Department of Farm Animals and Veterinary Public Health
University of Veterinary Medicine Vienna

Institute of Animal Welfare Science
(Head: Univ.-Prof. Jean-Loup Rault PhD.)

Monitoring feather pecking in pullets and identification of risk factors and indicators

Thesis submitted for the fulfilment of the requirements for the degree of
DOCTOR OF VETERINARY MEDICINE (DR. VET. MED.)
University of Veterinary Medicine Vienna

submitted by
Mag. vet. med. Caroline Mels
Vienna, May 2022

Supervisor

Ao. Univ. Prof. Dr.med.vet. Dipl. ECAWBM (AWSEL) Susanne Waiblinger
susanne.waiblinger@vetmeduni.ac.at
+43 1 25077-4905

Institute of Animal Welfare Science, Department of Farm Animals and Veterinary Public Health, University of Veterinary Medicine, Vienna, Veterinärplatz 1, 1210 Wien, Austria

Co-supervisor:

Univ.-Prof. Mag. Dr. Andreas Futschik
Andreas.futschik@jku.at
+43 732 2468 6822

Institute of Applied Statistics, Johannes Kepler University, Linz, Altenberger Straße 69, 4040 Linz, Austria

Reviewer:

Dipl. ECPVS Univ.-Prof. Dr. med. vet. Michael Hess
michael.hess@vetmeduni.ac.at
+43 25077-5150

University Clinic for Poultry and Fish Medicine, Department of Farm Animals and Veterinary Public Health, University of Veterinary Medicine, Vienna, Veterinärplatz 1, 1210 Wien, Austria

Table of Contents

1. Introduction

In 1997, by signing the “Treaty of Amsterdam”, the Member States of the European Union (EU) agreed to give full regard to the welfare requirements of animals to ensure improved protection and respect for the welfare of animals as sentient beings. Since then, there has been more legislative attention devoted to animal welfare in the EU compared to other regions in the world (van Horne and Achterbosch 2008). Welfare is becoming an increasingly important aspect for consumers and animal-related products should be produced with respect for the animal (European Commission 2016, Alonso et al. 2020). Conventional cages have already been banned since 2012 and other welfare issues such as beak-trimming (which is already banned in Austria) and killing the day-old chicks of laying hens (prohibited in Germany since January, 2022) are now in the centre of attention (Bessei 2018).

Management and housing conditions (e.g. stocking density, lighting, climate, feeding systems, nests, health care, inspection or hygiene measures) for poultry in the European Union (EU) are regulated in detail by national laws and EU-Directives such as Directive 98/95/EC for all farmed animals or Directive 1997/74/EC for laying hens. The Council Directive 98/95/EC of EU legislation on the welfare of farm animals contains general requirements that reflect the principles for meeting basic needs of the so-called “Five Freedoms”, published by the Farm Animal Welfare Council in 1993: freedom from hunger, thirst and malnutrition; freedom from thermal and physical discomfort; freedom from pain, injury and disease; freedom from fear and distress; and, freedom to express normal behaviour (Webster 2016). In recent decades, supermarkets, quality labels and animal welfare organisations have become drivers in demanding higher welfare standards (Veissier et al. 2008). In various European countries, quality labels (e.g. the company-specific organic labels ‘Alnatura’ in Germany or ‘Ja Natürlich’ in Austria) and special welfare labels, often established by NGOs (e.g. “Für mehr Tierschutz” in Germany or “Tierschutz kontrolliert” in Austria), are considerably surpassing national legislation and aim to improve animal welfare above the standards (Veissier et al. 2008). In many cases, farmers are even paid an extra allowance for meeting the required welfare-friendly production standards (Bessei 2018).

In response to the increasing demand for the assurance of high quality animal products, monitoring schemes for assessing animal welfare have become essential as an advisory and management tool for businesses (Fraser 2008). The industry is required to ensure that animal welfare standards are being met. Therefore, there is a need for practical on-farm welfare assessments. Originally, these monitoring schemes aimed to guarantee a certain quality level of production by focussing predominantly on resource-based assessment, which has an impact on animal welfare (Veissier et al. 2008; Butterworth et al. 2009). Since the early 2000s, there are also moves to focus on the state of the animal, itself, and implement protocols assessing animal-based measures which indicate animal welfare (Waiblinger et al. 2001; Veissier et al. 2008; Butterworth et al. 2009).

Protocols for the monitoring of animal welfare provide a standardized, thorough assessment of animal-based parameters and of the actual husbandry conditions (Veissier et al. 2008; Butterworth et al. 2009). They should provide feedback for the farmers, information about the current animal welfare status and information about animal-related products for consumers (Butterworth et al. 2009). Several animal welfare assessment protocols have been developed, including Welfare Quality® for broilers and laying hens (Butterworth et al. 2009), AssureWel (Main et al. 2012) or LayWel (Blokhuis et al. 2007) for laying hens. No monitoring protocol specifically for rearing hens has yet been developed.

The implementation of the full protocol of Welfare Quality® for laying hens is time-consuming, with an estimated elapsed time of 6-7 hours with 100 animals of one flock being caught and examined (Butterworth et al. 2009). Data of four certain welfare principles with in total 12 welfare criteria is collected. This includes the assessment of good feeding (feeder and drinker space), good housing (comfort around resting, thermal comfort, ease of movement), good health (absence of injuries, disease and pain induced by management procedures), appropriate behaviour (expression of social and other behaviours, good human-animal relationship and positive emotional state). It further includes data collection at the slaughterhouse (e.g. breast deformation). The assessment of expression of social behaviours focusses on a detailed scoring of plumage damage and comb-pecking wounds. The AssureWel protocol was developed for commercial use with an estimated time of 15 minutes with 50 animals assessed per flock in the head/neck area and the back/vent area without handling the birds (Assurewel. http://www.assurewel.org/layinghens/featherloss.html; access: 27.04.2022). The protocol focusses on seven indicators: feather loss; bird dirtiness; beak trimming; ‘antagonistic’ behaviours (consisting of aggressive pecking and feather pecking); flightiness; birds needing further care; and, mortality. The protocol of the LayWel project, with a special focus on enriched cages, consists mainly of the assessment of plumage condition, pecking wounds on the comb and the rear, and bumble foot syndrome

(Laywel. https://laywel.eu/; access: 27.04.2022). Decina et al. (2019) tested the practical application and stated that AssureWel took about 30 minutes and LayWel about 50 minutes per flock.

However, despite the increasing demand for animal welfare, the above-mentioned protocols have not yet been implemented in Austria. The Welfare Quality® protocol is a detailed, but time-consuming welfare assessment to enable farms and slaughterhouses to be assigned to one of four categories, with animal welfare rankings ranging from ‘poor’ to ‘good’ (Butterworth et al. 2009). However, flock management always includes routine veterinary visits and visits of advisors of the integration. Inclusion of a broader welfare assessment during these visits might enable early detection of problems, allow early counteractions and thus improve flock welfare. However, it is difficult to apply time-consuming monitoring protocols such as Welfare Quality®. There have been encouraging attempts to establish monitoring systems on a routine basis for broilers. De Jong et al. (2016) developed a more simplified protocol based on the Welfare Quality® protocol and could reduce the on-farm assessment time to two-thirds of the time required originally, yet with reliable results.

All monitoring schemes for laying hens developed thus far focus on the assessment of plumage condition in addition to other parameters. Feather pecking is still a widespread problem (Gilani et al. 2013; Nicol et al. 2013; van Staaveren et al. 2021), is often described as a sign of reduced animal welfare for both performer and victim (McAdie and Keeling 2000; De Haas et al. 2013) and can further lead to cannibalism (Savory 1995). For the industry, poor performance and mortality due to feather pecking and cannibalism can lead to considerable economic losses (Nicol et al. 2013; Nicol 2017). Severe feather damage can cause a deterioration of the natural heat insulation of the bird, which results in an increased amount of heat loss that is compensated by consuming additional feed and, therefore, worsens the feed conversion rate (Mills et al. 1988; Peguri and Coon 1993; Yamak and Sarica 2012).

There are two different forms of feather pecking that can be observed, gentle feather pecking (GFP) and severe feather pecking (SFP; Rodenburg et al. 2013). GFP is only associated with minor plumage damage (Nicol 2019, Van Niekerk 2019). It is described as pecking or licking at the tips and edges of feathers and usually ignored by the recipient (Savory 1995). GFP was observed in young chicks pecking mainly at unfamiliar conspecifics, perhaps as a form of social exploration (Riedstra and Groothuis, 2002), but also occurs commonly during both the rearing and laying periods (Lambton et al. 2010; Nicol et al. 2013). In contrast, SFP is painful for the recipient when feathers are pulled out and might lead to increased fearfulness and stress in flocks (McAdie and Keeling 2000; Rodenburg et al. 2013). It is described as a form of redirected ground-pecking and foraging behaviour, but not as a form of aggression (Blokhuis 1986; Aerni et al. 2000). Although, there is still a debate whether GFP and SFP are associated (Lambton et al. 2010; Rodenburg et al. 2013), in practice GFP is regarded as the first sign of the occurrence of SFP (Van Niekerk 2019).

Factors affecting the onset of feather pecking are widely investigated and feather pecking is seen as a multi-factorial problem (Rodenburg et al. 2013, Nicol 2019, Van Niekerk 2019). Potential influencing factors can be the genetic background, fearfulness, hormonal status, health status (e.g. red mites, infections), nutrition, housing system, stocking density and group size, air quality, management and rearing conditions (for review see Van Niekerk 2019). The rearing conditions are considered to be crucial for the development of feather pecking not only during rearing, but also later as an adult (Bestman and Wagenaar 2003; Rodenburg et al. 2013) since the rearing of pullets determines their later behaviour as laying hens (Rodenburg et al. 2013; Schreiter et al. 2020). Flocks which have already started feather pecking during rearing are more likely to continue pecking as adult laying hens (Bestman and Wagenaar 2003). Taking all these aspects into account, feather pecking is one of the greatest welfare concerns and it is critical to detect feather pecking as soon as possible to avoid larger outbreaks.

1.1 Aims

The aim of the study was to devise and establish a monitoring system for rearing hens on a routine basis, in collaboration with a large poultry integration company, ‘Die Eiermacher’. The system should contribute to early detection of problems in flocks and identify possible causes for the occurrence of feather pecking and underperformance. Furthermore, it should offer a benchmark for farmers.

The following paper is one part of the establishment of this monitoring system, where we focused on the assessment of plumage damage and the occurrence of bloody lesions in the 6^{th}, 10^{th} and 16^{th} week as a proxy for feather pecking. The development of this monitoring protocol was based on previous welfare schemes (Welfare Quality®; Raubek et al. 2007) and modified for our purpose. We wanted to identify potential influencing factors such as environmental factors of housing and management or the role of the human-animal relationship for feather pecking and further identify easy-to-assess animal-related indicators that might contribute to early detection of its occurrence. The final scope was to identify problem flocks which perform constantly below others and to try to improve the situation there (e.g. improvement of management, housing conditions).

