
Managing laying hen flocks with intact beaks

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1 Introduction

Worldwide, the majority of laying hens are beak trimmed to prevent injurious pecking. Although this procedure has been refined over the past few years from hot blade trimming (in Europe mostly at 6 weeks of age) to infrared treatment in the hatchery (which is less painful and therefore is referred to as 'treatment' instead of 'trimming'), it is still a mutilation causing pain and discomfort to the birds (Cheng 2006, Marchant-Forde et al. 2008). Therefore, in various countries a ban on beak treatments has come into force (e.g. Sweden) or is being discussed (e.g. the United Kingdom, Germany and the Netherlands). In addition, the European legislation prohibits beak treatment of organic flocks. When it is no longer allowed to treat the beaks, farmers are facing the challenge of preventing injurious pecking behaviour in their flocks. This requires specific management skills.

Injurious pecking comprises any pecking that leads to feather or skin damage. It leads to bald flocks, which have a lower feed efficiency, and it may lead to wounds and mortality. Birds with trimmed beaks also perform injurious pecking behaviour, but the blunt beaks do not cause as much damage as intact beaks do. This makes the necessity to prevent this behaviour less urgent in flocks with trimmed beaks.

2 Types of feather pecking

There are various types of injurious pecking behaviour: (1) aggressive pecking, forceful pecks directed at the head or neck of the recipient to establish and maintain a dominance hierarchy, but usually not resulting in much feather damage; (2) gentle feather pecking, usually directed at the tips of the feathers without causing any damage; (3) severe feather pecking, consisting of forceful pecks and pulling out of feathers that are frequently eaten and resulting in feather loss on the back, vent and tail area; (4) tissue pecking in denuded areas, a form of cannibalistic pecking where pecking continues on the skin, leading to wounds; (5) vent pecking, possibly leading to the pulling out of the inner organs (Rodenburg et al. 2004, 2013, Savory 1995). Feather pecking is the pecking at feathers of conspecifics, as described under type 2 and 3 of injurious pecking behaviour. Sometimes a feather pecking bird may also peck at its own feathers. As gentle feather pecking does not harm the feathers, it is usually not regarded as problematic behaviour. However, gentle feather pecking can develop into severe feather pecking when the severity of the pecks increases and, therefore, is often regarded as a first sign in the onset of severe feather pecking (Rodenburg et al. 2004). Not all scientists support this hypothesis, as a relationship between gentle and severe feather pecking has not always been observed (Newberry et al. 2007). Aggressive pecking is part of the agonistic behavioural repertoire of chickens and most likely has a different motivational basis than feather pecking (Savory 1995). Tissue pecking and vent pecking are also distinct types of pecking behaviour, although they may be triggered by damage caused by severe feather pecking (Rodenburg et al. 2004).

Gentle feather pecking can already be seen in day-old chicks. Severe feather pecking can be seen in the rearing phase, but is mostly not very frequent. The first signs of severe feather pecking usually appear early in the laying period (Rodenburg et al. 2004, 2013). Rodenburg et al. (2004) found 15% of the hens performing severe feather pecking at 30 weeks of age. According to farmers' observations in the United Kingdom, feather pecking started on average at 23 weeks of age, with a range of 14–40 weeks of age (Lambton et al. 2015).



Figure 1 Signs of feather pecking at the base of the tail.



Figure 2 Rough feather cover due to moulting.

Not all feather damage is caused by feather pecking. Feather damage may also be caused by abrasion at feed troughs (front of the neck), wire side partitions (wings) or artificial grass mats in nest boxes (breast/belly) (Heerkens et al. 2015, Rodenburg et al. 2004, Savory 1995). Figure 1 presents clear signs of feather pecking, which often (but not exclusively) starts at the base of the tail. Sometimes feather pecking damage is hard to distinguish from rough feather cover due to moulting (Fig. 2).

3 The origin of feather pecking behaviour

In (semi-)wild conditions, chickens spend about 60% of their time foraging. Pecking behaviour is an element of foraging and part of the natural behavioural repertoire of chickens. Blokhuis (1986) showed that the motivation for non-aggressive pecking at conspecifics varies along with ground-pecking motivation, supporting the view of a common regulating mechanism. On the basis of this, Blokhuis developed the theory that feather pecking is redirected ground-pecking.

