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Effect of brooders on feather pecking and cannibalism in domestic fowl (*Gallus gallus domesticus*)

Anja Brinch Jensen [a,*], Rupert Palme [b], Björn Forkman [a]

[a] *The Royal Veterinary and Agricultural University, Department of Large Animal Sciences, Division of Ethology, Grønnegaardsvej 8, DK-1870 Frederiksberg C, Denmark*
[b] *University of Veterinary Medicine, Institute of Biochemistry, Veterinärplatz 1, A-1210 Vienna, Austria*

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Abstract

Several studies have shown that the tendency to feather peck is influenced by events early in life and preventive measures should therefore be introduced at hatching. Separating inactive chicks from active chicks by providing dark electrical brooders was predicted to reduce the risk of chicks developing pecking preferences for conspecifics.

Twelve groups of 15 layer hen chicks (Lohmann Tradition) were reared in pens (2.55 m^2); during the first 5 weeks after hatching six pens were provided with dark brooders and six pens with heating lamps. All pens were observed continuously for 30 min per pen once a week until the chickens were 23 weeks old, and each bout of severe feather pecks was recorded. The chickens were observed several times daily, and all injured individuals were removed from the experiment. Faecal samples were collected from the pens when the chicks were 16, 17 and 18 days old and analysed for corticosterone metabolites. At the end of the experiment, the plumage and skin damage were scored. Data were analysed using repeated measures ANOVA.

The dark brooders completely prevented severe feather pecking in the dark brooder pens, whereas the frequency of severe feather pecking rose with age in the heating lamp pens (treatment $\times$ age: $P < 0.0001$). At the last observation (week 23), the frequency of severe feather pecking bouts in the dark brooder pens was 0.3 ± 0.4 (mean $\pm$ S.E.) compared to 31.3 ± 10.1 in the heating lamp pens.

* Corresponding author. Tel.: +45 35283012; fax: +45 38283022.
E-mail address: abrj@kvl.dk (A.B. Jensen).

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The frequency of gentle feather pecking was significantly higher in the heating lamp pens at all ages ($P < 0.0001$). Mortality followed the same pattern as severe feather pecking; it was almost non-existent in the dark brooder pens, whereas from point of lay it continued to rise with age in the heating lamp pens (1 versus 24 casualties, treatment × age: $P < 0.0001$). The high level of severe feather pecking in the heating lamp pens was also reflected in the scores of plumage and skin damage as both were found to be significantly higher in the heating lamp pens (plumage: $P = 0.0004$; skin: $P = 0.0273$). There was no difference between treatments in concentrations of faecal corticosterone metabolites ($P = 0.8146$).

The results suggest that the provision of dark brooders has a long-lasting reducing effect on the frequency of feather pecking and cannibalistic attacks, resulting in reduced mortality and an improved condition of both plumage and skin.

Keywords: Cannibalism; Chickens; Dark brooders; Faecal corticosterone metabolites; Feather pecking; Plumage and skin damage

1. Introduction

Feather pecking and cannibalism remain serious problems in today's poultry production in terms of decreased welfare of the animals and deflated economy of the farmers. So far, no management plans have been developed that efficiently and consistently prevent the problems from occurring. Hence, the need for developing successful methods to prevent or reduce feather pecking and cannibalism persists.

Feather pecking, i.e. pecking at other birds' feathers, can be divided into (a) gentle feather pecking causing no damage to the plumage and (b) severe feather pecking, where serious damage can be inflicted on the plumage in terms of broken feathers and loss of feathers (Bilčík and Keeling, 1999). During cannibalistic attacks skin and tissue are being pinched off, often resulting in the death of the victim bird. There has been some controversy about the connection between feather pecking and cannibalism. Some authors suggest that severe feather pecking leads to cannibalism and that the two behaviours are under control of the same motivational system (Schaible et al., 1947; Blokhuis and van der Haar, 1992; Savory and Mann, 1997), whereas others indicate that feather peckers and cannibals are different individuals and that the behaviours are controlled by different motivational systems (Keeling, 1994; Vestergaard, 1994; Kjaer and Vestergaard, 1999).