2. Publication

Predictors for plumage damage and bloody lesions indicative of feather pecking in pullets reared in aviaries

Caroline Mels, Knut Niebuhr, Andreas Futschik, Jean-Loup Rault, Susanne Waiblinger

Published in: Applied Animal Behaviour Science
https://doi.org/10.1016/j.applanim.2022.105607

Applied Animal Behaviour Science 250 (2022) 105607

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Predictors for plumage damage and bloody lesions indicative of feather pecking in pullets reared in aviaries

Caroline Mels[a,b], Knut Niebuhr[b,1], Andreas Futschik[c], Jean-Loup Rault[b], Susanne Waiblinger[b,*]

[a] Veterinary Practice: Tierarzt GmbH Dr. Mitsch, Hauffgasse 24, 1110 Wien, Austria
[b] Institute of Animal Welfare Science, Department of Farm Animals and Veterinary Public Health, University of Veterinary Medicine, Vienna, Veterinärplatz 1, 1210 Wien, Austria
[c] Institute of Applied Statistics, Johannes Kepler University, Linz, Altenberger Straße 69, 4040 Linz, Austria

ARTICLE INFO

Keywords:
Rearing
Injurious behaviour
Risk factor
Young laying hens
Early environment
Human-animal relationship

ABSTRACT

Feather pecking remains a serious problem in poultry farming. This study aimed to identify risk factors for plumage damage as a proxy for feather pecking, and the predictive value of practical animal-based parameters. Data were collected in 100 flocks on 28 rearing farms in Austria, recording plumage damage in the 10th and bloody lesions in the 6th, 10th and 16th weeks of age; housing (e.g. pre-rearing on another farm, early rearing on the floor or aviary), management (e.g. provision of litter) and human-animal relationship (e.g. avoidance distance, farmers' attitudes). Linear mixed models were calculated for plumage damage and generalized linear models for bloody lesions in the 10th week. Early floor-rearing of pullets with access to litter, instead of confinement in the aviary in the first weeks without access to litter, was associated with less plumage damage ($P = 0.011$). A shorter pre-rearing period on a different farm was associated with less plumage damage ($P = 0.035$). In organic flocks, bloody lesions tended to occur with a nearly three times lower probability with early floor-rearing than early aviary-rearing ($P = 0.062$) and when litter quantity in the 10th week was scored as high ($P < 0.001$). There were fewer down feathers on the ground when pullets had bloody lesions in the 10th week ($P<0.001$). Farmers' attitudes were associated with both plumage damage and bloody lesions; e.g. less plumage damage was observed when farmers ascribed more positive characteristics to pullets ($P = 0.020$). Avoidance of an unfamiliar human by the birds was associated with breed ($P = 0.001$) and was lower at higher stocking density ($P = 0.005$), but did not significantly predict plumage damage or bloody lesions. Farmers' attitude analyses revealed that farmers who agreed more on the importance of regular contact had pullets with lower avoidance distance ($P = 0.022$). The results confirm the importance of access to litter from the first day of life onwards: early floor-rearing with access to litter can substantially reduce the risk of feather pecking compared to confinement in the aviary with chick paper only, in the first weeks of life. However, the pre-rearing period is best kept relatively short and appropriate litter later in life is important for the prevention of feather pecking. The absence of down feathers on the floor is easy to record on a regular basis for the early detection and potentially prevention of feather pecking. Farmers' attitudes are important predictors for further variation in feather pecking between farms as well as in pullets' fear of humans.

1. Introduction

The occurrence of feather pecking is still a serious problem in poultry husbandry (Appleby and Hughes, 1991; Savory, 1995; Rodenburg et al., 2013; Nicol et al., 2013). It is often described as a sign of reduced welfare for both performers and victims, and it has a significant impact on pullets and adult laying hens in terms of welfare and performance (McAdie and Keeling, 2000; Bestman and Wagenaar, 2006; De Haas et al., 2013). Feather pulling is painful (Gentle and Hunter, 1991) and might lead to increased fearfulness (De Haas et al., 2013) and stress in flocks (McAdie and Keeling, 2000; Rodenburg et al., 2013). Feather pecking can also lead to cannibalism and increased mortality (Savory,

* Corresponding author.
E-mail address: susanne.waiblinger@vetmeduni.ac.at (S. Waiblinger).
[1] Deceased on 1.2.2020.

https://doi.org/10.1016/j.applanim.2022.105607
Received 26 November 2021; Received in revised form 16 February 2022; Accepted 14 March 2022
Available online 17 March 2022
0168-1591/

1995; McAdie and Keeling, 2000). In addition, feather damage reduces the insulation power of the plumage, which can decrease feed conversion rate and laying performance (Tahamtani et al., 2016). Thus, besides reduced animal welfare, economic losses can be a major concern (Nicol et al., 2013).

Feather pecking is described as a redirected pecking behaviour that originates from deprived foraging and pecking behaviour during early development (Blokhuis and Arkes, 1984; Vestergaard et al., 1993; Rodenburg et al., 2013). Hens often start feather eating and later peck at conspecifics if feathers are no longer available on the ground (Bestman et al., 2009; Rodenburg et al., 2013). Flocks that started feather eating and feather pecking during rearing might continue to do so in their adult life (Bestman and Wagenaar, 2003).

The occurrence of feather pecking is largely viewed as a multifactorial problem (for a review see Nicol et al., 2013) and risk factors and underlying causes of feather pecking have been investigated in previous experimental and on-farm studies (Kjaer und Vestergaard, 1999; Bestman und Wagenaar, 2006; Jong et al., 2013; Rodenburg et al., 2013; van Niekerk, 2019). Nevertheless, feather pecking is still a major problem, also on organic farms (Kjaer and Sørensen, 2002; van Niekerk, 2019), and there are still conditions and factors not yet considered.

One factor associated with feather pecking is genetics (Kjaer and Sørensen, 1997; Kjaer et al., 2001). Hens from a white breed origin tended to show more fearfulness and feather pecking than hens from a brown origin (De Haas et al., 2013; Rodenburg et al., 2013). So far, there are no studies that investigate feather pecking behaviour in Lohmann Sandy (LS). Lohmann Sandy is a relatively new breed originating from crossing a Lohmann Braun (LB) rooster with a Lohmann Selected Leghornhen (LSL). Hens from the LS line are increasingly used in Austrian organic egg production for several years due to their higher suitability for raising the male chicks for meat, with the issue of culling male chicks now rising as an international problem (Krautwald-Junghanns et al., 2018).

In addition to breed differences, rearing conditions are crucial for the development of feather pecking both during rearing and later as an adult (Bestman and Wagenaar, 2003; Bestman et al., 2009; Jong et al., 2013; Rodenburg et al., 2013). The rearing of pullets determines later behaviour and performance of the laying hen (Bestman et al., 2009; Rodenburg et al., 2013; Gilani et al., 2013; Schreiter, 2020). In Austria, it is common to rear young pullets on a different farm (specialised pre-rearing farm) in the first 3–6 weeks of age before transporting them to the rearing farm where they stay until being sold to a laying hen farm at approximately 17 weeks of age. Transportation and environmental changes can cause stress and weight loss (Lalonde et al., 2021), which might influence the occurrence of feather pecking in interaction with genetic dispositions and later laying performance (El-Lethey et al., 2000; De Haas et al., 2013; Rodenburg et al., 2013). However, to our knowledge there have been no studies on the effects of this pre-rearing practice on the development of feather pecking including transportation of pullets at 3–6 weeks of age.

High stocking density during rearing is also described as a risk factor for developing feather pecking during the rearing period (Huber-Eicher and Audigé, 1999; Bestman et al., 2009). Rearing pullets at lower stocking densities reduced plumage damage during rearing and also improved feather condition in the laying period (Hansen and Braastad, 1994; Bestman et al., 2009). Higher light intensity during rearing and light changes from the rearing farm to the layer farm result in poorer plumage condition and increases the prevalence of severe feather pecking (Kjaer and Vestergaard, 1999; Drake et al., 2010). Furthermore, fewer light hours (shorter light programs) can be another risk factor for the development of feather pecking (Gilani et al., 2013).

In addition to those risk factors, particular conditions may prevent feather pecking. Exposing young pullets to appropriate enrichment experiences reduces the risk of developing feather pecking or cannibalism (Johnsen et al., 1998; Tahamtani et al., 2016; Liebers et al., 2019), resulting in better plumage condition, and lower fear-related behaviour during rearing (Johnsen et al., 1998; Bestman et al., 2009; Tahamtani et al., 2016). Early access to litter such as straw, sand or wood shavings is important for promoting foraging, dust-bathing and pecking behaviour (Aerni et al., 2005; Rodenburg et al., 2013). In aviary systems, early access to litter or wood shavings compared to keeping pullets on wired floor lowers mortality and reduces feather pecking in adult laying hens (Nicol et al., 2001; Aerni et al., 2005). Similarly, access to an outdoor grazing area promotes natural foraging behaviour and can reduce the risk of feather pecking (Bestman and Wagenaar, 2003; Lambton et al., 2010; Gilani et al., 2014; Petek et al., 2015).

Fear of humans causes stress in animals and is negatively related to performance (Barnett et al., 1992; Hemsworth and Coleman, 2010), which can also contribute to the development of feather pecking (El-Lethey et al., 2000; De Haas et al., 2013). The farmer's behaviour is crucial for the human-animal relationship, especially in influencing the level of fear of humans by the animal, and is strongly based on farmers' attitudes (Waiblinger et al., 2006; Hemsworth and Coleman, 2010, 2011). Positive human behaviour (walking slowly through the flock, crouching and scattering grain) improves hens' relationship to humans (Graml et al., 2008). Farmers' attitudes relate not only to their handling behaviour but are also associated with management or daily care, thus affecting animal welfare via several pathways (Hemsworth and Coleman, 2010; Waiblinger, 2019). Accordingly, links between farmers' attitudes and plumage damage were found in a previous study on laying hen and rearing farms with brown commercial hybrids (Waiblinger et al., 2018).

The aims of this study were to investigate plumage damage as a proxy to feather pecking in pullets and to identify potential environmental and animal-related risk factors for its development. Besides the environmental factors of housing and management, we also studied the role of the human-animal relationship from both the animal (reactions to humans) and human side (attitudes of farmers) for feather pecking. Finally, we also aimed to identify animal-related measures that may contribute to early detection of feather pecking in the context of an on-farm routine-based monitoring system.

2. Material and methods

The study was reviewed and approved by the institutional ethics and animal welfare committee of the University of Veterinary Medicine, Vienna, in accordance with the Good Scientific Practices guidelines and national legislation (ETK-09/11/2018). The farmers were informed about the aim of the study and signed an informed consent form including the agreement for analysing and publishing the results of the study including questionnaire and interviews data in anonymized form.

2.1. Farms, animals and study design

Data were collected on 100 rearing pullet flocks, raised on 28 different farms. Eleven of those farms were conventional and the other 17 farms were organic. Conditions on organic farms differ systematically in some aspects from conventional ones: in organic rearing farms the provision of daylight and litter on the ground is mandatory, there is a lower stocking density (up to 12 animals per m^2 in organic vs. 20 animals per m^2 in conventional farms) and pullets must have access to a covered veranda as well as actual free range at a certain age. There are also differences in organic vs. conventional feed. All animals had intact beaks given that beak-trimming is prohibited in Austria. Farms raised pullets of three different hybrids: Lohmann Sandy (LS, 53 organic flocks, no conventional flocks). Lohmann Braun (LB, one organic and 25 conventional flocks) and Lohmann Selected Leghorn (LSL, 4 conventional flocks). In addition, 13 organic flocks were mixed of LS and LB hens and four conventional flocks were mixed of LSL and LB hens. Fourteen farms were farming on a regular basis, 14 on a sideline basis. All 28 farms were family-run without any other employees. Organic farms had one to two barns and conventional farms had one up to three barns in the same location. Organic farms kept from one up to four flocks on the farm in parallel. Conventional farms kept one to three flocks in parallel. On organic farms, most flocks were kept in two units (usually 4800 pullets per unit) in one building, separated by a wall. Flock size ranged from 4659 to 10,783 (mean±SD: 9360 ± 952.5) pullets on organic and 14,251–52,400 (mean±SD: 29,427 ± 11,496.6) pullets on conventional farms. The sample was a convenience sample comprising all farms of one single poultry integration company in service of one single veterinary poultry practice. This practice performed routine visits to each flock four times per rearing period, in the first, sixth, tenth and sixteenth week of age, as part of their flock health management program. These visits were performed by the six veterinarians working in the veterinary practice, except for the farm visits at the tenth week of age, which were conducted by only two of the six veterinarians, veterinarian I (CM) and II. All veterinarians were trained in data collection; for the main data collection in week 10 inter-observer reliability was tested (see below).

2.2. General information on data collection

Animal-based parameters were recorded at each farm visit, but there were differences between ages (see Section 2.3.) in the way those parameters were recorded. Some environmental factors were only relevant at specific ages (see Section 2.4). For data recording, age-specific sheets were, therefore, developed compiling animal-based and environmental parameters. General housing, general management and farmers' attitudes did not vary on the same farm and, therefore, these were only collected once by one person. The veterinary routine visit in the 6th, 10th and 16th week usually started with the vaccination via drinking water with the barn lights turned off. A sub sample of birds were then caught in the dark and feather condition score was assessed in a lighted environment in the anteroom. Once the light was turned back on, the veterinarian assessed the avoidance distance (see below for the exact procedure) and afterwards walked through the barn together with the farmer to assess animal reactivity, and body weight and uniformity were noted down from the automatic scale. Finally, various environmental factors were noted by checking computer records.