Vestergaard et al. (1993) indicated a relationship between feather pecking and absence of suitable dustbathing substrate. There is also evidence that early feather pecking could be interpreted as social exploration (McAdie and Keeling 2002, Rodenburg et al. 2004). Feather pecking has a hereditary component with a reported heritability ranging from 0.04 to 0.50 (Bessei 1996, Kjaer and Hocking 2004, Rodenburg et al. 2004). Selection for higher levels of feather pecking may also result in more fearfulness, higher stress levels and lower immune response (Bolhuis et al. 2009, Buitenhuis et al. 2004, De Haas et al. 2013). De Haas et al. (2014b) found a correlation for stress and feather damage between parents and offspring. They measured feather damage and stress in parent flocks and found that flocks with high levels of maternal feather damage and stress produced

offspring with higher stress levels and more feather damage. This was particularly the case for white genotypes; for brown genotypes, the relations were not significant. This indicates that feather pecking may be a problem that needs to be addressed throughout the whole production chain.

4 Prevention of feather pecking: rearing conditions

Apart from the genetic predisposition and maternal influences, many factors have been identified as affecting the onset and severity of feather pecking. They can be led back to the theory of redirected ground pecking (Blokhuis 1986, Vestergaard et al. 1993) or to the findings that stress and fear may trigger feather pecking. All factors add up until a threshold is surpassed; at that point, feather pecking will start. Good management can reduce the amount each factor adds to reaching the threshold at which feather pecking starts. This is most successful in preventing the onset of feather pecking but, once it has started, it also helps to prevent escalation. Lambton et al. (2013) indeed showed that a management package does help to reduce levels of feather pecking, although, once started, feather pecking is very hard to stop (Bestman et al. 2009, De Haas et al. 2014a). This section will concentrate on how rearing conditions can be managed to minimise feather pecking. Section 5 then covers the prevention of feather pecking during the laying period.

Bestman et al. (2009) showed that the rearing period has a major influence on the incidence of feather pecking later in life. If (organic) birds did not show feather pecking in the rearing period, there was a 71% chance they would not start feather pecking in the laying period. Flocks that did perform feather pecking in the rearing period also did this in the laying period in 90% of cases. These findings were confirmed by other authors (De Jong et al. 2013, Gilani et al. 2013, Janczak and Riber 2015). Several authors have reported risk factors for feather pecking in the rearing period. One of the major factors is the presence or absence of litter. Although Nicol et al. (2001) indicated that birds could compensate for an earlier absence of litter, most authors find that early presence of litter influences the incidence of feather pecking later in life and disruptions in litter availability during rearing may lead to feather pecking in both the rearing and laying periods (Bestman et al. 2009, De Haas and Rodenburg 2014, Gunnarsson et al. 1999, Huber-Eicher and Sebö 2001, Vestergaard et al. 1997). Higher stocking densities during rearing are also associated with a higher risk for feather pecking. Bestman et al. (2009) found more feather pecking at a density of 34 birds/m² compared to 21 birds/m² (both during the first 4 weeks of rearing). Huber-Eicher and Audige (1999) found more feather pecking in flocks reared at densities of more than 10 birds/m². Stocking density, as such, only influences the space per bird. However, apart from the space availability, it is also important what the birds can do with it and thus what the design of the space is.

Various studies reported positive effects of a more complex environment on bird welfare (Colson et al. 2008, Janczak and Riber 2015). More complex refers to the presence of perches, elevated platforms with feed and water supplied on them, foraging material and other enrichments. Other enrichments may be provided as objects stimulating pecking behaviour, like pecking blocks and string devices. These reduce feather pecking, especially when introduced at a young age, preferably as early as day 1 (De Haas and Rodenburg 2014, McAdie et al. 2005). A more complex environment keeps birds busy and thus prevents them from developing feather pecking. This not only applies to the rearing

period, but may also have a long-lasting effect throughout the laying period. For instance, perches in the rearing period reduce the incidence of feather pecking in the laying period (Huber-Eicher and Audige 1999) and may also reduce vent pecking (Donaldson and O'Connell 2012, Gunnarsson et al. 1999). Special measures in the rearing period may, therefore, be one of the best ways to prevent feather pecking throughout the whole life of the laying hen. One of these special measures is the so-called dark brooders. These are heaters with a dark enclosure underneath, placed on the litter in the rearing house, mimicking the brooding hen. Especially in the first week of rearing, when the chicks are held under 24-h light, the brooders are used by the chicks to hide and seek warmth. Gilani et al. (2012) found direct effects on the level of feather pecking during rearing, but also found less feather damage in the laying period in flocks that had been reared with dark brooders. Only a few trials on commercial farms have been carried out with dark brooders, but they seem to have a long-term preventive effect on feather pecking (Gilani et al. 2012, Jensen et al. 2006).