Many factors have been reported to influence feather pecking and cannibalism. Among the most generally accepted are light intensity (Hughes and Duncan, 1972; Kjaer and Vestergaard, 1999), floor type (Blokhuis and van der Haar, 1989; Huber-Eicher and Wechsler, 1997), food form (Lindberg and Nicol, 1994; Aerni et al., 2000), hormonal changes (Hughes, 1973), group size (Hughes and Duncan, 1972; Allen and Perry, 1975) and genetic background (Kuo et al., 1991; Kjaer and Sørensen, 1997). Many of these factors may act as stressors if they deviate from optimum (e.g. group sizes, floor types and light intensity) or they may make the animals more susceptible to stress (e.g. hormonal changes and genetic background) (Korte et al., 1997; El-lethey et al., 2000; Yngvesson and Keeling, 2001).

Despite the fact that many causal factors have been identified, outbreaks of feather pecking and cannibalism can still occur even when recommendations based on the above studies are followed. Therefore more recent research has concentrated mainly on the development of feather pecking and cannibalism. Two hypotheses explaining the development of feather pecking have dominated the discussion and both of them emphasize the importance of early experiences. One hypothesis suggests that feather pecking is misdirected pecks to feathers of conspecifics because the feathers are perceived as a substrate for dustbathing and thus controlled by motivation for dustbathing (Vestergaard and Lisborg, 1993; Vestergaard et al., 1993). Today, the most supported hypothesis is the redirected ground pecking hypothesis, which considers that feather pecking evolves as part of foraging behaviour and thus is controlled by motivation to forage (Hoffmeyer, 1969; Blokhuis and Arkes, 1984; Blokhuis, 1986; Huber-Eicher and Wechsler, 1997, 1998).

In the original redirected ground pecking hypothesis the focus was on the explorative part of the foraging behaviour. By enriching the litter, foraging exploration towards conspecifics was reduced as the attention of the animals was directed towards the litter (Blokhuis and Arkes, 1984; Blokhuis, 1986, 1989). Various stimuli can, however, become associated with the foraging behaviour, e.g. feathers. The behavioural systems of both feeding and dustbathing in chicks lack a prefunctionally developed perceptual mechanism recognizing food and dust, respectively (Hogan, 1994). Both nutritious and non-nutritious objects are therefore pecked and swalloved during the first days of life (Hogan-Warburg and Hogan, 1981), but postingestion nutritional effects are necessary for long term perception of objects as food (Hogan, 1973). Although the domestic fowl does not possess the ability to digest feathers, it has been shown that birds do eat them (Savory and Mann, 1999) and that feather pecking flocks have more feathers in their faeces than non-feather pecking flocks (McKeegan and Savory, 1999). The fatty acid composition of preen oil on the feathers have been found to differ between feather pecked birds and non-pecked birds, i.e. birds may gain gustatory and nutritive feedback from preen oil when ingesting feathers (Sandilands et al., 2004). This is further supported by the finding that unwashed feathers are preferred over washed feathers (McKeegan and Savory, 2001). Thus, chicks may by coincidence learn to perceive feathers as a source of food as well as a source of dust.

From both of these hypotheses the prediction can therefore be made that minimising the exposure of foraging or dustbathing chicks to feathers during the sensitive period of food or dust recognition will reduce the risk of misperception of feathers as either food or dust. As moulting is very limited during chicks' first weeks of lives, the main source of feathers is those on pen-mates. Consequently, separating chicks engaged in foraging or dustbathing activities from inactive chicks lying on the ground will result in fewer misdirected ground pecks to feathers of conspecifics, and as a result development of feather pecking is impeded. This prediction was investigated in the present experiment, where the development of feather pecking and cannibalism was investigated in groups of layer hens provided with dark brooders during the first 5 weeks after hatching. The dark brooders provided chicks in need of rest the possibility of resting separately from active chicks. Since stress has been suggested to enhance development of feather pecking (El-Lethey et al., 2000), we also measured corticosterone metabolites in the chicks' faeces using a new non-invasive method (Rettenbacher et al., 2004).