2.3. Feather condition and other animal-based parameters

Feather condition and the other animal-based parameters were recorded either on all visits (mortality, diseases); in the 6th, 10th and 16th week (weight and uniformity in weight, reactivity score, feather condition on flock level); only in the 10th week of age (feather condition on individual level, avoidance distance); or only in the 1st week (body temperature of chicks).

For assessing **feather condition**, a scoring system was developed (Table 1), based on previous scoring systems (e.g. Welfare Quality®, Niebuhr et al., 2007). For routine veterinary visits in the 6th and 16th week of life, ten animals per flock and per week were evaluated individuallyfor bloody lesions, where "yes" was assigned if one single animal was affected. Because the main focus of this study was on the 10th week of life, 15 animals were scored at this age for feather condition in addition to bloody lesions and a total plumage damage score was determined for each individual animal (see Section 2.7). Bloody lesions only occurred in the back/base of tail area and never in the belly area. Therefore, the scoring of "bloody lesions" and "back feathers" were not completely independent of one another, since as soon as bloody lesions occurred, there was also a score 2 or 3 for the area "back feathers/base of tail". The sampled birds in 6th, 10th and 16th week were independent random samples. We calculated sample size according to Noordhuizen et al. (1997). The sample size of 15 animals in week 10 allowed to detect a prevalence of > 17% of bloody lesions / plumage damage with a probability of 95%, while for the 10 birds in week 6 and 16 the according prevalence is 25%. Inter-observer reliability was tested for feather condition between veterinarians I and II. Both veterinarians assessed feather score of the same 30 hens in parallel but independently.

Table 1
Definitions for the evaluated feather condition score for the 6th, 10th and 16th week.

evaluated area	score	description
back/base of tail feathers	1	no damage
	2	slight damage, few back feathers missing, LB: white down feathers visible at the base of the tail, sporadic encrusted feather shafts
	3	unfeathered cutaneous areas visible, bloody feather shafts, cutaneous lesions possible
belly feathers	1	no damage
	2	slight damage, few back feathers missing, LB: white down feathers visible, sporadic encrusted feather shafts
	3	unfeathered cutaneous areas visible, bloody feather shafts, cutaneous lesions possible
tail feathers (quantity)	1	all tail feathers present
	2	few tail feathers missing
	3	most tail feathers missing
tail feathers (quality)	1	no damaged tail feathers
	2	some damaged tail feathers or broken feather shafts
	3	all tail feathers damaged, all feather shafts broken
quill feathers	1	no damage
	2	some damaged quill feathers or broken feather tips
	3	all quill feathers damaged, many broken feather tips
bloody lesions	yes	one or more encrusted feather shafts and/or skin lesions
	no	no bloody lesions

They had a 100% agreement in assessment, except for quill feathers, where agreement was 97% (one animal was scored differently).

To assess the animal-human relationship, the animals' reaction towards an unfamiliar human (**avoidance distance**) was assessed in the 10th week using a test with a moving and stationary phase of the human (Waiblinger et al., 2006) modified from earlier tests (Barnett et al., 1992; Graml et al., 2008). The assessor walked slowly, one step per two seconds, through the flock in the litter area of the aviary, stopped after five steps, stood stationary for 10 s and then assessed the distance to the hens. Single animals which were clearly closer than the others were ignored. This procedure was repeated six times per barn directly after each other covering the whole barn. The mean value of the six repetitions was calculated and used as the flock's avoidance distance. Repeatability between the two veterinarians was high with a correlation coefficient of 0.94.

General animal reactivity (**reactivity score**) was evaluated on a three-point scale as calm (animals are curiously watching the unfamiliar person, some even come closer and show explorative pecking behaviour), medium (some animals are curiously watching the unfamiliar person, some try to escape and flee) or nervous (the whole flock shows flight reactions or even panic and tries to escape).

Weight and uniformity in weight of the individual animals were recorded from an automatic scale in the barn. One scale per barn calculated average weight and uniformity for the whole day from all animals that were on the scale platform (ranging from 500 to 3000 animals weighed per day). At the day of the visit, weight and uniformity were noted from scale records of the day before to increase standardization. Mortality was recorded by the farmers, themselves, in their electronic data base and cumulative mortality between visits was noted.

Body temperature was assessed in the 1st week of life on twenty chicks per barn caught in random areas of the barn. Cloacal temperature was measured using a thermometer (Braun Thermoscan Infrared ear thermometer). At every visit, it was further assessed, if **diseases** occurred before the day of the visit and depending on how often diseases occurred during the whole rearing period.

2.4. Flock-specific factors

Flock characteristics and flock-specific management factors were assessed at the different visits (Table 2). Litter quantity was evaluated on

Table 2
Environmental variables recorded.

influencing factor	measurement/description	when assessed
breed	Lohmann Sandy (LS), Lohmann Braun (LB), Lohmann Silver Line (LSL), LS + LB, LSL + LB	once per flock
stocking density[a]	animals per m^2	once per flock
pre-rearing[b]	days	once per flock
rearing form	floor or aviary	once per flock
aviary opened[b]	weeks	once per flock
antibiotic treatment[c]	yes (1) or no (0)	1st, 6th, 10th & 16th week
use of supplements[c]	yes (1) or no (0)	1st, 6th, 10th & 16th week
barn temperature[c]	°C degree Celsius	1st week
feed changes[b]	number per period	6th, 10th & 16th week
feed mill changes[a]	number per period	6th, 10th & 16th week
litter quantity[c] (subjective)	no (1), small (2), large (3)	6th, 10th & 16th week
light hours per day[a]	hours	6th, 10th & 16th week
light intensity[c] (subjective)	dark (1), average (2), bright (3)	6th, 10th & 16th week
daylight provided[c]	yes (1) or no (0)	6th, 10th & 16th week
occurring technical problems[b]	yes (1) or no (0)	10th & 16th week
pecking stones[b]	yes (1) or no (0)	10th & 16th week
access to free covered area[c]	yes (1) or no (0)	10th & 16th week
access to free range[c]	yes (1) or no (0)	10th & 16th week

[a] Recorded from computer records.
[b] Recorded by asking the farmer.
[c] Assessed by the vet during the visit and when walking through the barn.

a three-point scale as no litter on the floor, small amounts of litter (floor partly covered with litter) and high amounts of litter (whole floor covered with litter). Conditions in the first weeks of life differed regarding floor- or aviary-rearing and pre-rearing on a different farm (see Fig. 1); Out of the 100 flocks, 54 flocks were reared on the rearing farm from the first day of life and virtually all of them (53 flocks) were confined in the aviary without access to litter (only chick paper) for the first 28–49 days of life before the aviary was opened and pullets had access to the whole system, including the floor ("early rearing in aviary"). One organic flock was raised on the floor of the aviary system and had access to litter for 4 weeks and was then confined in the aviary for about 1.5 weeks before the aviary was opened ("early floor-rearing"). 46 flocks were pre-reared (37 organic, nine conventional), i.e. they were raised on a specialised pre-rearing farm (always a floor-pen system with straw as litter) for 24–51 days before they were transported to the actual rearing farm (named rearing farm in the rest of the paper). When arriving in the rearing farm, they were confined within the aviary for three days to three weeks before also having access to the floor of the aviary system. Thus, all pre-reared flocks were also considered as early floor-rearing.

2.5. Farm and barn characteristics and farm-specific management

The general barn size (measured by the official veterinarian and employees of the integrated company using a laser measuring device) and size of the aviary were noted from farm records and summarized to determine the usable area per barn. The size of the covered veranda was also recorded on organic farms.

Detailed information about farm characteristics, barn characteristics, farmers' management and their handling practices was gathered by a structured interview of the farmer (decision-maker), performed once on all 28 farms during the course of the study by veterinarian I. The interview comprised three sections.

The first section of the interview was about housing and management conditions. The first nine questions dealt with housing conditions (construction year, farming type organic/conventional, barn size,

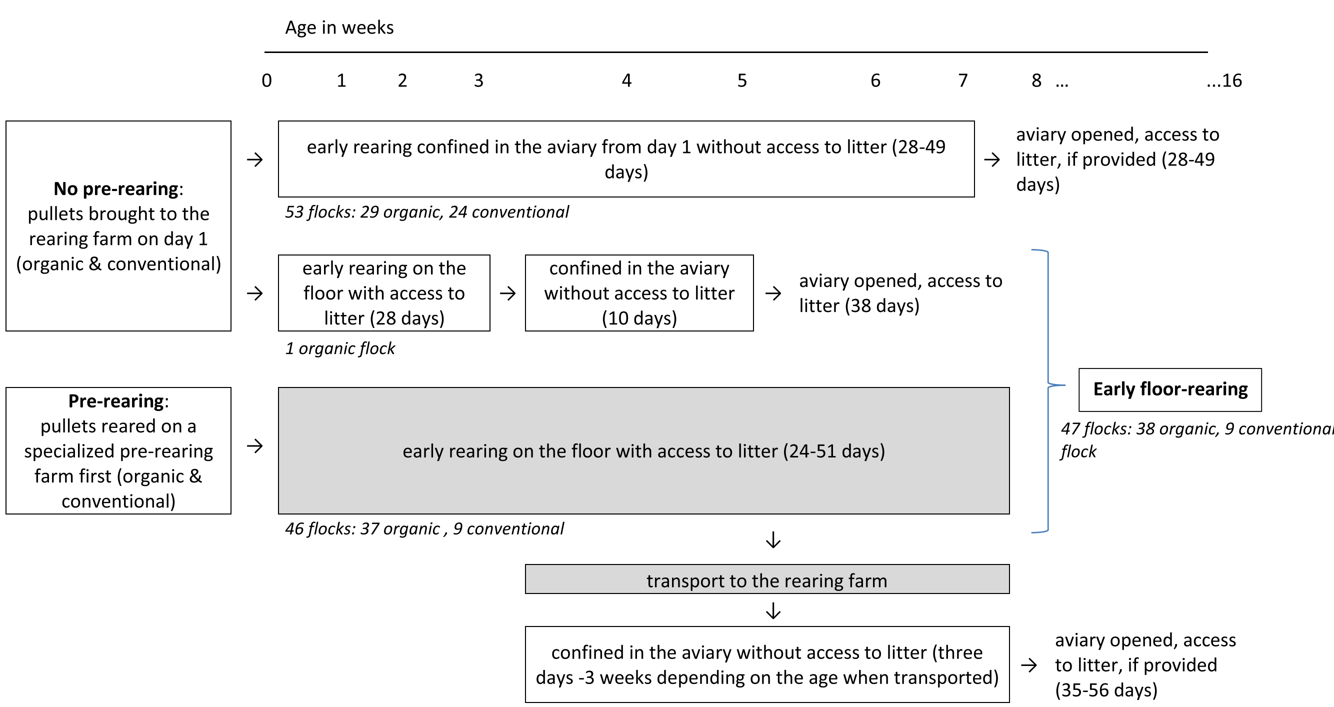

Fig. 1. Scheme of the early rearing conditions of 100 flocks. Early rearing on the floor on a specialised pre-rearing farm is shown in grey boxes: early rearing on the rearing farm, either confined in the aviary or on the floor is shown in white boxes. The number of organic and conventional flocks is shown for each different rearing condition.

drinking and feeding system, drinking and feeding space per animal, type and arrangement of the lighting system, and size of covered free area and free range). The next five questions were about hygiene management such as use of separate barn clothing, use of a hygiene barrier or disinfection mats, routine of cleaning and disinfection, interval between flocks and other special hygiene measures.

The second section comprised 12 questions about farm characteristics (years of farmers' experience, farm run as full-time job or part-time job) and daily work organization (when and how often does the farmer visit the barn, average working hours per day in the barn and with the animals, how often does the farmer check the covered veranda and the free range, are there more visits in the first weeks when the chicks or pre-reared pullets arrived, does the farmer spread additional grain on the floor).

The third section was focused on contact with and care for the animals; containing questions about how much time the farmer spent watching the animals' behaviour, about using a radio in the house, or if there was a separate area to keep sick birds apart from the healthy flock. The farmers were also asked if they regularly caught animals to assess their feather condition, or for other reasons and if so, how often and for what reason.

