ANIMAL WELL-BEING AND BEHAVIOR

Effect of pecking stones and age on feather cover, hen mortality, and performance in free-range laying hens

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ABSTRACT Severe feather pecking is frequently associated with impaired egg production, poor hen welfare, and increased mortality. The aim of this study was to investigate the potential of pecking stones to ameliorate the incidence of feather pecking. A total of 18 flocks of Hy-Line Brown laying hens were randomly assigned to control (n = 9 no pecking stone access) or treatment (n = 9 pecking stone access) flocks and housed in commercial fixed sheds (farm A, n = 10) or commercial mobile sheds (farm B, n = 8) differing in various housing conditions. Beak length, feather score, egg production, and mortality were evaluated at 16 wk of age and every 10 wk until at least 46 wk of age. On farm A, hens with access to pecking stones had significantly lower mortality than hens without pecking stone access ($P = 0.001$). A significant interaction between pecking stone and age was observed on feather scores of wings of hens housed in farm A. Hens of the pecking stone group in farm A had higher wing feather score (indicating better feather condition) at the age of 56 and 66 wk than hens with no access to pecking stones (pecking stone × age, $P = 0.002$). The age of the hens was significantly associated with lower overall feather scores (poorer feather condition), reduced egg production, and higher mortality ($P < 0.05$). Although pecking stones reduced some feather loss and mortality, this effect was only present on one farm and therefore may be related to farm management. Especially the impact of pecking stones on mortality was inconclusive as the cumulative mortality in farm B was nearly twice as high compared with that in control flocks. Further investigations are warranted including the effects of pecking stone provision at an early age such as during rearing (0–17 wk of age).

Key words: poultry, environmental enrichment, management, welfare, cannibalism

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INTRODUCTION

Feather pecking is a widespread social behavior in commercial laying hens and can be categorized into gentle and severe feather pecking (Savory, 1995). Gentle feather pecking can be directed at particles of food or litter and dust located on the tip of feathers and also at feathers itself (for instance tips of tail feathers), resulting in no or very minor damage to feather cover (Savory, 1995). It is usually expressed by hens at young age and may be considered as allopreening (Kjaer and Sørensen, 1997). In contrast, severe feather pecking is defined by forceful pulling and, in some cases, consumption of feathers from the back, vent, and tail of other hens (Savory, 1995; Hartcher et al., 2015b). Severe feather pecking has been recognized as a persistent multifactorial behavior with a diverse range of causes including the environment, stocking density, hen genetic influences, and nutrition (Bestman and Wagenaar, 2003; Rodenburg et al., 2003; Drake et al., 2010; Lambton et al., 2010, 2013). Although it has been suggested that feather pecking can spread among the individuals through social interaction, this could only rarely be demonstrated (Zeltner et al., 2000; Appleby et al., 2004; McAdie et al., 2005). Severe feather pecking has been estimated to occur in 40 to 50% of layer flocks in Europe housed on barn or free-range systems (Blokhuis et al., 2007). Severe feather pecking is therefore a potential threat and a major challenge for the egg production industry because of welfare,

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production, and economic implications (Rodenburg et al., 2012; Yamak and Sarica, 2012).

Historically, beak trimming was considered the only effective tool to manage the occurrence and implications of severe feather pecking (Petek and McKinstry, 2010; Gilani et al., 2013). However, beak trimming can cause acute and chronic pain and thus can be a serious welfare concern by itself (Petek and McKinstry, 2010; Gilani et al., 2013). Subsequently beak trimming has been banned in several countries. This in turn necessitates finding alternatives to beak trimming to reduce the prevalence and severity of feather pecking. Environmental enrichment has been proposed as an effective solution to manage feather pecking behavior without beak trimming as it might divert hens' attention from feather pecking to competing stimuli (Jones, 2001; Jones et al., 2002). Such an environmental enrichment approach to reduce feather pecking in hens has been successful with the provision of straw, branches, polystyrene blocks, string, hay bales, and chains (Huber-Eicher and Wechsler, 1997; Johnsen et al., 1998; Sherwin et al., 1999; Huber-Eicher and Sebö, 2001a; McAdie et al., 2005). However, there has been little investigation into the success of commercially available pecking stones to reduce feather pecking and subsequently improve hen welfare. Pecking stones have an abrasive component that is hypothesized to blunt beaks as hens peck at the stone. This additional benefit might not only reduce the incidence of feather pecking by redirecting this behavior but may also reduce the need to trim the beak manually (Glatz and Runge, 2017). To date, there is little information on the impact of pecking stones on beak length and feather coverage in free-range laying hens.