2. Materials and methods

2.1. Animals and housing

A total of 180 non-beaktrimmed day-old Lohmann Tradition female layer hen chicks were randomly assigned to two different treatment groups; six pens with each 15 chicks were provided with dark brooders, supplying heat without light, and the remaining six pens were provided with conventional heating lamps with a 150 W red bulb. The dark electrical brooders measured 40 cm × 40 cm and consisted of a heat panel (45 W) placed on metal legs. To prevent light from penetrating under the brooders, they were shielded off with fringes of black fabric on all sides. The temperature under both types of heating sources was kept at approximately the same temperature; 32 °C for the first 5 days after hatching and lowered gradually thereafter. When the chickens were 5-week old, the temperature was 22 °C and the heating sources were removed; thus there was no longer any difference in treatment of the groups.

The pens housing the experimental chickens had a floor area of 150 cm × 170 cm, resulting in a density of 5.9 chickens/m^2. The chickens had access to two perches at 40 cm height (170 cm long each) and the floor of the pens was covered with wood-shavings. Food and water were available ad libitum and the feeding regimes were those recommended by suppliers of commercial layers, i.e. starter feed (mash) from 0 to 6 weeks, grower feed (mash) from 6 to 15 weeks and finally layer feed (mash) from week 15 and onwards. The layer feed was supplemented ad libitum with whole grain barley and crushed shells, and the hens also had access to grit from week 14. The feed and all supplements were provided in separate feed troughs. In each pen, three adjacent nests boxes were placed 48 cm above ground along the back wall. The covered nest boxes measured 30 cm × 28 cm and contained wood-shavings as nesting material. Day length was kept constant at 14 h (06:00–20:00 h) with a light intensity 0.2 m above ground level of approximately 70 lx. Fluorescent tubes in the ceiling illuminated the room and each pen was provided with a light bulb (25/40 W, adjusted to obtain equal light intensity in the pens). There was no natural light in the room and the room temperature was fixed at 18 °C (±1). A radio was switched on during all light hours in order to mask disturbing sounds from other pens or the surroundings.

2.2. Ethical note

The chickens were checked several times daily for injuries by observing the groups of chickens from outside their pens. Individuals with bloody wounds were immediately removed from the pens and killed when found. At the age of 23 weeks, the incidence of cannibalism was high in some pens. Based on that and on the fact that the chickens had developed into full-grown hens with a rate of lay of 84%, which is near the peak egg production of ≥90%, it was decided to terminate the experiment at this stage.

2.2.1. Data collection

During the behavioural observations, the observer was sitting in front of the pens in full view of the animals. The order of the pens was always randomly decided by pulling a number between 1 and 12 from a bag.

2.3. Feather pecking activity

All pens were observed continuously for 30 min per pen once a week from week 0 to 23, and each occurrence of non-aggressive feather pecking was recorded. Only pecks to feathered parts of the body were classified as feather pecking, and the activity was divided into two separate categories: (a) gentle feather pecking; feathers were neither being pulled out nor did the recipient bird show a reaction to the peck and (b) severe feather pecking; feathers were sometimes pulled out and/or the recipient bird of the pecks reacted to the peck by abruptly moving away. Repeated pecks to the same individual were counted and judged as one bout of feather pecking, which was deemed to have ended, when there were no more pecks during a period of 5 s. It was recorded whether the recipient bird of feather pecks was dustbathing when pecked.

2.4. Mortality

The group sizes were recorded weekly on the same day as the feather pecking observations were carried out. The individuals that had been taken out of the experiment due to wounds were categorized as dead on equal terms with the individuals found dead due to feather pecking and cannibalism.