In terms of increasing environmental complexity, free range is probably the most enriched environment. Although providing additional ranging area is very uncommon in rearing birds, free range is available in organic rearing. Owing to climatic reasons, this only comprises the second half of the rearing, when the pullets are able to maintain their body temperature and have a good feather cover to withstand outside temperatures. Only a few studies have been conducted regarding the use of outdoor range for pullets (Janczak and Riber 2015) and all find similar results. Early use of, or access to, a free-range area reduced fearfulness, even if the duration of the outdoor access was only one week. In addition, birds that had access to free range during rearing tended to use the outdoor area in the laying period better (Krause et al. 2006). Other management measures that reduce stress and fear in both the rearing and laying phases, for example, a radio and frequent contact with humans, may also reduce the incidence of feather pecking (De Haas and Rodenburg 2014, Jones 2004, Lambton et al. 2013).

An often underestimated effect on the onset of feather pecking is the climate in the poultry house. Bad climatic conditions (high CO₂, ammonia) can result in stress and feather pecking (Drake et al. 2010). In a large survey on commercial farms, Drake et al. (2010) found an average of 20.9 ppm ammonia in rearing houses between 15 and 17 weeks of age, with the lowest being 0 and the highest being 100 ppm. Each 15 ppm higher ammonia level raised the chance of feather pecking by 10%. Average levels of CO₂ were 586, with the lowest being 43 and the highest being 2000 ppm. Each 200 ppm more CO₂ represented an almost 15% higher risk for feather pecking. Maintaining a good climate may be easier in multi-tier systems with manure belts compared to floor systems with a manure pit (Dekker et al. 2011).

Most authors report more feather pecking in flocks kept under higher light intensities (Drake et al. 2010, Janczak and Riber 2015, Kjaer and Vestergaard 1999), but some find the opposite (Bestman et al. 2009, Gunnarsson and Hermansson 2011). However, light sources in the different studies vary greatly, making the spectrum of the light completely different. Studies reporting daylight often do not mention if this is filtered by a glass window, taking out the UV component. Most artificial light sources hardly contain the ultraviolet spectrum, which can be seen by the birds and which may play an important role in their perception of the environment (De Jong et al. 2013, Gunnarsson et al. 2008). UV does not play a role in reproduction, but it does have an influence on the synthesis of vitamin D3 and thus on skeletal and skin health (Lewis et al. 2000). Moreover, it seems to play a role in the recognition of conspecifics and in vision of the environment. The exact

mechanism is not known, but UV light seems to have an influence on feather pecking, where there is less feather pecking in the presence of UV (Lewis and Gous 2009). In recent years, LED has become increasingly popular. As this type of light does not seem to have a limitation in spectral range, it can be adapted to the needs of the birds. Although a lot is known about the vision of poultry (Lewis and Morris 2006), the optimal spectrum and best illumination in relation to the onset of feather pecking is not yet completely understood. In general, it is agreed that low-frequency light sources should be avoided, as poultry can see the flickering and may respond in a more stressful way (Lisney et al. 2012). Not only does this apply to fluorescent lights, but also LED may have a flickering frequency due to the dimming electronics. Dimming is often realised by rapid on–off switching of the LED. In some LEDs with low frequency of on–off switching, at a certain stage of dimming, this may be perceived as flickering (Niu and Takagaki 2016).

Feed has an important influence on the prevalence of feather pecking in both the rearing and laying periods. It is well known that deficiencies in minerals, proteins or amino acid levels (methionine, arginine) will lead to feather pecking (Krimpen et al. 2007). Structure also influences the prevalence of feather pecking. Small particle size will keep the birds occupied for a longer time and thus prevent the development of feather pecking behaviour. Not only research findings but also analysis of results on commercial farms confirmed this finding (Lambton et al. 2010). Low-energy diets require birds to eat more and thus may have the same result. Diets with high-fibre content will provide a longer satiation to the birds, may improve gut health and postpone the onset of feather pecking (Krimpen et al. 2005, Lambton et al. 2015, Van Krimpen et al. 2009). With regard to feed composition, Lambton et al. (2010) indicated that changes in formulation may lead to feather pecking. This seems to be in conflict with phase feeding strategies, where different formulations are used in different periods of the life of the laying hen in order to meet the demands of the birds as best as possible. Further research is needed to fine-tune these two seemingly conflicting interests. If the changes in formulation are limited, the risk for feather pecking may be lower than the benefit of an optimal feed formulation.