2.6. Farmers' personal characteristics

Farmers and other caretakers' attitudes, behaviour towards the animals, and experience with pullets as well as demographic variables were assessed by using a questionnaire. All persons (in total 39) caring for the pullets filled in the questionnaire once. Twenty-eight of them were making decisions on management (decision makers) and 11 only cared for the animals. On 17 farms only one person was the caretaker, on 11 farms two people were working with the animals on a daily basis. The questionnaire was based on a previous version used in rearing and laying hen farms (Waiblinger et al., 2018) and modified for this study. Attitude was assessed with a total of 32 attitude items in four divisions (supplementary material Table S5); division 1 on farmers' beliefs about caring for pullets; division 2 on farmers' beliefs about factors influencing flock behaviour; division 3, farmers' beliefs about pullets in general and division 4, farmers' attitudes towards their work. Farmers responded to all items on a seven-point Likert scale, with 1 indicating complete disagreement, lowest importance or least enjoyment, and 7 indicating strongest agreement, highest importance or enjoyment. After the attitude questions, farmer demographics, gender, age, educational background in general and agricultural, and their childhood experience (i.e. growing up on a farm with or without poultry or other livestock) were assessed.

2.7. Data analysis

The statistical evaluation was done with the program SPSS 25. Data from the feather condition assessment of the 15 individual animals scored in the 10th week of age were combined to form a total plumage score of all evaluated areas per animal. Animals that had at least one area with a score 2 were counted as animals with plumage damage. The percentage of animals with plumage damage was calculated per flock and used as a dependent variable for risk factor analysis (see below). Bloody lesions only occurred in 29 flocks; the variable was dichotomized into bloody lesions occurring on the farm or not.

The attitude questionnaire was reduced to 11 components by using Principal Components Analysis (PCA) with Varimax rotation, one PCA per division. Components were selected according to scree plot and eigenvalue (>1). For calculating component scores, the average value of included items was used. Items that had a loading of at least 0.5 and did not load on any other component were included. Further, if the highest loading on a component exceeded 0.6 and there was a loading less than 0.4 on any other component, the items were also included. Chronbach's α was calculated and components with low values (<0.5) not used for further analysis. A list of all components and the included items can be found in the Supplementary material Table S5.

For identifying factors associated with the dependent variables plumage damage, bloody lesions and avoidance distance, multivariable analyses were performed. For pre-selecting independent variables for the models, i.e. the potentially influencing factors, bi-variable associations were investigated by use of Spearman rank correlation coefficients and Mann-Whitney-U tests. Descriptive data of the potential influencing factors that were analysed for bi-variable associations are shown in the Supplementary material in Table S3 for nominal and ordinal scale variables and in Table S4 for continuous variables. To be included in model analysis, variables had to be associated with the dependent variable significantly or by trend (i.e. $p < 0.1$) in bi-variable analysis or be of specific interest (e.g. farmer attitudes). In both cases a science-based hypothesis was a precondition. Linear mixed models (LMM) were calculated for the dependent variables percentage of animals with plumage damage and avoidance distance, with farm as random effect and the variables of potentially influencing factors as fixed effects. Because there was only one data value per variable per flock in the model, flock was not included as a random factor. Models were reduced by backward elimination of variables with a p-value in the model larger 0.1 step by step as long as the AIC was improving. Due to this model selection step p-values should be treated with caution. However, main predictors were also significant in the full model with all potential predictors included. This supports our findings. With the proportion of plumage damage we also calculated generalized linear mixed models (GLMM) with binomial distribution and the same fixed and random factors as for the LMMs. Main predictors were the same as in LMM model, but with the binomial GLMM model we encountered problems with model convergence. Thus as another validation we ran LMM models using arcsin-transformation of the target variable plumage damage, with similar results. Since the residual plots for the LMMs did not show signs of non-homogeneous variances, we think that a binomial response model may not be appropriate here. Consequently the LMM results should also be more reliable than those from the arcsin-transformed data. For bloody lesions, a logistic regression model was calculated with stepwise inclusion of independent variables including farm. For all models, assumptions of normality and homoscedasticity were checked graphically. Models for plumage damage were calculated for all farms (i.e. both conventional and organic) as well as for organic farms only, because there are some inherent differences between these two farm types (see 2.1). Models for all farms were calculated with farming type and breed included as well as without, since strains used on organic farms were largely different from those in conventional farms. There was no strong change in p-values. There was no model calculated for only conventional farms due to the relatively low sample size (only 33 flocks on 11 farms). Bloody lesions were found only in two conventional flocks and thus only a model for organic farms was calculated. Furthermore, we calculated models without attitude components first and then models including attitude components to be able to draw conclusions about the potential effect of the human-animal relationship, as reflected in farmers' attitudes, on the occurrence of plumage damage and bloody lesions.

To identify potential animal-based indicators for the occurrence of bloody lesions, regression models were calculated for the dependent variable bloody lesions in the 6th and 10th week. There was no regression model calculated for the 16th week, because there were only 4 flocks with bloody lesions. The animal-based variables, bloody lesions of previous weeks, reactivity score, weight, uniformity, cumulative mortality, avoidance distance, plumage damage and down feathers present on the floor were included as independent variables and a stepwise inclusion procedure was performed.

Two farms with only one flock each had to be excluded in model analysis to be able to include farm as random effect into the model thus reducing sample size to 98 flocks. One flock was pre-reared on a farm in Germany which was supervised by another veterinary practice. There were no data available for this specific flock until the 6th week of age, thus sample size was further reduced to 97 flocks, if variables depending on data from the first week were included in the model.

3. Results

3.1. *Descriptive analysis of plumage damage, bloody lesions and avoidance distance*

In the 10th week, the percentage of animals with **plumage damage** ranged from 0% (9 flocks) to 100% (9 flocks) with a mean±SD of 49.8 ± 0.31%. **Bloody lesions** were observed in 29 flocks in week 10, and were associated with plumage damage (P = 0.005). Regarding changes over weeks, of 23 flocks that had bloody lesions in the 6th week, 12 flocks (52%) also had bloody lesions in the 10th week, but none of them showed lesions in the 16th week. Two flocks which had bloody lesions in the 6th week showed lesions in the 16th week again, but not in the 10th week. On the other hand, out of the 17 flocks, for which bloody lesions were observed for the first time in week 10, only two flocks still had bloody lesions in the 16th week. For more detailed descriptive data on feather scoring in the different weeks, see Supplementary material Table S1 and S2.

For the avoidance distance towards an unfamiliar human, the **mean distance** ranged from 0.0 m to 6.0 m (mean±SD: 2.41 ± 1.197 m).

3.2. *Environmental factors and animal-based influencing factors*

Presence of down feathers on the floor was higher in the 10th week than the 16th and older flocks were assessed as calmer in the reactivity score (see Supplementary material Table S2). Duration of **confinement in the aviary** varied largely; aviaries were opened earliest at week 4 and latest at week 8 (see supplementary material Table S3). The duration of **pre-rearing** ranged between 24 and 51 days; organic flocks were pre-reared longer than conventional flocks (see Supplementary material Table S4). For most of the conventional flocks, no or only a small **quantity of litter** was offered, while organic flocks mostly were offered larger quantities (see Supplementary material Table S3). There was a large variation in **light intensities** throughout the different ages, but generally organic flocks had brighter light than conventional flocks (see Supplementary material Table S3). The **stocking density** was on average 11.6 animals per m^2 usable area in organic farms and 20.5 animals per m^2 usable area in conventional farms. Regarding **attitude components**, there was no complete disagreement on Characteristics_-positive, Important genetics or Important Care (for further descriptive analysis of farmers' attitudes see Supplementary material Graph S1 and for more information regarding included items see Table S5). For more detailed descriptive data on environmental factors and animal-based influencing, see Supplementary material Table S3 and S4.

3.3. *Results of the statistical models*

A shorter pre-rearing period (pre-rearing on another farm for 3–6 weeks) and early floor-rearing instead of rearing in the aviary were associated with less plumage damage in all models calculated (Table 3). Light intensity was also associated with plumage damage in three of the four calculated models (not included in the model for conventional and organic farms without attitudes) models, with a medium light intensity showing lowest estimated means when it was included (Table 3).

Regarding farmers' attitude components, there was less plumage damage when farmers rated intensive care for the animals more important for obtaining a calm flock (Important care) and when they agreed more on pullets having positive characteristics (Characteristics_positive) in the overall model including conventional and organic farms (Table 3). In the model including organic flocks only, Characteristics_positive showed again a negative association with plumage damage (Table 3). Further, there was a tendency for less plumage damage

Table 3
Results of the linear mixed models explaining the proportion of pullets with plumage damage for both conventional and organic farms (N = 98) and for organic farms only (N = 67). Only the estimated means/coefficients of significant associations and tendencies are shown; the entire linear mixed model, including non-significant predictor variables, can be found in the Supplementary material (see Table S6).

Target variable	influencing factor	unit		without attitudes						including attitudes					
				estimate[a]		CI				estimate[a]		CI			
			N		SE	min.	max.	F	P		SE	min.	max.	F	P
plumage damage[b] (conv. & organic)	days of pre-rearing	days	98	0.009	0.004	0.001	0.017	4.625	0.035	0.009	0.003	0.002	0.015	6.459	0.013
	early rearing on floor or in the aviary	floor	47	0.526	0.117	0.293	0.759	6.800	0.011	0.357	0.078	0.202	0.512	6.487	0.013
		aviary	51	0.916	0.116	0.684	1.148			0.692	0.074	0.545	0.839		
	light intensity	low	22							0.611	0.064	0.481	0.740	3.157	0.048
		med.	60							0.445	0.040	0.360	0.529		
		high	16							0.518	0.069	0.379	0.657		
	Important care	Score	98							0.118	0.043	0.026	0.211	7.414	0.016
	Characteristics_ positive	Score	98							-0.092	0.034	-0.167	-0.017	7.458	0.020
plumage damage[b](organic)	days of pre-rearing	days	67	0.009	0.004	0.001	0.018	5.072	0.029	0.009	0.003	0.002	0.016	6.909	0.011
	early rearing on floor or in the aviary	floor	39	0.466	0.147	0.170	0.761	4.010	0.051	0.376	0.073	0.229	0.522	4.895	0.031
		aviary	28	0.812	0.143	0.524	1.100			0.699	0.091	0.517	0.882		
	light intensity	low	17	0.674	0.120	0.432	0.916	3.737	0.031	0.582	0.062	0.452	0.712	4.913	0.011
		med.	38	0.527	0.121	0.282	0.771			0.425	0.043	0.331	0.519		
		high	12	0.715	0.147	0.419	1.011			0.606	0.072	0.460	0.751		
	Important genetics	Score	67							0.081	0.038	-0.009	0.172	4.558	0.072
	Characteristics_ positive	Score	67							-0.105	0.031	-0.184	-0.027	11.895	0.019
	Enjoy poultry	Score	67							-0.147	0.077	-0.324	0.031	3.609	0.093

[a] Estimates are estimated means for categorical variables and estimated coefficients for continuous variables.
[b] Proportion of pullets with plumage damage.

when farmers reported enjoying working with pullets more and when they rated the importance of genetics for a calm flock lower (Table 3).

In the models without attitude components variation between farms was significant in the overall model for plumage damage (random factor farm: Wald Z = 2.010; SD=0.0185; P = 0.044) and there was a tendency in the organic only model (Wald Z = 1.819; SD=0.0276; P = 0.062). When including attitude components in the models on plumage damage, farm variations were no longer significant (random factor farm in the conventional and organic model: Wald Z = 1.165; SD=0.0118; P = 0.244; in the organic only model: Wald Z = 0.616; SD=0.0106; P = 0.538).

The model for bloody lesions calculated without considering attitudes explained 32.8% of the occurrence; bloody lesions tended to occur with a nearly three times higher probability when pullets were early reared in the aviary, i.e. confined in the aviary compared to early rearing on the floor in the first weeks of life, and when litter quantity was lower at the visit in the 10th week (Table 4). In the model including attitudes, a higher litter quantity significantly reduced the risk of bloody lesions by nearly four times (Table 4). There were more bloody lesions when farmers described pullets as more reactive (Characteristics_reactive) and when they rated the importance of genetics for a calm flock lower (Important_genetics); there were also more bloody lesions when farmers found their work more challenging (Work_challenging; Table 4). The last step of this regression model explained 34.9% of the occurring bloody lesions in the 10th week.