2.5. Measurement of faecal corticosterone metabolites

Faecal samples were collected from all pens, when the chicks were 16, 17 and 18 days old. Around 8:00 in the morning, a piece of paper (60 cm $\times$ 100 cm) was placed in the pens, and thirty minutes later droppings on the paper were collected. The procedure was repeated until at least eight droppings were obtained. To avoid degradation of the corticosterone metabolites in the samples after voidance, the 30 min time limit was kept strictly and the samples were stored at -18 °C immediately after collection. The level of corticosterone metabolites in the faecal samples were analysed using a cortisone enzyme immunoassay validated for domestic fowl (Rettenbacher et al., 2004).

2.6. Plumage and skin scoring

At the end of the experiment, the plumage and skin damage were determined using the scoring method used by Bilčík and Keeling (1999). All hens were taken from their pens and individually scored. For the scoring of the plumage, the body was divided into 11 regions: head, upper neck (back side of the neck), back (part between the wings), rump, tail, belly (abdomen), breast, under neck (front side of the neck), wing-primary feathers, wing-coverts and legs. Each body part was given a score from 0 (best) to 5 (worst; Table 1). Slightly different criteria were used for scoring flight feathers (tail and primaries) compared to feathers on the rest of the body, because of the different types of feathers and damage. The sum of scores given to the 11 body parts of a hen was taken as a whole body index. During the scoring of the skin, the 11 body parts described above plus the comb was evaluated after a different scale ranging from 0 (no injuries) to 4 (large wound; Table 1). Only data from the birds still alive when scoring the plumage and skin were included in the analysis.

Table 1
Description of scoring method used to evaluate the plumage and skin damage

Score	Body feathers	Wing-primary and tail feathers	Skin
0	Intact feathers	Intact feathers	No injuries or scratches
1	Some feathers scruffy, up to 3 missing feathers	Few feather separated but none broken or missing	<5 pecks or scratches
2	More damaged feathers, >3 feathers missing	A lot of feathers separated and/or a few broken or missing	≥5 pecks/scratches or 1 wound, <1 cm diameter
3	Bald patch <5 cm diameter or <50% of area	All feathers separated, a lot of broken or missing feathers	Wound >1 cm in diameter but <2 cm
4	Bald patch >5 cm diameter or >50% of area	Most of the feathers missing or broken	Wound >2 cm in diameter
5	Completely denuded area	Almost all feathers missing	–

A different scale was used for wing-primary and tail feathers compared to feathers on the rest of the body. Modified from Bilčík and Keeling (1999).

2.6.1. *Statistics*

All data were subjected to the repeated measures analysis in SAS® statistical programme using the Mixed procedure (SAS, 2000). The frequencies of feather pecking were summed weekly for all individuals within each pen, and the pens were used as the experimental units. The analysis of gentle feather pecking was conducted on two data sets; one including and one excluding pecks directed to dustbathing individuals. The reason for this distinction is that gentle pecking can be divided into normal gentle feather pecking, stereotyped gentle feather pecking and gentle pecking at particles on the plumage. The latter is not feather pecking behaviour, but can be mistaken for it, and is most often directed to dustbathing individuals (Rodenburg et al., 2004).

All data, except the data on faecal corticosterone metabolites, were log-transformed before analysis in order to obtain a normal distribution and homogeneity of variances. Least-square means and standard errors reported below are transformed back to the original scale, which is why the positive and negative standard errors may differ. The basic models used for analysis of the data on feather pecking, mortality and faecal corticosterone metabolites included the factors treatment and age. In the analysis of the plumage and skin scores, only treatment was included because the scoring was only conducted once.

3. Results

The chicks used the dark brooders without difficulties from day 0 until the dark brooders were removed at 5 weeks of age. However, the use of the dark brooders diminished when the chicks began to use the perches. Crowding outside the dark brooders was rarely seen.

