found more feather pecking in the larger cage group, but more aggression in the larger pen-housed group. Savory et al. (1999), when looking at the feather damage in groups of 10 and 20 chickens, found group size and density interaction, however, found no effect of group size only. In our study (paper II), the most pronounced difference was between groups of 120 and smaller groups in numbers of feather pecks received and aggressive pecks received. Our largest group size, however, was still much smaller than commercial flocks in floor housing systems.

Feather pecking in slightly larger groups (72-368 hens) was studied by Nicol et al., (1999), however, in these groups the stocking density was confounded with the size of the group. They observed higher levels of feather pecking in larger/higher density groups, but the highest frequency of aggressive pecking was observed in the smallest group (72 birds). The authors explain this increase in aggression as an (unsuccessful) attempt by individuals in the flock to form social relationships. This is to a certain extent similar to our observations. In paper II, we found slightly more severe feather pecks and aggressive pecks received in the groups of 30, than in the groups of 60 birds. We observed the same tendency in the duration of tonic immobility (paper III), with groups of 30 birds having slightly longer TI duration than groups of 60 birds. All this might indicate that whereas in small groups individuals can form a stable hierarchy, individuals in medium sized groups struggle to establish stable social relationships and may have problems individually recognising the other group members. The fact that in much larger groups (300 and 700 birds respectively) Hughes et al. (1997) found a rather low incidences of aggression, supports Pagel and Dawkins (1997) suggestion, that birds in very large groups may have a different strategy to establish relations in the group, based not on individual recognition, but on more general signs of the status, forming dyadic dominance relationships.

Individual differences between feather peckers and non peckers

Detailed studies of individual birds revealed that only a small percentage of birds peck severely on other birds and, hence, are responsible for feather damage. Keeling (1994) found that less than 9 % of hens kept in floor pens accounted for over 50 % of all severe pecks and in Wechsler et al. (1998) 12% of the birds were classified as "high rate" peckers. In our experiment (paper II) only 8.3 % of all birds gave severe feather pecks.

It has already been found (for pheasants) that there are feather pecking specialists within flocks (Hoffmeyer, 1969). She also found that some individuals specialised in pecking on certain parts of the body. Wechsler et al. (1998) also found feather pecking "specialists", however, they did not confirm specialisation in pecking at specific areas.

When all birds in the group are raised together, under the same conditions, why do only some of them become feather peckers? How feather peckers differ from the other members of the flock is an interesting and important question. Cuthbertson (1978) found feather peckers to be generally more active. Eriksson (1995) reported that peckers spent significantly more time walking and Keeling and Wilhelmsson (1997) found in feather peckers the tendency to ground peck more. The latter is supported by our finding of a positive correlation between severe feather pecking and ground pecking (paper II).

Fear and fearfulness is another trait that has been investigated, unfortunately with inconclusive results. Vestergaard et al. (1993) found that feather peckers were most fearful (had longest tonic immobility) and were participating least in dustbathing in the group. Blokhuis and Beuving (1993) also found longer tonic immobility duration in birds from a high feather pecking line at the age of 14 weeks. Opposite result, i.e. significantly shorter tonic immobility duration in feather peckers compared to non peckers, was found by Johnsen (1998). In the study described in this thesis we found no significant correlation (in either direction)between tonic immobility duration and severe feather pecking (unpublished results from paper II and III).

Differences between peckers and non pecker birds have been found on the physiological level as well. Birds from a high feather pecking line had lower heterophil/lymphocyte ratios after being exposed to a stressor (Blokhuis and Beuving, 1993) and lower plasma corticosterone levels during resting and physical restraint (Korte et al, 1997). Birds from a high feather pecking line also showed a larger plasma noradrenaline response after physical restraint (Korte et al., 1997). The authors explain this as differences in terms of coping strategies at the behavioural level. Feather peckers show an active coping strategy, bound with sympathoadrenal response, whereas non peckers represent a passive coping style, characterised by adrenocortical activation (Korte et al., 1997). Individuals with an active coping style easily develop routines and do not react to changes in their environment (Benus et al., 1991). Johnsen (1998) found shorter tonic immobility duration in feather peckers, which supports the active coping theory, however, they did not find a differences in corticosterone levels.

One of the most important implications of individual differences between feather peckers and non peckers would be the possibility to use this as method to identify already at an early age those birds who have a higher propensity to feather peck and exclude them from further breeding. Jones et al. (1995) tried to link feather pecking of adults with tonic immobility duration of young animals, however, found no predictive value of TI duration. A similar approach was used by Cloutier et al. (2000) in a study where they tried to use pecking at inanimate stimuli as a predictor of future cannibalistic and feather pecking behaviour in laying hens. They found high levels of pecking at moving feather stimuli, however, this was not correlated to either feather pecking or cannibalistic attacks in adult birds. In our experiments (paper IV) we tried to use individual differences in dopaminergic sensitivity in young chicks to predict the susceptibility to become feather pecker in adult birds, however, again there was no significant relationship.