The final regression models of potential animal-based indicators for the occurrence of bloody lesions in week 6 and 10 are shown in Table 5. Model 1 on bloody lesions in the 6th week had an explained variance of 25%. The occurrence of bloody lesions at this age was strongly associated with the reactivity score at this age: calmer flocks had a lower occurrence of bloody lesions (Table 5). Neither body weight, uniformity or cumulative mortality at this age were associated with bloody lesions and thus not included in the final regression model. Explained variance of model 2, investigating between-age association only, was much lower with only 11%. The starting model includes only the animal-based variables of the 6th week to check the indicative value of measures in an earlier age on later occurrence of bloody lesions. If a flock had bloody lesions in the 6th week, there was a nearly four times higher risk for occurrence of bloody lesions in the 10th week (Table 5). In contrast, in model 3, targeting the bloody lesions at week 10the explained variance was much higher at 41%. The starting model here included both animal-based variables assessed at the 6th and the 10th week of age, but only the latter ones were included in the final model. There were fewer down feathers present on the ground in the 10th week when bloody lesions occurred in the 10th week; higher weight in the 10th week also tended to be associated positively with the occurrence of bloody lesions. Reactivity score was not significantly associated with bloody lesions in the 10th week, althought this variable remained in the model.

Avoidance distance was associated with breed, with LSL showing highest distances (Table 6). Avoidance distance was shorter when stocking density was higher and tended to be shorter when two different persons took care of the animal rather than only one (Table 6). Avoidance distance was shorter when farmers' rated frequent and close contact to pullets more important (higher score on Important contact), when farmers rated work with pullets as being challenging (Work challenging) and, by tendency, when they enjoyed working with poultry more (Enjoy poultry) and when they assessed pullets as more curious and more sensitive to pain (Characteristics_curious (Table 6). Avoidance distance was higher when farmers rated the importance of genetics for animal behaviour higher (Important genetics) and, by tendency, when farmers agreed more on pullets' being aggressive and calm (Characteristics_reactive; Table 6).

4. Discussion

Our results confirm the importance of the conditions in the first weeks of life and of the provision of litter for the risk of feather pecking. Both the percentage of plumage damage as well as the occurrence of bloody lesions were higher if chicks were reared in the aviary as compared to being early floor-reared with access to litter in the first weeks of life and a larger quantity of litter prevented bloody lesions. In addition, the duration of pre-rearing on a specialised pre-rearing farm (before being transported to the rearing farm) and light intensity were associated with plumage damage. Further, the importance of farmers' relationship to their animals for animal behaviour and welfare was confirmed: farmers' attitudes were relevant predictors for plumage damage, for bloody lesions and for avoidance distance. However, avoidance distance was not related to plumage damage and bloody lesions.

4.1. Plumage damage and bloody lesions

There was less plumage damage and the occurrence of bloody lesions was lower when pullets were reared on the floor in the first few weeks of life rather than in the aviary. Early floor-rearing differed from the flocks with early-rearing in the aviary in several aspects in this study. Firstly, animals that were early floor-reared had access to litter from day one, whereas that was not the case for flocks which were confined in the aviary from day one for some weeks on a wired floor covered with chick paper but no additional litter. This confirms previous experiments indicating the importance of early provision of adequate substrate to direct pecking behaviour to the ground rather than toward conspecifics

Table 4
Final logistic regression models for the occurrence of bloody lesions in organic farms (N = 67) without inclusion of farmers' attitudes and with inclusion in the starting model. Explained variance (V) see column 1.

model	variable	reg. coeff.	SD	Wald-Chi^2	P	Exp (B)	Exp (B) min.	Exp (B) max.
bloody lesions occurred (without attitudes) V= 32.8%	constant	2.391	1.383	2.990	0.084	10.921		
	technical problems[a]	1.055	0.675	2.444	0.118	2.873	0.765	10.788
	Early rearing in aviary[b]	1.024	0.548	3.495	0.062	2.785	0.952	8.148
	litter quantity[c]	-0.948	0.505	3.521	0.061	0.388	0.144	1.043
bloody lesions occurred (incl. attitudes) V= 34.9%	constant	-0.134	2.567	0.003	0.958	0.875		
	access to covered veranda[d]	1.694	1.142	2.200	0.138	5.441	0.580	51.036
	litter quantity[c]	-1.280	0.573	4.988	0.026	0.278	0.090	0.855
	Characteristics_reactive	0.642	0.318	4.059	0.044	1.899	1.018	3.545
	Work challenging	0.825	0.335	6.053	0.014	2.282	1.183	4.405
	Important genetics	-0.719	0.341	4.432	0.035	0.487	0.250	0.952

[a] 0, no technical problems; 1, technical problem occurred.
[b] 0, raised on floor; 1, raised in aviary.
[c] 1, no litter; 2, small quantity of litter; 3, large quantity of litter.
[d] 0, no access to free covered area; 1, access to free covered area.

Table 5
Final logistic regression models of potential indicators for the occurrence of bloody lesions in organic farms in the 6th and 10th week of age (N = 67).

Indicator	regression coefficient	SD	Wald-Chi^2	P	Exp (B)	Exp (B) min.	Exp (B) max.
Model 1: bloody lesions occurred in 6th week with animal-based parameters of the 6th week							
constant	2.040	0.919	4.925	0.026	7.689		
reactivity score[a] 6th week	-1.555	0.486	10.243	0.001	0.211	0.082	0.547
Model 2: bloody lesions occurred in 10th week with animal-based parameters of the 6th week							
constant	-0.788	0.311	6.411	0.011	0.455		
bloody lesions 6th week	1.327	0.568	5.453	0.020	3.771	1.238	11.492
Model 3: bloody lesions occurred in 10th week with animal-based parameters of the 6th&10th week							
constant	-6.151	5.177	1.411	0.235	0.002		
reactivity score[a] 10th week	-0.778	0.497	2.446	0.118	0.459	0.173	1.218
down feathers present[b] 10th week	-1.401	0.393	12.698	0.000	0.246	0.114	0.532
body weight 10th week	0.012	0.006	3.466	0.063	1.012	0.999	1.024

[a] 1, nervous; 2, medium; 3, calm
[b] 1, none; 2, few; 3, many

Table 6
Results of the linear mixed model for the mean avoidance distance of the animals towards an unfamiliar human for both organic and conventional flocks (N = 98). Only the estimated means/coefficients of significant associations and tendencies are shown; the entire linear mixed model, including non-significant predictor variables, can be found in the supplementary material (see Table S7).

influencing factor	Value/*unit*	N	estimate[a]	SE	CI min.	CI max.	F	P
breed	LS	53	2.09	0.339	1.38	2.81	5.731	0.001
	LB	24	2.02	0.654	0.64	3.40		
	LSL	4	4.53	0.844	2.77	6.28		
	LS+LB	13	2.15	0.370	1.38	2.91		
	LSL+LB	4	3.31	0.791	1.69	4.93		
stocking density	*N/m^2*	98	-0.36	0.119	-0.60	-0.11	8.974	0.005
number of stockperson	1	59	3.34	0.412	2.44	4.23	5.403	0.070
	2	39	2.30	0.460	1.24	3.36		
Important contact	Score	98	-0.87	0.293	-1.56	-0.17	8.718	0.022
Important genetics	Score	98	0.33	0.169	-0.07	0.74	3.912	0.093
Characteristics_curious	Score	98	-0.50	0.227	-1.09	0.09	4.894	0.079
Characteristics_reactive	Score	98	0.71	0.271	0.07	1.35	6.959	0.034
Enjoy poultry	Score	98	-0.82	0.415	-1.81	0.16	3.948	0.089
Work challenging	Score	98	-0.64	0.235	-1.18	-0.10	7.405	0.026

[a] Estimates are estimated means for categorical variables and estimated coefficients for continuous variables.

(de Jong et al., 2013), promote foraging and natural pecking behaviour (Huber-Eicher and Wechsler, 1997; Nicol et al., 2001), and thus to lower the risk of feather pecking (Johnsen et al., 1998; Liebers et al., 2019). Secondly, early floor-reared pullets were confined in the aviary at a later age and for a shorter duration (three days to a maximum of three weeks, depending on the duration of early floor-rearing). Animals on the floor probably had a larger total area in which to move around compared to chicks early-reared in the aviary where they were confined in smaller sections of the aviary during this period. In addition, although plumage damage was strongly correlated with the occurrence of bloody lesions, plumage damage might not necessarily be solely the result of feather pecking. Aviary systems or other equipment can cause plumage damage, at least in adult laying hens (McAdie and Keeling, 2000; Guinebretière et al., 2013). Thirdly, virtually all flocks with early floor-rearing were pre-reared on a specialised pre-rearing farm and later transported to the rearing farm; only one early floor-rearing flock remained on the same farm. Transportation can cause stress (Lalonde et al., 2021), which, in turn, can increase the risk of feather pecking (El-Lethey et al., 2000; De Haas et al., 2013). However, we did find improved plumage damage and fewer bloody lesions when pullets were pre-reared and thus transported during rearing. The beneficial effect of being early floor-reared with access to litter seems to override the likely short-lasting stress caused by transportation. In sum, our results on early floor-rearing indicate that confining pullets in aviaries even with the use of chick paper, that can reduce the occurrence of feather pecking compared to wired floor (Tahamtani et al., 2016), does not provide a sufficient foraging and pecking substrate. Although we cannot disentangle the differences observed regarding access to litter, restricted space and potential further differences such as an easier control of the pullets by the farmer when birds are on the ground, it is likely that the access to litter (in our case straw and/or wood shavings) from the first day on was the main factor reducing risk of feather pecking (Huber-Eicher and Sebö, 2001).

Although early floor-rearing (and thus, as well, pre-rearing as such) was beneficial, a longer duration of pre-rearing was negatively associated with plumage damage. Confining older and thus, larger pullets in the aviary, results in a higher stocking density (in kg/m^2) which may have increased the risk of developing feather pecking (Hansen and Braastad, 1994; Huber-Eicher and Audigé, 1999; Bestman et al., 2009). An age-dependent increase in fearfulness after the age of three weeks (Ghareeb et al., 2008) and thus, likely higher stress responses in new situations (transport, new barn), may also have contributed, as stress is a risk factor for feather pecking (McAdie and Keeling, 2000; Rodenburg et al., 2013).

As expected, we found fewer bloody lesions on organic farms in the 10th week of age when pullets had access to larger quantities of litter. Our findings support previous studies, where the provision of litter reduced the outbreaks of feather pecking (Rodenburg et al., 2013; Hartcher et al., 2013; Tahamtani et al., 2016; Brantsæter et al., 2017).

Results on light intensity were not very clear and have to be interpreted with great caution. In the overall model, i.e. including both conventional and organic farms, most plumage damage was observed at low light intensities, but least at medium light intensities. This is in contrast to earlier studies (Kjaer and Vestergaard, 1999; Drake et al., 2010), where more feather pecking and plumage damage was found at high light intensities (Kjaer and Vestergaard, 1999; Drake et al., 2010), and reducing light intensity is a common recommendation in case of feather pecking outbreak. It is possible that our results reflect farmers' reaction to an occurring problem with feather pecking that had developed between the visits.

Accounting for farmers' attitudes removed the significant effect of the farm on plumage damage. This finding suggests that the farmers' attitudes explain farm effects, supporting previous studies on the importance of the "human factor" leading to differences in animal production and welfare (Hemsworth and Coleman, 2011; Waiblinger, 2019). The human factor comprises differences in farmers' handling behaviour, but also decisions on management and housing that are based on differences in their attitudes (Hemsworth and Coleman, 2011; Waiblinger, 2019). In our study, less plumage damage occurred when stock people had a more positive general attitude, i.e. assigned positive characteristics to pullets, and, by tendency, when farmers agreed more to enjoy working with pullets. This is in line with expectation of more positive attitudes being related to improved human behaviour and management and improved animal welfare in other species, while negative attitudes relate negatively to welfare (Waiblinger et al., 2002; Andreasen et al., 2020). Further associations with attitudes were partly inconsistent and more difficult to interpret and may relate to our relatively small sample size regarding attitude analysis interacting with the different farming types.