3.1. *Feather pecking activity*

Only very sporadic severe feather pecking was observed in the dark brooder pens throughout the observation period; the maximum frequency per pen observed at any age was 0.5 ± 0.5 (mean $\pm$ S.E.) pecks/30 min (Fig. 1). A completely different result was

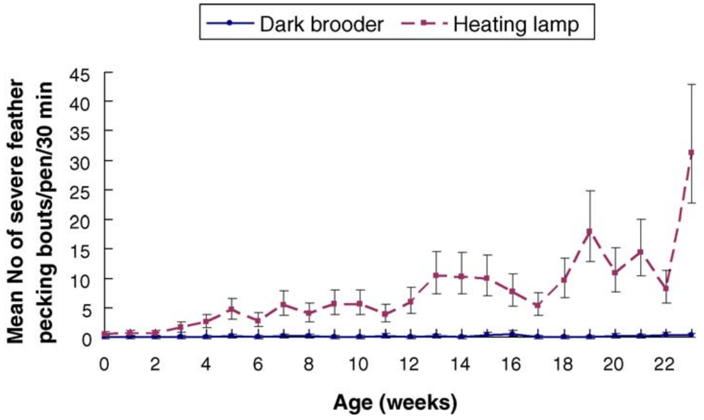

Fig. 1. Mean number and S.E. of severe feather pecking bouts per pen per 30 min for the dark brooder pens and the heating lamp pens.

found in the heating lamp pens, where the frequency of severe feather pecking continued to rise with age until the termination of the experiment at age 23 weeks, at which time the mean frequency per pen was 31.3 ± 10.1 (mean $\pm$ S.E.) pecks/30 min (Fig. 1). The frequency of severe feather pecking was found to be highly significantly dependent on the interaction between treatment and age (Mixed model ANOVA, $F_{23,229} = 3.78$, $P < 0.0001$), i.e. there was an overall (for all ages) positive effect of the treatment of dark brooders on severe feather pecking as compared to the treatment of heating lamps, but the magnitude of the effect was much more pronounced for higher age levels than for low age levels.

The weekly development of gentle feather pecking was quite similar for the two treatment groups, but the frequencies were higher in the heating lamp pens (Fig. 2). Gentle

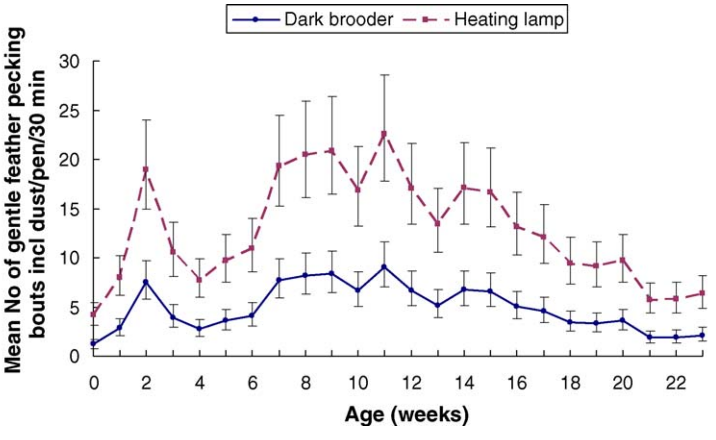

Fig. 2. Mean number and S.E. of gentle feather pecking bouts per pen per 30 min for the dark brooder pens and the heating lamp pens.

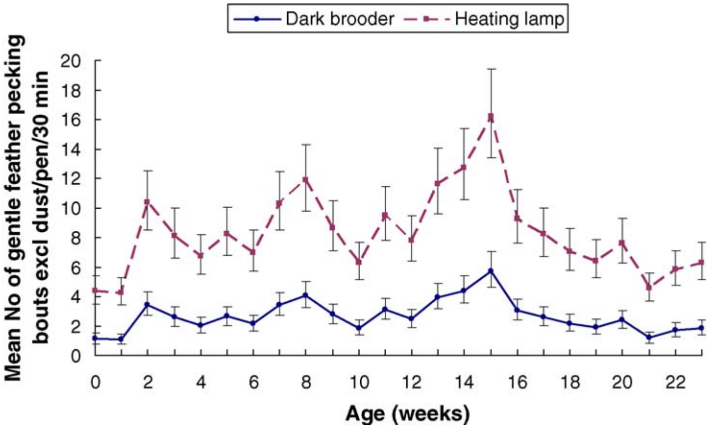

Fig. 3. Mean number and S.E. of gentle feather pecking bouts excluding the bouts directed to dustbathing individuals per pen per 30 min for the dark brooder pens and the heating lamp pens.