Finally, any change in husbandry may induce stress and lead to feather pecking (De Jong et al. 2013, Drake et al. 2010, Janczak and Riber 2015, Van de Weerd and Elson 2006). Changes are most pronounced in the transition from rearing to the laying house. This potentially stressful event can easily lead to feather pecking. The more similar the rearing and laying environments, the lower will be the level of stress. Similarities may concern the housing system (layout, feeder system, drinkers and light) and management (e.g. lighting conditions and schedule, feeding times and enrichment) (Janczak and Riber 2015). It is therefore advisable for laying hen keepers to have close contact with the rearer to prepare the pullets in the best way for their stay in the laying house. This also enables the laying hen keeper to start the laying period with a management package that is as much similar to the rearing management as possible.

5 Prevention of feather pecking: laying period

The prevention of feather pecking in the laying period does not differ to a large extent from the rearing period, as similar management and housing factors are involved and should be addressed. Some additional elements related to egg laying are involved, putting other demands on the birds. For some flocks, the free range may be an additional

factor. Finally, the laying period comprises a longer period and problems at the start may have long-lasting effects. Hence it is important to monitor performance and behaviour of the birds thoroughly from the beginning. Although the propensity to develop feather pecking behaviour may originate in the rearing period, feather damage generally is not a problem before 20 weeks of age, and the severity increases with age (De Haas and Rodenburg 2014, Huber-Eicher and Sebö 2001, Lambton et al. 2010).

Although the possibilities to provide enrichments are limited in furnished cages, feather quality in general is better compared to non-cage systems (Nicol et al. 2013). This could be related to group size, as smaller groups are less prone to initiate feather pecking (Rodenburg and Koene 2007). Both group size and stocking density have effects on feather pecking, but often experimental setups fail to distinguish between the two. Higher stocking densities and larger groups seem to result in higher levels of fear and stress, and this may trigger feather pecking (De Haas et al. 2013, Nicol et al. 2013, Rodenburg et al. 2013, Zimmerman et al. 2006).

In addition, the type of housing system has an influence on feather damage. Birds in single-tier non-cage systems tend to have poorer feather cover than birds in aviaries (Sherwin et al. 2010). This may be because multi-level systems allow birds to escape from conflicts more easily. This is in line with the finding that elevated perches result in better feather cover if positioned well (Forkman 2005, Sandilands et al. 2009). Well positioned not only means easily accessible to prevent keel bone damage but also refers to the height of the perch. Perches on a height of 45 cm may lead to vent pecking, whereas perches at 70 cm height will not have this risk (Bilcik and Keeling 2000). The type of multi-tier system also has an influence on the feather cover. Flocks in aviaries with wire floors tend to have better feather cover compared to flocks in aviaries with plastic floors (Heerkens et al. 2015). This might be related to the presence of red mites, as in the same study infestations with red mites were higher in systems with plastic slats. In large quantities, red mites not only lead to anaemia and higher mortality in affected flocks, but also lead to higher levels of stress (Kowalski et al. 2006, Mul et al. 2009). Both health and stress issues increase the risk for feather pecking.

Enrichment in the hen house is important to prevent the development of feather pecking. Several researchers report the positive effects of enrichment materials, such as roughage, hay bales, string devices or pecking stones (Daigle et al. 2014, De Haas and Rodenburg 2014, Holcman et al. 2008, Lambton et al. 2013, McAdie et al. 2005). Dixon et al. (2010) reported the lowest level of feather pecking when foraging materials were provided and the highest level when no additional material was present. The presence of dustbaths and novel objects gave intermediate results. In general, enrichment material is thought to be more effective if it contains edible particles, as it keeps hens interested in the material (Lambton et al. 2010).

Free range is an important enrichment factor as well, with a known positive effect on feather pecking. Several studies have shown that a higher usage of the free range was associated with less feather damage due to feather pecking (Bestman and Wagenaar 2003, Green et al. 2000, Lambton et al. 2010). Hens may be encouraged to use the free range by providing suitable shelter, which can be artificial (roofs and nettings) or natural (trees and bushes). The size of the range is less important, but the degree of shade and shelter (i.e. quality of cover) does have a relation with the use of the range and thus the preventive effect on feather pecking (Bright et al. 2016).