The risk of bloody lesions was higher in organic farms when stock people agreed more that working with the pullets is especially challenging. This may indicate that farmers who feel especially challenged by caring for the animals, whether due to lack of experience, knowledge, too high work load or other factors, indeed have lower success with their husbandry. However, with our epidemiological approach we can only report correlation and not causation. It could also be that stock people who did not succeed in preventing outbreaks of feather pecking developed a negative attitude and feel a more demanding workload (Hemsworth and Coleman, 2011), or that both factors act together. Compared to other epidemiological studies investigating feather condition and skin lesions our sample size of 15 animals was somewhat lower. However, this sample size still allows to detect clear problems (in the sense of the prevalence of bloody lesions exceeding a certain limit of 17%) and precision of prevalence assessment is still acceptable for the whole range of potential true prevalences. Our main results are in line with earlier epidemiological and experimental studies supporting that the chosen sample size of focal animals yields valuable results. Nevertheless, as mentioned in the methods part, the results need to be interpreted with caution due to our model selection process and further studies are needed to confirm our preliminary results, including experimental approaches.

4.2. *Indicators for early detection of bloody lesions*

According to our expectation, flocks assessed as nervous had a higher risk of about 20% for the occurrence of bloody lesions in the 6th and about 50% for the 10th week of age. This supports studies indicating that increased fearfulness, which may be reflected in our reactivity score, increases the risk of developing feather pecking (De Haas et al., 2013, 2014; van Niekerk, 2019).

Another animal-based indicator assessed in the 6th week that could predict bloody lesions in the 10th week was the occurrence of bloody lesions. Animals that already had bloody lesions in the sixth week of age had a 3.8 times higher risk to have lesions in the 10th week as well. About half of the affected flocks in the 6th week were also affected in the 10th week. However, most feather pecking outbreaks could be stopped after the 10th week; only four flocks had bloody lesions in the 16th week. It would be interesting to evaluate in more detail the causes of this success. Access to the covered veranda after the 10th week and access to free range after the 12th week of age might have contributed to this improvement (Bestman and Wagenaar, 2003; Lambton et al., 2010; Gilani et al., 2014).

Fewer down feathers were present on the floor when bloody lesions occurred in the 10th week, with the risk being 25% lower per each score. Out of 29 flocks with bloody lesions, 17 (58.6%) had no down feathers on the floor and 7 flocks (24.1%) only had a few down feathers presents. In only five flocks bloody lesions occurred, despite many down feathers present on the floor. When down feathers had vanished, there was a higher probability that flocks started feather pecking (85% of flocks without down feathers). These results are consistent with previous studies where flocks which started feather eating were more likely to develop feather pecking behaviour (Bestman et al., 2009; Rodenburg et al., 2013). Hence, regularly monitoring the presence of down feathers may be a predictive tool to assess the risk of feather pecking outbreaks.

The risk for occurrence of bloody lesions tended to be higher in flocks with a higher body weight. Body weight was generally higher when pullets were confined to the aviary from day one and not early floor-reared. This factor was also related to the occurrence of bloody lesions, which could explain this association. Literature on this topic in laying hens remains contradictory: in a study by Kjaer et al. (2001) body weight was positively correlated to feather pecking in White Leghorn laying hens, while Guinebretière et al. (2013) found better plumage condition in ISA brown strain and Kjaer and Sørensen (1997) found less feather pecking also in White Leghorn laying hens when body weight was higher. The relationship between body weight and feather pecking may depend on the time point relative to the outbreak with reduced weight gain over the course of feather pecking behaviour. Uniformity, in contrast to expectations, was no predictor of bloody lesions.

4.3. *Avoidance distance*

Avoidance distance was associated with breed with the white LSL flocks showing highest distances and the flocks mixed of LSL and LB the second highest distance, while LB and LS did not differ. This is consistent with previous studies, where lines (De Haas et al., 2013; Meuser et al., 2021) and most probably caused by higher general fearfulness (Albentosa et al., 2003; Uitdehaag et al., 2011; De Haas et al., 2013).

Avoidance distance towards an unfamiliar human was shorter at a higher stocking density. To our knowledge, there are no studies in poultry that investigated the avoidance distance towards humans at different stocking densities; however our findings agree with results in cattle (Calderón-Amor et al., 2020), where calves with a larger space allowance kept a larger avoidance distances to a human experimenter. Two aspects may contribute to this result: a higher stocking density likely makes it more difficult for pullets to keep distance from the human and at the same time, closeness of conspecifics may reduce fear. Avoidance distance tended to be shorter when more people cared for the pullets (2 vs. 1). Pullets with two caretakers can become accustomed to different people, different moving patterns and different human behaviour, which may ease generalisation to other humans. This contradicts a study in dairy cows where avoidance distance was higher with increasing number of milkers (Waiblinger et al., 2003); there, farms with more than two stock people and employees were included and herd size was relatively small, which may explain the difference in our study. Avoidance distance was also related to attitudes largely in line with above-mentioned sequential human attitude – human behaviour – animal behaviour and welfare relationship found in other species. Avoidance distance was shorter when farmers agreed more on the importance of regular and frequent contact with the pullets and of constant caretakers and, by trend, enjoyed working with poultry more. We did not expect a shorter avoidance distance when they agreed on working with pullets being especially challenging. The term "challenging" might be perceived differently by different people with a positive connotation in some individuals and a negative in others.

5. Conclusions

This on-farm study confirms that feather pecking is still a prevalent problem in pullets, with influences of the conditions in the first weeks of life and especially the crucial role of access to appropriate litter from the first day of life onwards. Early floor-rearing with access to litter and thus the possibility to develop normal pecking behaviour can substantially reduce the risk of feather pecking compared to rearing chicks in aviaries with only chick paper in the first weeks of life. However, the pre-rearing period should be kept relatively short and appropriate litter later in life appeared important for the prevention of feather pecking. The assessment of the presence or absence of down feathers on the floor and the subjective assessment of hens' reactivity are easy to record on a regular basis and may support the early detection and potentially even prevention of feather pecking. Farmers' attitudes are important predictors for further variation in feather pecking between farms as well as for pullets' fear of humans. Farmers' attitudes thus should be taken into account in further studies on feather pecking prevention as well as in advisory and intervention measures.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank the entire veterinary practice "Tierarzt GmbH Dr. Mitsch" for supporting CM in all aspects. We especially thank Ass.Prof.Dr. Knut Niebuhr (†deceased on 1.2.2020) for his substantial contribution, which made this study possible. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2022.105607.

References

Aerni, V., Brinkhof, M.W.G., Wechsler, B., Oester, H., Fröhlich, E., 2005. Productivity and mortality of laying hens in aviaries: a systematic review. World's. Poult. Sci. J. 61 (1), 130–142. https://doi.org/10.1079/WPS200450.

Albentosa, M.J., Kjaer, J.B., Nicol, C.J., 2003. Strain and age differences in behaviour, fear response and pecking tendency in laying hens. Br. Poult. Sci. 44 (3), 333–344. https://doi.org/10.1080/00071660310001598085.

Andreasen, S.N., Sandøe, P., Waiblinger, S., Forkman, B., 2020. Negative attitudes of Danish dairy farmers to their livestock correlates negatively with animal welfare. Anim. Welf. 29 (1), 89–98. https://doi.org/10.7120/09627286.29.1.089.

Appleby, M.C., Hughes, B.O., 1991. Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. World'S. Poult. Sci. J. 47 (2), 109–128. https://doi.org/10.1079/WPS19910013.

Barnett, J.L., Hemsworth, P.H., Newman, E.A., 1992. Fear of humans and its relationships with productivity in laying hens at commercial farms. Br. Poult. Sci. 33 (4), 699–710. https://doi.org/10.1080/00071669208417510.

Bestman, M.W.P., Wagenaar, J.P., 2003. Farm level factors associated with feather pecking in organic laying hens. Livest. Prod. Sci. 80 (1–2), 133–140. https://doi.org/10.1016/S0301-6226(02)00314-7.

Bestman, M., Koene, P., Wagenaar, J.P., 2009. Influence of farm factors on the occurrence of feather pecking in organic reared hens and their predictability for feather pecking in the laying period. Appl. Anim. Behav. Sci. 121 (2), 120–125. https://doi.org/10.1016/j.applanim.2009.09.007.

Bestman, M., Wagenaar, J.P., 2006. Feather pecking in organic rearing hens. Poster at Joint Organic Congress, Odense, Denmark. 〈https://orgprints.org/id/eprint/7353/〉.

Blokhuis, H.J., Arkes, J.G., 1984. Some observations on the development of feather-pecking in poultry. Appl. Anim. Behav. Sci. 12 (1–2), 145–157. https://doi.org/10.1016/0168-1591(84)90104-7.

Brantsæter, M., Tahamtani, F.M., Nordgreen, J., Sandberg, E., Hansen, T.B., Rodenburg, T.B., 2017. Access to litter during rearing and environmental enrichment during production reduce fearfulness in adult laying hens. Appl. Anim. Behav. Sci. 189, 49–56. https://doi.org/10.1016/j.applanim.2017.01.008.

Calderón-Amor, J., Beaver, A., Keyserlingk, M.A.G., Gallo, C., 2020. Calf- and herd-level factors associated with dairy calf reactivity. J. Dairy Sci. 103 (5), 4606–4617. https://doi.org/10.3168/jds.2019-16878.

De Haas, E.N., Kemp, B., Bolhuis, J.E., Groothuis, T., Rodenburg, T.B., 2013. Fear, stress, and feather pecking in commercial white and brown laying hen parent-stock flocks and their relationships with production parameters. Poult. Sci. 92 (9), 2259–2269. https://doi.org/10.3382/ps.2012-02996.

De Haas, E.N., Bolhuis, J.E., Jong, I.C. de, Kemp, B., Janczak, A.M., Rodenburg, T.B., 2014. Predicting feather damage in laying hens during the laying period. Is it the past or is it the present? Appl. Anim. Behav. Sci. 160, 75–85. https://doi.org/10.1016/j.applanim.2014.08.009.

Drake, K.A., Donnelly, C.A., Dawkins, M.S., 2010. Influence of rearing and lay risk factors on propensity for feather damage in laying hens. Br. Poult. Sci. 51 (6), 725–733. https://doi.org/10.1080/00071668.2010.528751.

El-Lethey, H., Aerni, V., Jungi, T.W., Wechsler, B., 2000. Stress and feather pecking in laying hens in relation to housing conditions. Br. Poult. Sci. 41 (1), 22–28. https://doi.org/10.1080/00071660086358.

Gentle, M.J., Hunter, L.N., 1991. Physiological and behavioural responses associated with feather removal in Gallus gallus var domesticus. Res. Vet. Sci. 50 (1), 95–101. https://doi.org/10.1016/0034-5288(91)90060-2.

Ghareeb, K., Niebuhr, K., Awad, W.A., Waiblinger, S., Troxler, J., 2008. Stability of fear and sociality in two strains of laying hens. Br. Poult. Sci. 49 (5), 502–508. https://doi.org/10.1080/00071660802290390.

Gilani, A.M., Knowles, T.G., Nicol, C.J., 2013. The effect of rearing environment on feather pecking in young and adult laying hens. Appl. Anim. Behav. Sci. 148 (1–2), 54–63. https://doi.org/10.1016/j.applanim.2013.07.014.

Gilani, A.M., Knowles, T.G., Nicol, C.J., 2014. Factors affecting ranging behaviour in young and adult laying hens. Br. Poult. Sci. 55 (2), 127–135. https://doi.org/10.1080/00071668.2014.889279.

Graml, C., Niebuhr, K., Waiblinger, S., 2008. Reaction of laying hens to humans in the home or a novel environment. Appl. Anim. Behav. Sci. 113 (1–3), 98–109. https://doi.org/10.1016/j.applanim.2007.10.004.

Guinebretière, M., Huneau-Salaün, A., Huonnic, D., Michel, V., 2013. Plumage condition, body weight, mortality, and zootechnical performances: the effects of linings and litter provision in furnished cages for laying hens. Poult. Sci. 92 (1), 51–59. https://doi.org/10.3382/ps.2012-02576.

Hansen, I., Braastad, B.O., 1994. Effect of rearing density on pecking behaviour and plumage condition of laying hens in two types of aviary. Appl. Anim. Behav. Sci. 40 (3–4), 263–272. https://doi.org/10.1016/0168-1591(94)90067-1.