feather pecking activity peaked in both treatment groups in week 7–15 with the exception of a peak in week two, where after the frequencies gradually declined (Fig. 2). However, when removing gentle feather pecks directed to dustbathing individuals from the dataset, a clear peak in the frequency of gentle feather pecking bouts was found in week 15, which was the point of lay (Fig. 3). The proportion of gentle feather pecks directed to dustbathing individuals averaged over the entire experimental period was 0.54 for the chickens from the dark brooder pens and 0.65 for the heating lamp chickens. The effect of both treatment and age on gentle feather pecking was found to be highly statistically significant, both when excluding and including pecks directed to dustbathing individuals (Mixed model ANOVA, $F(\text{incl. dust, treatment})_{1,252} = 39.94$, $P < 0.0001$; $F(\text{incl. dust, age})_{23,252} = 4.22$, $P < 0.0001$; $F(\text{excl. dust, treatment})_{1,252} = 92.18$, $P < 0.0001$; $F(\text{excl. dust, age})_{23,252} = 3.29$, $P < 0.0001$).

3.2. Mortality

In the dark brooder pens, only one individual was found with injuries inflicted by cannibalism during the entire experiment, whereas a total of 24 individuals from five of the six heating lamp pens were either found dead or injured due to feather pecking or cannibalism during the daily inspections (Fig. 4). Nine of the cannibalised birds had been pecked around the cloaca or partly eviscerated, and the remainder had wounds on other parts of the body, frequently the back or the base of the tail. The first cannibalistic attack coincided with the onset of lay at 15 weeks of age, as shown in Fig. 4. Mortality was found to be highly significantly dependent on the interaction between treatment and age (Mixed model ANOVA, $F_{23,227} = 6.69$, $P < 0.0001$), i.e. there was an overall (for all ages) positive effect of the treatment of dark brooders on mortality as compared to the treatment of heating lamps, but the magnitude of the effect was much more pronounced for higher age levels than for low age levels.

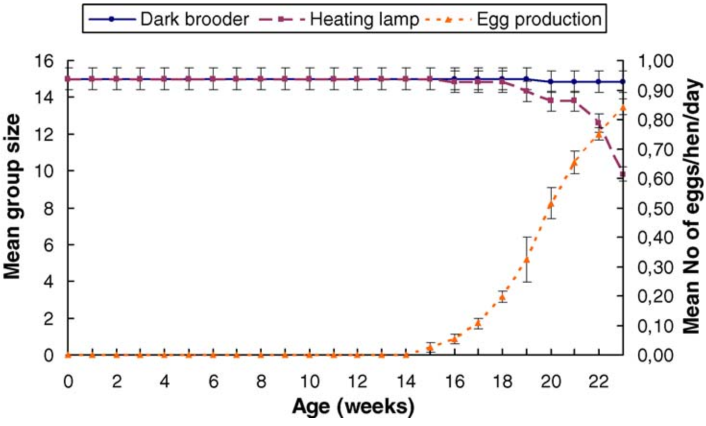

Fig. 4. Mean group size and S.E. for the dark brooder pens and the heating lamp pens in relation to mean daily egg production per hen.

3.3. Faecal corticosterone metabolites

The mean level of faecal corticosterone metabolites was 104.6 ± 10.5 (mean ± S.E.) ng/g faeces for the dark brooder pens and 101.0 ± 10.5 (mean ± S.E.) ng/g faeces for the heating lamp pens. The concentration of faecal corticosterone metabolites did not differ between the two treatment groups (Mixed model ANOVA, $F_{1,22} = 0.06$, $P = 0.8140$) or between the three consecutive days of faecal collection (Mixed model ANOVA, $F_{2,22} = 1.83$, $P = 0.1846$).