Conclusions

Feather scoring, when done on separate body parts, is a reliable indicator of severe feather pecking.

Severe feather pecks were found to be strongly related both to feather damage and skin injuries; no relation with gentle feather pecks was found.

Group size is an important factor in the aetiology of feather pecking, with large group sizes having most feather pecking.

When looking at the behaviour of individuals, birds doing a lot of feather pecking also showed more ground pecking, which points towards individual differences between feather peckers and non peckers.

Feather pecking and aggression in large groups is associated with a higher level of fearfulness, as indicated by longer tonic immobility duration.

Dopaminergic sensitivity of young chicks is not a suitable indicator of susceptibility to become feather pecker. The role of the dopaminergic system in the regulation of feather pecking behaviour needs further investigation.

Summary in Swedish

Fjäderhackning hos värphöns: Sociala faktorer och utvecklingsfaktorer

Fjäderhacking är ett av de allvarligaste beteenndeproblemen inom kommersiell fjäderfäskötsel. Ett annat allvarligt problem är kannibalism. Fjäderhackning innebär att en höna hackar på eller drar av fjädrar från andra hönor, vilket har negativa konsekvenser för både hönornas välfärd och lantbrukarens ekonomi. Beteendeproblemet förekommer både hos höns som hålles i burar och hos frigående hönor, men det får oftast större konsekvenser hos hönor i frigående system och det kan även leda till kannibalism. Burhönsförbudet i Sverige och de föreslagna ändringarna av EU-lagstiftningen angående inhysningen av värphöns har ökat behovet av kunskaper om fjäderhackning. Följaktligen är syftet med denna avhandling är att öka kunskaperna om fjäderhackning med tyngdpunkten på sociala faktorer och utvecklingsfaktorer.

I första delen av avhandlingen (delstudie I), var syftet att beskriva och undersöka sambandet mellan de hack individuella hönor fick mottaga och skador på fjäderdräkt och hudskador hos dessa hönor. Den sociala faktor som undersöktes var gruppstorlek, eftersom den faktorn förändras mest då djuren flyttas från burar till golvsystem. Utvecklingen av fjäderhackningsbeteende och skador på fjäderdräkt och hud studerades sedan under 20 veckor. Värphönorna hölls i golvavdelningar med olika gruppstorlekar, 15, 30, 60 respektive 120 hönor per avdelning. Vid fyra olika tillfällen gjordes detaljerade bedömningar av fjäderdräkt och hud (11 olika kroppsdelar bedömdes separat), samt beteendestudier. Fjäderdräktens kondition var sämre hos hönorna i de större grupperna än hos hönor i de mindre grupperna och hönor i grupperna med 120 hönor hade sämst fjäderdräkt. Förekomsten av hårda fjäderhack var starkt relaterad till både fjäder- och hudskador. Fjäderhackningen var framför allt riktad mot stjärtfjädrarna, gumpryggen och övre delen av ryggen, men buken blev först naken därefter gumpryggen och övre delen av ryggen. Ett annat intressant resultat var att kroppsvikten var negativt korrelerad med antalet mottagna aggressiva hackningar, men inte med mottagna fjäderhackningar (mjuka och hårda).

Den andra delen av avhandlingen (delstudie II) fokuserade på relationen mellan fjäderhackning och pickande på marken hos individuella hönor. I denna delstudie användes samma experimentdesign som i den första delstudien med fyra olika gruppstorlekar. Resultaten visade att det förekom mest fjäderhackningsbeteende i den största gruppstorleken (120 hönor) och det fanns en tendens till att förekomsten av aggressiv hackning ökade med ökande gruppstorlek. Var på kroppen fjäderhackningen skedde berodde på var någonstans den hackade hönan och den hackande hönan befann sig. Om den fjäderhackande hönan befann sig på sittpinnarna så riktades fjäderhackning mot hals och gumprygg, men om den fjäderhackande hönan befann sig på golvet så riktades fjäderhackningen mot buken. De fjäderhackande hönorna utförde mer pickade mera på marken än andra hönor, vilket överensstämmer med tidigare forskning, som visat att fjäderhackande hönor har ett mer aktivt beteende.