Feed has been identified as a major factor in the prevention and control of feather pecking. Wild jungle fowl allocate 60% of their daytime to foraging (Dawkins 1989).

Laying hens still have this urge for foraging. Feed that is high in insoluble fibres, such as non-starch polysaccharides (NSPs), increases feeding time, and this leads to a later onset of feather pecking (Krimpen et al. 2007). Van Krimpen et al. (2009) increased the NSP concentration of the rearing diet from 124 to 184 g/kg, and in the laying diets from 72 to 115 g/kg, and found a significant better feather cover. Lambton et al. (2010) indicate that fibre content should be above 80 g/kg to reduce feather pecking. Fibres also have a positive effect on gut motility and health, which may reduce the incidence of feather pecking (Rodenburg et al. 2013). Finally, small particle sizes like mash feeding instead of pellets can prolong the feeding time and lead to less damage due to feather pecking (Lambton et al. 2010). Lambton et al. (2010) stated that, in addition to particle size and fibre content, protein content and the prevention of deficiencies are also important in preventing feather pecking (increased feather pecking was associated with the following: crude protein <125 g/kg, lysine <8.2 g/kg, methionine + cysteine <5.1 g/kg). Although it is often mentioned that feather pecking has increased after animal origin protein was removed from the feed (as a measure to reduce the risk of BSE-like health problems), Krimpen et al. (2011) could not confirm this effect. The ban on processed animal proteins in poultry feed made it necessary to use other protein sources. This resulted in a major change in feed formulation, which makes it hard to find a precise cause for the possibly higher levels of feather pecking. Lambton et al. (2010) found differences in feather pecking between flocks fed from different feed companies, indicating that feed formulation may have a major influence. This was also confirmed by Green et al. (2000) in a large survey of flocks in alternative housing systems. These authors found that three or more diet changes in the laying phase were associated with a higher risk for feather pecking.

Not only changes in feed but also changes in management may cause stress to the birds (Hemsworth 2009). Stress is known to have a relationship with feather pecking in that more stressed and fearful birds tend to perform more feather pecking (Rodenburg et al. 2010), which itself may also result in more fearful birds (Vestergaard et al. 1993). The level of stress and fearfulness varies between genetic lines (Bolhuis et al. 2009, Kjaer and Hocking 2004). Rodenburg et al. (2013) indicated that genetic lines that differ in the tendency to show feather pecking often also differ in fearfulness. The authors found White Leghorns to be more fearful than brown egg layers; this was confirmed by De Haas et al. (2013). On commercial farms, white hens indeed tend to be more fearful than brown hens. However, it also tends to be easier to keep white layers with intact beaks in non-cage systems compared to brown hens. This is not in compliance with the findings that higher fearfulness more easily leads to feather pecking. As white and brown hens have genetically different founder lines, there are probably more factors that may play a role and interact with fearfulness and feather pecking. For instance, white hens tend to be more susceptible for influences of the parent stock: stressful events in the parent stock causes the offspring to be more stressful and more likely to start feather pecking. Brown egg layers are more sensitive to the presence of good foraging material (De Haas et al. 2014b). Reduction of stress in laying hens can also be done through management measures such as knocking on the door before entering the house, walking calmly through the flock and turning on a radio (De Haas et al. 2014a, Hemsworth 2004). Flocks can be trained to react less to changes in management. If daily routines are varying over time, birds get used to different situations, which then do not cause stress anymore. In this perspective, one can think of wearing overalls, of different colours or changing the inspection route through the hen house frequently (not always from left to right, but also from right to left and sometimes starting in the middle of the house). In flocks that are extremely fearful from the start this may be a

problem, but in other flocks this is a good measure to prevent stress in unforeseen cases (e.g. reparations in the house, vet visits).

Fearfulness and stress can be influenced by light intensity. Hens tend to react more calmly to novel objects in brighter light (Van Niekerk, non-published data), whereas dim lights may impair vision, making the birds less able to monitor their environment (Prescott and Wathes 2002). Negotiating distances may be more difficult in dimmed lighting, making it more difficult for birds to move through aviary systems (Moinard et al. 2004). In addition, hens are stimulated to forage under brighter light intensities (Prescott and Wathes 2002). A survey of 46 commercial farms in the Netherlands revealed that feather cover was better in flocks that were exposed to more daylight (with UV, not filtered by glass) (Van Niekerk, non-published data). This seems to be in conflict with the advice to dim the lights to prevent or reduce feather pecking. However, results on commercial farms are not always better in houses with dim lights. The quality of the light, and more specifically the spectrum, may be a key factor in this. There is still a lot unknown regarding the optimum light (spectrum and light intensity) for laying hens.