3.4. Plumage and skin scoring

In the dark brooder pens, 39 out of 89 hens had no wear of the feathers on any of the body parts, 48 hens had a score of 1 on single body parts, and only two hens were found with a score of 2 on single body parts (cf. Tables 1 and 2). The condition of the plumage of the individuals from the heating lamp pens was considerably worse; only 10 out of 67 hens were found with no wear of the feathers, 17 hens had a score of 1 on single body parts, 16 hens had a score of 2, 17 hens had a score of 3 and seven hens had a score of 4 on single body parts (cf. Tables 1 and 2). The body parts that were mainly affected were the back, rump, coverts and tail. The difference between the individuals from the two treatments was found to be highly significant (Mixed model ANOVA: $F_{1,144} = 13.11$, $P = 0.0004$).

Table 2
Mean body indexes and S.E. for plumage and skin damage of the hens in the dark brooder pens and the heating lamp pens

Treatment	Plumage	Skin
Dark brooder	0.74 (±0.3)	0.04 (±0.1)
Heating lamp	3.27 (±0.8)	0.44 (±0.2)

No hens from the dark brooder pens were found with injuries on the skin, except five out of 89 hens that had minor pecks on the comb (Table 2). Twelve hens out of 67 from the heating lamp pens were found with pecks, scratches and minor wounds and six hens with large wounds. The body part mainly injured was the rump. The difference between the individuals from the two treatments was found to be statistically significant (Mixed model ANOVA, $F_{1,144} = 4.97$, $P = 0.0273$).

4. Discussion

The findings support the prediction that dark brooders providing inactive chicks the possibility of resting separately from active chicks impede development of feather pecking. The dark brooders provided a hide for resting individuals and also prohibited foraging or dustbathing chicks from visible contact with the resting chicks, i.e. the dark brooders separated active chicks from inactive chicks, whereby the risk of developing severe feather pecking was reduced due to an impediment of misimprinting on feathers as either food or dust. The importance of separating active chicks from inactive chicks is supported by Riedstra and Groothuis (2002), who found that feather pecking was mainly seen under the heating source and took place particularly around the onset and offset of resting bouts, which is also the time where the chicks within a group are the least synchronized in activity (Jensen et al., in prep.).

The effect of the dark brooders proved to be long-lasting in that severe feather pecking and cannibalism had not developed by the time the full-grown laying hens had reached a near peak egg production. In addition, the dark brooders had a preventive effect on cannibalism due to vent pecking, which has been regarded by some authors to be independent of feather pecking, because even fully feathered individuals may become victims (Hughes and Duncan, 1972; Allen and Perry, 1975). An abrupt increase in severe feather pecking was not observed at the onset of lay, but a peak in the frequency of gentle feather pecking excluding pecks to dustbathing individuals did coincide with point of lay, supporting a previous study reporting an increase in feather pecking around point of lay (Hughes, 1973). The onset of cannibalism also coincided with the point of lay.

Until the present experiment was conducted, the effect of dark brooders on feather pecking has only been investigated in one previous experiment, where only the short-term effects were investigated (Johnsen and Kristensen, 2001). Johnsen and Kristensen (2001) tested the effect of dark versus light brooders on development of feather pecking during the first 3 weeks of life in layer hen chicks and found a significant lower frequency of severe feather pecking in the groups provided with dark brooders. They did, however, not find a difference in plumage condition and speculated whether that was due to feather pecking taking place under the dark brooders, where the chicks were out of sight. In the present study, no sharp increase in the observed frequency of feather pecking was recorded in the dark brooder pens, when the dark brooders were removed at 5 weeks of age, making it unlikely that any appreciable amount of feather pecking took place under the dark brooders. As far as the observer in the present study could hear and observe, the darkness under the dark brooders instigated immediate resting, when a chick went under a dark brooder.