I de två första delarbetena förekom mer fjäderhackning i större grupper än i mindre. Detta kan tillsammans med ökad konkurrens mellan hönorna, vara relaterat till ökad rädsla. För att undersöka om så är fallet undersöktes skillnader i tonisk immobilitet (TI) hos hönorna, dvs hur länge en höna ligger still efter att man utlöst dess frysningsreflex, vilken kan användas som ett mått på rädsla hos hönan (delarbete III). Varaktigheten av TI jämfördes hos hönor från de olika grupperna, både när hönorna testades i sin hemavdelning och i ett separat rum i anslutning till avdelningarna. När hönorna testades i hemavdelningen ökade varaktigheten av TI med ökande gruppstorlek och det var en signifikant skillnad mellan hönor från grupper med 15 hönor jämfört med hönor från grupper med 120 hönor. Då hönorna testades i det separata rummet, fanns det en tendens att varaktigheten av TI ökade med ökande gruppstorlek. Resultaten tyder på att rädslan hos individuella hönor ökar med ökande gruppstorlek. I avhandlingen diskuteras metodologiska aspekter var hönorna testas.

I det sista delarbetet (delarbete IV) i avhandlingen studerades neurokemiska aspekter av fjäderhackningsbeteende. Trots att fjäderhackning är en speciell typ av hackningsbeteende, påminner beteendemönstret om den stereotypa hackning som kan framkallas med hjälp av stimulantia, såsom apomorfin (en dopamin agonist). Detta tyder på att en dopaminerg kontroll av fjäderhackingsbeteendet. Syftet med delstudien var att undersöka individuella skillnader i dopaminerg känslighet och att avgöra huruvida apomorfinbehandling kan användas för att förutsäga vilka kycklingar som utvecklar fjäderhackning. Det andra syftet var att undersöka skillnaderna i densiteten av dopaminreceptorer mellan fjäderhackarna och icke-fjäderhackande kycklingar. Kycklingarna kunde delas in i tre olika grupper beroende på behandlingsrespons: (1) kycklingarna hackade och drog i egna eller andra kycklingars tår, eller sprang baklänges, (2) kycklingarna hackade mot huvud eller kropp på andra kycklingar, (3) kycklingarna hackade på inredningsdetaljer, sprang framlänges, eller skakade på huvudet. Det fanns ingen korrelation mellan beteendet hos kycklingarna efter apomorfinbehandling och fjäderplockningsbeteendet när djuren blivit vuxna. Trots dessa resultat, tycks dopamin vara relaterat till fjäderhackning. Densiteten av dopaminreceptorerna D1 och D2 i basala delar av hjärnan, närmare bestämt i lobus parolfactorius och paleostriatum augmentatum, uppmättes med hjälp av kvantitativ autoradiografi. Det fanns en trend att fjäderhackande kycklingar hade en högre densitet av D2 receptorer i paleostriatum augmentatum.

Summary in Slovak

Klovanie peria u nosníc: Sociálne a vývinové faktory.

Klovanie peria je jedným z najvážnejších behaviorálnych problémov vo veľkochovoch nosníc. Pod klovaním peria rozumieme klovanie a vytrhávanie peria druhým sliepkam a má negatívne dôsledky na welfare zvierat aj na ekonomiku chovu. Toto abnormálne správanie sa vyskytuje rovnako v klietkových, ako aj podlahových chovných systémoch, avšak dôsledky sú pri podlahovom chove zvyčajne vážnejšie a klovanie peria môže prerásť až ku kanibalizmu. Zákaz chovu sliepok v konvenčných klietkach vo Švédsku, ako aj plánované zmeny v legislatíve krajín EU, viedli k potrebe lepšie porozumieť tomuto problému. Cieľom tejto práce bolo prispieť k poznaniu príčin vzniku klovania peria, so zameraním na sociálne a vývinové faktory.

Cieľom prvej časti práce (článok I) bolo popísať a zistiť vzťah medzi klovaním peria a stavom operenia a vplyv veľkostichovnej skupiny. Sliepky boli chované na hlbokej podstielke v skupinách 15, 30, 60 a 120 vtákov a ich správanie a stav operenia boli sledované počas 20. týždňov. Detailné skórovanie operenia sme robili osobitne na 11. častiach tela. Stav operenia bol horší vo väčších skupinách, s najvýraznejším rozdielom skupiny 120 sliepok. Klovanie peria označené ako drsné klovanie (severe pecking), silne korelovalo s poškodením operenia a poraneniami pokožky. Najviac klovnutí smerovalo na chvost, bázu chvosta a chrbát, avšak najrýchlejšie odperenou časťou tela bolo brucho. Zaujímavým zistením bola negatívna korelácia medzi počtom agresívnych klovnutí (avšak nie počtom drsných a jemných klovnutí) a telesnou hmotnosťou.