As mentioned earlier, health status does have an influence on feather pecking. Fibre content in the feed may have an influence on gut health. Consequently, a malfunction of the digestive and metabolic processing of the nutrients may result in deficiencies leading to feather pecking (Krimpen et al. 2005). Infectious diseases or worm infestations may cause a similar effect, although this is not always apparent or easy to prove (Gauly et al. 2007, Green et al. 2000). Hoglund and Jansson (2011) indicated that parasites reproduce more easily in hosts with a suboptimal condition, which could mean that birds that are under stress of feather pecking may be more susceptible to parasite infections. Meyer et al. (2013) found a correlation between feather eating and intestinal microbes, suggesting a relationship between feather eating and intestinal health. On the other hand, feather pecking may also be a result of suboptimal health. Buitenhuis and Kjaer (2008) found a relationship between selection against feather pecking and immune response, indicating that feather pecking may start in birds with a lower immune response, for example, as a result of a disease problem. Keeping the flock healthy and stress-free, therefore, may be one of the best measures to prevent feather pecking.

One of the measures to maintain a healthy poultry flock is good ventilation. This not only regulates temperature but also reduces ammonia and dust levels, and thus reduces the presence of endotoxins, airborne bacteria, fungi and other particles that may challenge bird health (Matkovic et al. 2009, 2010). Maintaining a good climate will also improve litter quality which, in turn, will encourage birds to be engaged with the litter instead of pecking at the feathers of conspecifics.

Lambton et al. (2013) investigated the effect of management on the prevalence of feather pecking and found that a bespoke management package indeed was protective against injurious pecking. This means that, even if feather pecking started in a flock, management can control it and thus is worth the effort.

6 Summary

Beak trimming of laying hens, as a measure to prevent injurious pecking behaviour, is a painful procedure that in several countries is or will be banned. Therefore, other strategies need to be applied to successfully keep laying hens with intact beaks. This phenomenon already starts in the rearing period with the provision of suitable litter material, providing perches and feed in small particles. If no feather pecking occurs in the rearing period,

there is an increased chance it will not develop in the laying period either. The transition from rear to lay is important as it implies a stressful period for the birds, which can give rise to feather pecking. The more similar the environment, equipment, feed and management is between rearing and lay, the lower the risk for the development of feather pecking. During the laying period, suitable litter, additional foraging material, feed with high-fibre content and small particle size are important factors in preventing the start of feather pecking. Maintaining good health and preventing or counteracting stressors will further reduce the risk, as does a free-range area with enough cover. If feather pecking does occur, a package of management factors, similar to the preventive measures, can be used to counteract the problem. This may even reduce the pecking behaviour.

7 Future trends in research

Drake et al. (2010) reported less feather pecking if birds were reared in the same house that was used for laying. Further research is needed to confirm this and to investigate how to realise and optimise this.

Feed formulation is one of the key factors in preventing the onset of feather pecking. Research has been conducted to find optimum formulations with regard to fibre, protein and energy. Feed is often formulated in various phases, so it meets the specific demands of the laying hen in the different phases of the rearing and laying period. However, changes in feed formulation are indicated as risk factor for feather pecking as well. Therefore, research should focus on phase feeding formulations that meet the requirements of the birds, but are subtle and thus not triggering feather pecking.

Light is a factor that has not yet been thoroughly examined. Although a lot is known about the vision of poultry, little is known about the ideal spectrum with regard to production and the prevention of feather pecking. Further research is needed so that manufacturers of LED light sources can build the optimal light source for laying hens. Also the role of natural daylight should be studied in more detail to find the specific aspects that play a role in either triggering or preventing feather pecking.

8 Where to look for further information

Several excellent review papers have been published on the causation and prevention of feather pecking (De Jong et al. 2013, Drake et al. 2010, Lambton et al. 2013, Nicol et al. 2013, Rodenburg et al. 2004, Van de Weerd and Elson 2006). A lot of more farmer-oriented information about feather pecking can be found on the project websites of FeatherWel (www.featherwel.org) and Hennovation (www.henhub.eu).

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