Hartcher, K.M., Tran, K.T.N., Wilkinson, S.J., Hemsworth, P., Cronin, G., 2013. Effect of rearing conditions on the development of featherpecking behaviours in free-range laying hens. 24th Annual Australian Poultry Science Symposium, Sydney, New South Wales, Australia, pp. 192–195.

Hemsworth, P., Coleman, G.J., 2010. Managing poultry: human–bird interactions and their implications. In: Duncan, Ian J.H., Hawkins, Penny (Eds.), The Welfare of Domestic Fowl and Other Captive Birds, vol. 9. Springer Netherlands (Animal Welfare), Dordrecht, pp. 219–235.

Hemsworth, P.H., Coleman, G.J., 2011. Human-livestock Interactions: The Stockperson and the Productivity and Welfare of Intensively Farmed Animals. CABI, Wallingford.

Huber-Eicher, B., Wechsler, B., 1997. Feather pecking in domestic chicks: its relation to dustbathing and foraging. Anim. Behav. 54 (4), 757–768. https://doi.org/10.1006/anbe.1996.0506.

Huber-Eicher, B., Audigé, L., 1999. Analysis of risk factors for the occurrence of feather pecking in laying hen growers. Br. Poult. Sci. 40 (5), 599–604. https://doi.org/10.1080/00071669986963.

Huber-Eicher, B., Sebö, F., 2001. The prevalence of feather pecking and development in commercial flocks of laying hens. Appl. Anim. Behav. Sci. 74 (3), 223–231. https://doi.org/10.1016/S0168-1591(01)00173-3.

Johnsen, P.F., Vestergaard, K.S., Nørgaard-Nielsen, G., 1998. Influence of early rearing conditions on the development of feather pecking and cannibalism in domestic fowl. Appl. Anim. Behav. Sci. 60 (1), 25–41. https://doi.org/10.1016/S0168-1591(98)00149-X.

Jong, I.C., de, Reuvekamp, B.F.J., Gunnink, H., 2013. Can substrate in early rearing prevent feather pecking in adult laying hens? Anim. Welf. 22 (3), 305–314. https://doi.org/10.7120/09627286.22.3.305.

Kjaer, J.B., Sørensen, P., 1997. Feather pecking behaviour in White Leghorns, a genetic study. Br. Poult. Sci. 38 (4), 333–341. https://doi.org/10.1080/00071669708417999.

Kjaer, J.B., Vestergaard, K.S., 1999. Development of feather pecking in relation to light intensity. Appl. Anim. Behav. Sci. 62 (2–3), 243–254. https://doi.org/10.1016/S0168-1591(98)00217-2.

Kjaer, J.B., Sørensen, P., 2002. Feather pecking and cannibalism in free-range laying hens as affected by genotype, dietary level of methionine + cystine, light intensity during rearing and age at first access to the range area. Appl. Anim. Behav. Sci. 76 (1), 21–39. https://doi.org/10.1016/S0168-1591(01)00209-X.

Kjaer, J.B., Sørensen, P., Su, G., 2001. Divergent selection on feather pecking behaviour in laying hens (Gallus gallus domesticus). Appl. Anim. Behav. Sci. 71 (3), 229–239. https://doi.org/10.1016/S0168-1591(00)00184-2.

Krautwald-Junghanns, M.E., Cramer, K., Fischer, B., Förster, A., Galli, R., Kremer, F., 2018. Current approaches to avoid the culling of day-old male chicks in the layer industry, with special reference to spectroscopic methods. Poult. Sci. 97 (3), 749–757. https://doi.org/10.3382/ps/pex389.

Lalonde, S., Beaulac, K., Crowe, T.G., Schwean-Lardner, K., 2021. The effects of simulated transport conditions on the muscle tissue characteristics of white-strain layer pullets. Poult. Sci. 100 (1), 103–109. https://doi.org/10.1016/j.psj.2020.09.064.

Lambton, S.L., Knowles, T.G., Yorke, C., Nicol, C.J., 2010. The risk factors affecting the development of gentle and severe feather pecking in loose housed laying hens. Appl. Anim. Behav. Sci. 123 (1–2), 32–42. https://doi.org/10.1016/j.applanim.2009.12.010.

Liebers, C.J., Schwarzer, A., Erhard, M., Schmidt, P., Louton, H., 2019. The influence of environmental enrichment and stocking density on the plumage and health conditions of laying hen pullets. Poult. Sci. 98 (6), 2474–2488. https://doi.org/10.3382/ps/pez024.

McAdie, T.M., Keeling, L.J., 2000. Effect of manipulating feathers of laying hens on the incidence of feather pecking and cannibalism. Appl. Anim. Behav. Sci. 68 (3), 215–229. https://doi.org/10.1016/S0168-1591(00)00107-6.

Meuser, V., Weinhold, L., Hillemacher, S., Tiemann, I., 2021. Welfare-related behaviors in chickens: characterization of fear and exploration in local and commercial chicken strains. Animals 11 (3), 679. https://doi.org/10.3390/ani11030679.

Nicol, C.J., Lindberg, A.C., Phillips, A.J., Pope, S.J., Wilkins, L.J., Green, L.E., 2001. Influence of prior exposure to wood shavings on feather pecking, dustbathing and foraging in adult laying hens. Appl. Anim. Behav. Sci. 73 (2), 141–155. https://doi.org/10.1016/S0168-1591(01)00126-5.

Nicol, C.J., Bestman, M., Gilani, A.M., Haas, E.N. d, Jong, I.C., de, Lambton, S., 2013. The prevention and control of feather pecking: application to commercial systems. World's. Poult. Sci. J. 69 (4), 775–788. https://doi.org/10.1017/S0043933913000809.

van Niekerk, T., 2019. Evidence-based management of injurious pecking. In: Olukosi, O. A., Olori, V.E., Helmbrecht, A., Lambton, S., French, N.A. (Eds.), Poultry Feathers and Skin: The Poultry Integument in Health and Welfare. CABI, Wallingford, pp. 57–69.

Noordhuizen, J.P.T.M., Frankena, K., van der Hoofd, C.M., Graat, E.A.M., 1997. Application of quantitative methods in veterinary epidemiology. Wageningen Press,, Wageningen, The Netherlands, pp. 49–50. ISBN: 9074134890.

Petek, M., Topal, E., Cavusoglu, E., 2015. Effects of age at first access to range area on pecking behaviour and plumage quality of free-range layer chickens. Arch. Anim. Breed. 58 (1), 85–91. https://doi.org/10.5194/aab-58-85-2015.

Rodenburg, T.B., Krimpen, M.M., van, Jong, I.C., de, Haas, E.N., de, Kops, M.S., Riedstra, B.J., 2013. The prevention and control of feather pecking in laying hens: identifying the underlying principles. World'S. Poult. Sci. J. 69 (2), 361–374. https://doi.org/10.1017/S0043933913000354.

Savory, C.J., 1995. Feather pecking and cannibalism. World'S. Poult. Sci. J. 51 (2), 215–219. https://doi.org/10.1079/WPS19950016.

Schreiter, R., 2020. Untersuchungen zum Einfluss einer Umweltanreicherung und der Futterzusammensetzung auf die Leistung und das Auftreten von Federpicken bei Jung- und Legehennen in Bodenhaltung. Dissertation, Martin-Luther-Universität, Halle-Wittenberg. https://doi.org/10.25673/32206.

Tahamtani, F.M., Brantsæter, M., Nordgreen, J., Sandberg, E., Hansen, T.B., Nødtvedt, A., 2016. Effects of litter provision during early rearing and environmental enrichment during the production phase on feather pecking and feather damage in laying hens. Poult. Sci. 95 (12), 2747–2756. https://doi.org/10.3382/ps/pew265.

Uitdehaag, K.A., Rodenburg, T.B., van Reenen, C.G., Koopmanschap, R.E., Vries Reilingh, G., de, Engel, B., 2011. Effects of genetic origin and social environment on behavioral response to manual restraint and monoamine functioning in laying hens. Poult. Sci. 90 (8), 1629–1636. https://doi.org/10.3382/ps.2010-01292.

Vestergaard, K.S., Kruijt, J.P., Hogan, J.A., 1993. Feather pecking and chronic fear in groups of red junglefowl: their relations to dustbathing, rearing environment and social status. Anim. Behav. 45 (6), 1127–1140. https://doi.org/10.1006/anbe.1993.1137.

Waiblinger, S., 2019. Agricultural animals. In: Hosey, G., Melfi, V. (Eds.), Anthrozoology: Human-animal Interactions In Domesticated and Wild Animals. Oxford University Press, Oxford, pp. 32–58.

Waiblinger, S., Menke, C., Coleman, G., 2002. The relationship between attitudes, personal characteristics and behaviour of stockpeople and subsequent behaviour and production of dairy cows. Appl. Anim. Behav. Sci. 79 (3), 195–219. https://doi.org/10.1016/S0168-1591(02)00155-7.

Waiblinger, S., Menke, C., Fölsch, D.W., 2003. Influences on the avoidance and approach behaviour of dairy cows towards humans on 35 farms. Appl. Anim. Behav. Sci. 84 (1), 23–39. https://doi.org/10.1016/S0168-1591(03)00148-5.

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.V., Janczak, A.M., Visser, E.K., Jones, R. B., 2006. Assessing the human–animal relationship in farmed species: a critical review. Appl. Anim. Behav. Sci. 101 (3–4), 185–242. https://doi.org/10.1016/j.applanim.2006.02.001.

Waiblinger, S., Zaludik, K., Raubek, J., Gruber, B., Niebuhr, K., 2018. Human-hen relationship on grower and laying hen farms in Austria and associations with hen welfare. 52nd Congress of the International Society for Applied Ethology, Ethology for Health and Wel-fare, Charlottetown, Prince Edward Island, Canada, pp. 187–187. ISBN: 978–90-8686–322-8.

3. Summary

In the last decades there is an increasing demand for the assurance that animal products are produced with regard for animal welfare. There is a need to ensure that animal welfare requirements are being met and that monitoring schemes have been developed as an advisory and management tool. All monitoring protocols developed thus far comprise a detailed scoring of plumage condition, since feather pecking remains a serious problem during the rearing and laying period, and has serious impact on animal welfare in terms of performance and mortality.

The goal of this study was to identify risk factors for plumage damage as a proxy for feather pecking, and the value of easy-to-asses animal-based parameters for early detection. Data were collected in 100 flocks on 28 rearing farms in Austria, recording plumage damage in the 10th and bloody lesions in the 6th, 10th and 16th weeks of age; housing (e.g. pre-rearing on another farm; early rearing on the floor or aviary; management (e.g. provision of litter); and, the human-animal relationship (e.g. avoidance distance, farmers' attitudes).

Early floor-rearing of pullets with access to litter, instead of confinement in the aviary in the first weeks without access to litter, was associated with less plumage damage ($P=0.011$). In organic flocks, bloody lesions tended to occur with a nearly three times lower probability with early floor-rearing than early aviary-rearing ($P=0.062$) and when litter quantity in the 10th week was scored as 'high' ($P<0.001$). There were fewer down feathers on the floor when pullets had bloody lesions in the 10th week ($P<0.001$). Farmers' attitudes were associated with both plumage damage and bloody lesions.

The results of this on-farm study confirm the importance of access to litter from the first day of life onwards: early floor-rearing with access to litter can substantially reduce the risk of feather pecking compared to confinement in the aviary with chick paper only, in the first weeks of life and access to appropriate litter from the first stage of life onwards is crucial for the prevention of feather pecking. The assessment of the presence or absence of down feathers on the floor and the assessment of pullets' reactivity are easy to record on a regular basis for the early detection and potential prevention of feather pecking. Farmers' attitudes are important predictors for further variation in feather pecking between farms as well as for pullets' fear of humans.

4. Zusammenfassung

In den letzten Jahrzehnten nahm die Forderung nach besserem Wohlergehen der Tiere in der Produktion zu. Es wurden aufgrund der Notwendigkeit, Tierwohl in der Haltung sicher zu stellen, Monitoring Protokolle entwickelt, die sowohl als Management-Tool dienen, als auch zur Bewertung des Tierwohls herangezogen werden. Alle bisher entwickelten Monitoring Protokolle beinhalten eine detaillierte Beurteilung des Gefieders, da Federpicken noch immer ein ernst zu nehmendes Problem in der Geflügelhaltung darstellt und starke negative Auswirkungen auf das Tierwohl hat (u.a. in Bezug auf Leistungsparameter als auch Mortalität).