Druhá časť práce (článok II) je zameraná na sledovanie vzťahu medzi klovaním peria a exploračným klovaním na podstielku u individuálnych jedincov. Použité bolo rovnaké experimentálne usporiadanie ako v prvej časti práce, s rovnakými veľkosťami skupín. Frekvencia klovania peria a agresívneho klovania narastala s veľkosťou skupiny, s najvýraznejším rozdielom skupiny 120 sliepok. Časti tela, ktoré boli preferovane klované, záviseli od lokalizácie klovajúceho a klovaného jedinca. Pokiaľ klovaný jedinec bol na bidielku, najviac klovnutí smerovalo na hruď, bázu chvosta, krídla a brucho. Ak bolo klované zviera na podlahe, najviac klovnutí smerovalo na chvost, bázu chvosta a na chrbát. Pri sledovaní správania individuálnych zvierat sme zistili, že jedince s vysokou frekvenciou klovania peria mali aj vysokú frekvenciu klovania na podlahu, čo podporuje zistenia, že klovači sú všeobecne aktívnejší než ostatné jedince.

V prvých dvoch častiach práce popísaný nárast frekvencie klovania peria v závislosti na veľkosti chovnej skupiny, môže spolu s nárastom intraskupinovej kompetície súvisieť s väčšou bojazlivosťou zvierat. Na overenie tejto hypotézy sme v tretej časti práce (článok III) porovnávali dĺžku tonickej imobility (ktorá

odráža riziko ohrozenia predátormi a úroveň bojazlivosti) u nosníc chovaných v skupinách o rozličnej veľkosti. Test tonickej imobility bol uskutočnený priamo vo voliére, alebo v oddelenej miestnosti. Pri teste uskutočnenom priamo v chovnej voliére dĺžka tonickej imobility narastala s veľkosťou skupiny, s preukazným rozdielom medzi skupinami s 15. a 120. sliepkami. Pri teste uskutočnenom v oddelenej miestnosti bol taktiež trend nárastu dĺžky tonickej imobility s veľkosťou skupiny. Výsledky tejto štúdie ukázali, že väčšie chovné skupiny sú spojené s väčšou bojazlivosťou sliepok.

Posledná časť práce (článok IV) sa zaoberá neurochemickými aspektami klovania peria. Napriek tomu, že klovanie peria je špecifický prípad klovania, motorické vzorce tohoto správania sú podobné stereotypnému klovaniu indukovanému stimulačnými farmakami, ako napríklad agonistom dopamínových receptorov apomorfínom. Toto naznačuje možnú dopaminergnú kontrolu klovania peria. Cieľom nášho experimentu bolo zistiť individuálne rozdiely v dopaminergnej senzitivite a preskúmať, či táto senzitivita môže byť použitá na predikciu predispozície na klovanie peria. Ďalším cieľom bolo štúdium individuálnych rozdielov v hustotách dopamínových receptorov v mozgoch klovačov a neklovačov. Vo veku 2-6 dní sme kurčatám jednorazovo intramuskulárne aplikovali apomorfín (0,5 mg/kg). Správanie sme sledovali počas 30 minút po aplikácii, vždy dve zvieratá naraz (testovaný jedinec a neošetrený oponent). Apomorfín spôsobil výrazný nárast motorických a klovacích aktivít, s veľkou individuálnou variabilitou. Podľa správania prevažujúceho v reakcii, bolo možné rozdeliť zvieratá na tri skupiny: (1) klovanie a ťahanie vlastných a oponentových prstov, pohyb dozadu, (2) klovanie na hlavu a telo oponenta, (3) klovanie na objekty, potriasanie hlavou a pohyb dopredu. Napriek výrazným rozdielom v správaní mladých zvierat po aplikácii apomorfínu, nepodarilo sa nám nájsť koreláciu s klovaním peria u dospelých jedincov. Pravdepodobnú účasť dopaminergného systému v regulácii klovania peria však podporila ďalšia časť experimentu, kde sme s použitím kvantitatívnej autorádiografie sledovali hustoty dopamínových D1 a D2 receptorov v bazálnej časti predného mozgu, v oblastiach lobus parolfactorius (LPO) a paleostriatum augmentatum (PA). Analýza variancie nepotvrdila rozdiely medzi zvieratami s vysokou a nízkou frekvenciou klovania peria v hustotách D1 ani D2 receptorov v týchto štruktúrach ako celku, avšak vysoko signifikantný bol vplyv umiestnenia meraného rezu pozdĺž rostro-kaudálnej osi ($p<0.001$), poukazujúci na rozdiely v hustotách v frontálnej, mediálnej a rostrálnej časti LPO a PA. Post hoc testy preukázali rozdiely medzi klovačmi a neklovačmi na úrovni jednotlivých rovín rezu. Zistili sme signifikantne vyššie hustoty D1 receptorov v rostrálnej oblasti ($p<0.05$), avšak nižšie hustoty D2 receptorov v kaudálnej oblasti LPO klovačov. U klovačov boli tiež signifikantne vyššie hustoty D2 receptorov mediálnej oblasti PA ($p<0.01$), zatiaľčo rovnaký trend v prípade D1 receptorv nebol signifikantný. Tieto zistenia naznačujú účasť dopaminergného systému v regulácii klovania peria.

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