The effect of the dark brooders was long-lasting despite only being provided during the first 5 weeks after hatching. This supports the generally accepted notion that early experience is very important in the development of pecking behaviour (Blokhuis and van der Haar, 1989, 1992; Braastad, 1990; Nørgaard-Nielsen et al., 1993; Johnsen et al., 1998). A sensitive period for recognition of food have been suggested around 3–5 days of age (Hess, 1964; Brown, 1964), and likewise has it been argued that chicks ‘‘imprint’’ on dustbathing substrate during the first 10 days of life with a sensitive period peaking around day 3 (Sanotra et al., 1995; Vestergaard and Baranyiova, 1996). Thus, the sensitive period for recognition of food and dust, and consequently where ‘‘misimprinting’’ on feathers was at risk, was embedded in the period where the dark brooders were provided.

The present study was designed to develop a device efficient in reduction or elimination of severe feather pecking and did not aim at differentiating between the redirected ground pecking hypothesis and the dustbathing hypothesis. However, a substantial amount of feather eating was observed in the groups, where severe feather pecking developed. Eaten feathers were taken both from the floor and plucked directly from pen-mates. It has previously been reported that feather eating is associated with feather pecking and that feather peckers pick up, manipulate and eat feathers significantly more often than non-feather peckers (McKeegan and Savory, 1999, 2001). Thus, the high level of feather eating by the feather peckers found in the present study could be taken as an indication of the feather pecking being connected to foraging.

In the dustbathing hypothesis, Vestergaard et al. (1993) suggested an association between dustbathing and feather pecking on the basis of their findings that feather pecking increased during periods with dustbathing activity. This was further supported by their findings that feather pecking is mainly performed by those individuals not engaged in dustbathing and that the act is often directed to dustbathing individuals (Vestergaard et al., 1993). From Figs. 2 and 3 in the present experiment it can be inferred that a notable proportion of gentle feather pecks were directed to dustbathing individuals. However, only a very small proportion of the recorded severe feather pecks were directed to dustbathing individuals, making the support of the proposed association between dustbathing and feather pecking minimal.

More recently a third hypothesis has been proposed by Riedstra and Groothuis (2002, 2004), who argue that gentle feather pecking at an early age is not related to dustbathing or foraging but is instead part of normal social behaviour with the function of building and maintaining social relationships between chicks. According to their hypothesis, severe feather pecking is an intensified form of gentle feather pecking caused by social stress. The heating lamp chicks in the present study, which had no separate resting area, may have experienced social stress due to disturbances during sleep by active chicks. As only the heating lamp chicks developed severe feather pecking, the behavioural results of the present study are in accordance with the hypothesis of Riedstra and Groothuis (2002). However, an increased stress level, measured as corticosterone metabolites in faecal samples, in the heating lamp chicks compared to the chicks from the dark brooder pens could not be found. Thus the hypothesis that social stress caused the development of severe feather pecking in the heating lamp chickens could not be supported by the physiological measurements. It has previously been shown that the concentration of plasma corticosterone can be a reliable indicator of acute and relatively short-lasting stress in chickens (Beuving and Vonder, 1978, 1986), and a correlation between plasma steroid concentrations and faecal metabolites have been reported in chickens (Dehnhard et al., 2003). Two possible explanations as to why a difference in corticosterone concentrations was not found are: (1) the stressor was not substantial enough to cause a difference and (2) adaptation to the lack of a separate resting area as a long term stressor may have occurred prior to taking the faecal samples, causing the concentration of corticosterone in the heating lamp chicks to return to a level similar to that of the chicks from the dark brooder pens. The latter has been found in mammals exposed to a chronic stressor (Becker et al., 1985; Ladewig and Smidt, 1989; Fordham et al., 1991; Cockram et al., 1994; Janssens et al., 1995) and indication of adaptation to 6–7 day long exposure to stressors has been found in laying hens (Beuving and Vonder, 1978).

5. Conclusions

The results suggest that the provision of dark brooders has a long-lasting reducing effect on the frequency of feather pecking and cannibalistic attacks, resulting in reduced mortality and an improved condition of both plumage and skin.

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