Ziel dieser Studie war es, Risikofaktoren für das Auftreten von Gefiederschäden und blutigen Läsionen als Anzeichen für Federpicken zu identifizieren. Zudem sollten einige tierbezogene Parameter auf ihre Eignung zur Früherkennung von Federpicken untersucht werden. Die Datenerhebung erfolgte an 100 Herden auf 28 Aufzuchtbetrieben in Österreich. Dazu wurden Gefiederschäden in der 10. und blutigen Läsionen in der 6., 10. und 16. Lebenswoche erhoben. Als potentielle Einflussfaktoren auf das Entstehen von Federpicken wurden Haltungsbedingungen (z.B. Voraufzucht auf einem anderen Betrieb, frühe Aufzucht auf dem Boden oder in der Voliere), Management (z. B. Bereitstellung von Einstreu, Lichtintensität, Lichtstunden) und Mensch-Tier-Beziehung (z.B. Ausweichdistanz, Einstellung der Tierhalter zum Tier, Umgang mit den Tieren) miteinbezogen.

Die frühe Aufzucht auf dem Boden mit Zugang zu Einstreu ab dem ersten Lebenstag (=frühe Bodenaufzucht) war mit weniger Gefiederschäden verbunden ($P=0.011$) als eine Aufzucht, in der die Küken in den ersten Lebenswochen in die Voliere, ohne Zugang zu Einstreu, eingesperrt waren. Blutige Läsionen traten mit fast dreimal geringerer Wahrscheinlichkeit bei früher Bodenaufzucht als bei früher Volierenaufzucht ($P=0.062$) auf. Außerdem fanden sich blutige Läsionen seltener, wenn viel Einstreu angeboten wurde ($P<0.001$). Wurden in der 10. Lebenswoche blutige Läsionen bei Junghennen gefunden, lagen weniger Flaumfedern auf dem Boden ($P<0.001$). Die Einstellung der Tierhalter stand sowohl mit Gefiederschäden als auch mit blutigen Läsionen in Zusammenhang.

Die Ergebnisse der Studie bestätigen die Bedeutung von Zugang zu Einstreu ab dem ersten Lebenstag: eine frühe Bodenaufzucht mit Zugang zu Einstreu kann in den ersten Lebenswochen das Risiko für das Entstehen von Federpicken maßgeblich reduzieren verglichen mit einer Aufzucht, in der Küken in den ersten Lebenswochen in die Voliere ohne Zugang zu Einstreu, nur mit Kükenpapier, eingesperrt waren. Das Anbieten einer angemessenen Menge Einstreu im späteren Leben ist ebenso wichtig, um Federpicken vorzubeugen. Das Fehlen von Flaumfedern auf dem Boden und die Beurteilung der Reaktivität der Tiere scheinen gute Indikatoren für Federpicken zu sein. Diese Parameter lassen sich schnell und einfach regelmäßig erfassen, um Federpicken frühzeitig zu erkennen oder möglicherweise zu verhindern. Die Einstellungen der Tierhalter tragen ebenfalls zur Erklärung von Unterschieden im Auftreten von Federpicken zwischen den Betrieben bei, ebenso stehen sie im Zusammenhang mit der Furcht der Junghennen vor Menschen.

5. References

Aerni V, El-Lethey H, Wechsler B. 2000. Effect of foraging material and food form on feather pecking in laying hens. British Poultry Science, 41(1): 16-21.

Alonso ME, González-Montaña JR, Lomillos JM. 2020. Consumers' Concerns and Perceptions of Farm Animal Welfare. Animals, 10(3).

AssureWel. Advancing Animal Welfare Assurance. http://www.assurewel.org/. Access: 27.04.2022.

Bessei W. 2018. Impact of animal welfare on worldwide poultry production. World's Poultry Science Journal, 74(2): 211-224.

Bestman MWP, Wagenaar JP. 2003. Farm level factors associated with feather pecking in organic laying hens. Livestock Production Science, 80(1-2): 133-140.

Blokhuis HJ. 1986. Feather-pecking in poultry: Its relation with ground-pecking. Applied Animal Behaviour Science, 16(1): 63-67.

Blokhuis HJ, Van Niekerk T, Bessei W, Elson A, Guémené D, Kjaer JB, Maria Levrino GA. 2007. The LayWel project: welfare implications of changes in production systems for laying hens. World's Poultry Science Journal, 63(1): 101-114.

Butterworth A, Van Niekerk T, Veissier I, Keeling LJ. 2009. Welfare Quality®, Assessment Protocol for Poultry (Broiler, Laying Hens). Welfare Quality Consortium, Lelystad, The Netherlands. ISBN:9789078240068.

Council Directive 98/58/EC. 1998. The protection of animals kept for farming purposes. Official Journal L221, 08/08/1998: 23-27.

Decina C, Berke O, Van Staaveren N, Baes CF, Harlander-Matauscheck A. 2019. Development of a Scoring System to Assess Feather Damage in Canadian Laying Hen Flocks. Animals, 9(7).

De Haas EN, Kemp B, Bolhuis JE, Groothuis T, Rodenburg TB. 2013. Fear, stress, and feather pecking in commercial white and brown laying hen parent-stock flocks and their relationships with production parameters. Poultry Science, 92(9): 2259-2269.

De Jong IC, Hindle VA, Butterworth A, Engel B, Ferrari P, Gunnink H, Perez Moya T, Tuyttens FAM, Van Reenen CG. 2016. Simplifying the Welfare Quality® assessment protocol for broiler chicken welfare. Animal, 10(1): 117-127.

European Commission. 2016. Directorate-General for Health and Food Safety, Attitudes of Europeans towards animal welfare. Report European Commssion. https://data.europa.eu/doi/10.2875/17980.

Farm AnimalWelfare Council (FAWC). 1993. Second Report on Priorities for Research and Development in Farm Animal Welfare; DEFRA: London, UK.

Fraser D. 2008. The role of the veterinarian in animal welfare. Animal welfare: too much or too little? Acta veterinaria Scandinavica, 50(1): 1-12.

Gilani AM, Knowles TG, Nicol CJ. 2013. The effect of rearing environment on feather pecking in young and adult laying hens. Applied Animal Behaviour Science, 148(1-2): 54-63.

Lambton SL, Knowles TG, Yorke C, Nicol CJ. 2010. The risk factors affecting the development of gentle and severe feather pecking in loose housed laying hens. Applied Animal Behaviour Science, 123(1-2): 32-42.

Laywel. The Laywel Project. https://laywel.eu/. Access: 27.04.2022

Main DCJ, Mullan S, Atkinson C, Bond A. 2012. Welfare Outcomes Assessment in Laying Hen Farm Assurance Schemes. Animal Welfare, 21(3): 389-396.

McAdie TM, Keeling LJ. 2000. Effect of manipulating feathers of laying hens on the incidence of feather pecking an cannibalism. Applied Animal Behaviour Science, 68(3): 215-229.

Mills AD, Faure JM, Williams JB. 1988. Feather loss and egg production in broiler breeders and layers. Annales de zootechnie, INRA/EDP Sciences, 37(3): 133-142.

Nicol CJ, Bestman M, Gilani AM, De Haas EN, De Jong IC, Lambton S, Wagenaar JP, Weeks CA, Rodenburg TB. 2013. The prevention and control of feather pecking: application to commercial systems. World's Poultry Science Journal, 69(4): 775-788.

Nicol CJ. 2019. Chapter 3: Feather Pecking in Laying Hens: Why They Do It, and Welfare Implications. In: Olukosi OA, Olori VE, Helmbrecht A, Lambton S, French NA. Poultry

Feathers and Skin: The Poultry Integument in Health and Welfare. Cambridge, England, UK, 31-46.

Peguri A, Coon C. 1993. Effect of Feather Coverage and Temperature on Layer Performance. Poultry Science, 72(7): 1318-1329.

Raubek J, Niebuhr K, Waiblinger S. 2007. Development of on-farm methods to assess the animal-human relationship in laying hens kept in non-cage systems. Animal welfare, 16(2).

Riedstra B, Groothuis TGG. 2002. Early feather pecking as a form of social exploration: the effect of group stability on feather pecking and tonic immobility in domestic chicks. Applied Animal Behaviour Science, 77(2): 127-138.

Rodenburg TB, Van Krimpen, MM, De Jong IC, De Haas EN, Kops MS, Riedstra BJ, Nordquist RE, Wagenaar JP, Bestman M, Nicol CJ. 2013. The prevention and control of feather pecking in laying hens: identifying the underlying principles. World's Poultry Science Journal, 69(2): 361-374.

Savory CJ. 1995. Feather pecking and cannibalism. World's Poultry Science Journal, 51(2): 215-219.

Schreiter R, Damme K, Klunker M, Raoult C, Von Borell E, Freick M. 2020. Effects of edible environmental enrichments during the rearing and laying periods in a littered aviary-Part 2: physical development of pullets and performance, egg quality, and carcass composition in laying hens. Poultry Science, 99(12): 6685-6696.

Van Horne PLM, Achterbosch TJ. 2008. Animal welfare in poultry production systems: impact of EU standards on world trade. World's Poultry Science Journal, 64(1): 40-52.

Van Niekerk T. 2019. Chapter 5: Evidence-based Management of Injurious Pecking. In: Olukosi OA, Olori VE, Helmbrecht A, Lambton S, French NA. Poultry Feathers and Skin: The Poultry Integument in Health and Welfare. Cambridge, England, UK, 57-69.

Van Staaveren N, Ellis J, Baes CF, Harlander-Matauschek A. 2021. A meta-analysis on the effect of environmental enrichment on feather pecking and feather damage in laying hens. Poultry Science, 100(2): 397-411.

Veissier I, Butterworth A, Bock B, Roe E. 2008. European approaches to ensure good animal welfare. Applied Animal Behaviour Science, 113(4): 279-297.

Waiblinger S, Knierim U, Winckler C. 2001. The Development of an Epidemiologically Based On-Farm Welfare Assessment System for use with Dairy Cows. Acta Agriculturae Scandinavia, Section A – Animal Science, 30: 73-77.

Webster J. 2016. Animal Welfare: Freedoms, Dominions and “A Life Worth Living”. Animals, 6(6).

Yamak US, Sarica M. 2012. Relationships between feather score and egg production and feed consumption of different layer hybrids kept in conventional cages. Archiv für Geflügelkunde, 76(1): 31-37.

Acknowledgments

Ich möchte mich bei meiner Betreuerin Ao.Univ.Prof. Susanne Waiblinger bedanken, für ihrem konstruktiven und immer hilfreichen Input bei unseren zahlreichen Skype-Meetings. Du hast mich immer wieder aufs Neue ermutigt, meine Arbeit weiter zu verbessern und genauer hinzusehen. Ich habe von dir sehr viel gelernt.

Ich möchte mich auch bei meinen Arbeitgebern Dr. Peter Mitsch und Dr. MMag. Alexander Tritthart, der Tierarzt GmbH Dr. Mitsch, für ihre großartige Unterstützung bedanken. Ihr habt immer an mich geglaubt, mich motiviert, dran zu bleiben und mir immer die nötige Zeit zur Arbeit an der Dissertation gegeben.

Weiters möchte ich der Firma „Die Eiermacher“ und allen Junghennen-Aufzuchtbetrieben dieser Integration meinen Dank aussprechen. Unsere Zusammenarbeit wurde durch das Projekt enorm gestärkt und ich hoffe auf viele weitere erfolgreiche gemeinsame Jahre.

Meinem Vater und meiner Mutter gilt ebenfalls besonderer Dank. Ihr habt mich mein ganzes Leben lang ermutigt: „Wenn du willst, kannst du alles schaffen. Wir sind immer für dich da, wenn du etwas brauchst.“ Ihr gebt mir ungeheuren Rückhalt, damit ich selbstbewusst und mit beiden Beinen im Leben stehen kann.

Zuletzt gilt mein Dank meinem Partner. Du hast auf mich Rücksicht genommen, wenn ich stundenlang an der Arbeit geschrieben habe, hast mich versorgt und dich um den Hund gekümmert. Außerdem danke ich auch seiner Familie, die mir eine wichtige seelische und auch sprachliche Unterstützung waren.