The present study was conducted to investigate the effects of pecking stones on commercial egg farms on plumage condition, beak length, laying performance, and mortality of free-range laying hens.

MATERIAL AND METHODS

Animal Experiment and Housing

The experimental procedures were approved by the Animal Ethics Committee at the University of New England (AEC15-008), Armidale, New South Wales, Australia. A total of 18 flocks of Hy-Line Brown hens were examined on 2 different commercial free-range laying hen farms, whereas multiple subsequent flocks were followed up on each farm in time (placed in monthly and bimonthly intervals). Ten flocks were examined on farm A and 8 flocks were examined on farm B. Farm A housed infrared beak-trimmed hens in fixed sheds with a flock size of 20,000 hens/shed. Farm B housed non–beak-trimmed hens in mobile sheds with a flock size of 2,000 hens/shed. Both farms differed in management conditions, flock size, and housing conditions (Table 1). At each farm, pullets were reared in one flock and then split into equal numbers of hens, randomly allocated to separate sheds that were assigned to either the control group or the pecking stone group at 16 wk of age. Therefore, 5 control and 5 treatment groups were housed in farm A and 4 control and 4 treatment groups were housed in farm B.

Pecking Stones

Commercially available pecking stones were provided and contained 20.5% calcium, 5.0% phosphorus, 4.3% sodium, and 2.5% magnesium (Deutsche Vilomix Tierernährung GmbH, Neuenkirchen-Vörden, Germany). One pecking stone (approximately 10 kg) per 1,000 hens was provided to the treatment flocks when hens were 16 wk of age. Pecking stones were evenly distributed inside the shed on the slatted floor. Every 10 wk, an additional pecking stone per 1,000 hens was provided regardless of whether the pecking stones from the previous time point(s) had diminished or not. All pecking stones were weighed at each time point.

Data Collection

In farm A, beak length, toe nail length, feather score, egg production, and mortality were evaluated every 10 wk when hens were 16 to 66 wk of age. In farm B, unexpectedly high cumulative mortality of unknown cause occurred, which led to an early depopulation of 4 flocks subject of this research at 46 wk of age and depopulation of the remaining 4 research flocks at 56 wk of age. Thus, data of all 8 flocks in farm B (4 control and 4 treatment flocks) were obtained until hens were 46 wk of age, while data of 4 flocks (2 control and 2 treatment flocks) were examined until hens were of 56 wk of age.

At each time point, 50 hens per flock were randomly selected from 5 different random locations (10 hens per location) and individually evaluated for beak length using vernier calipers (Supatool, Kincrome Australia Pty Ltd., Scoresby, Victoria, Australia) and toe nail length using a measuring tape. Beak length was measured from the outer tip of the nostril to the tip of the beak as described by Glatz and Runge (2017). The plumage condition of the 50 individual hens was evaluated on a scale from 1 (no feathers) to 4 (full feather coverage) following the method described by Tauson et al. (2005). At each time point, hen house egg production (%) and weekly mortality of each flock were obtained from the farm management. However, owing to a management change on farm B, data collection on egg production and mortality of all 8 flocks was performed until 36 wk of age while data of the remaining 4 of the flocks was recorded until hens were 46 wk of age.

Statistical Analysis

All analyses were performed using SPSS version 2.2 (IBM, Chicago, IL). Mean values (n = 50 hens) per flock at each time point were used for statistical analysis. The flock was defined as the experimental unit. Hen age/time points were treated as a repeated factor. Each response

Table 1. A comparison between housing conditions on both farms.

Flock characteristic	Farm A	Farm B
Hen strain	Hy-Line Brown	Hy-Line Brown
Flock size	20,000	2,000
Stock density, hens/m^2	9.0	7.9
Flocks examined	10	8
Beak trimming	Infrared trimmed	Non trimmed
Shed type	Fixed	Mobile
Shed dimension	130 × 16 m	21 × 2 m
Pop hole numbers	10 on each side along the length	3 on each side along the length
Pop hole dimension	2 × 0.45 m	6 × 1.5 m
Perch height	0.3 m	0.6 m
Floor cover	Slats	Slats
Range area	71 m × 46 m for 40 D	75 m × 45 m for 40 D
Range rotation	After 40 D, hens have access to new range areas	Every 40 D, the whole shed was moved to a new place

parameter was tested for normality before analysis (Kolmogorov-Smirnov). Egg production data obtained from farm B were square root transformed and subsequently met the criteria for normality. All normally distributed data were evaluated using a general linear mixed models (**GLMM**). All models included the random effects of flock and fixed effects of pecking stone and hen age/time point as well as their interaction. Mortality was not normally distributed and therefore was analyzed using a generalized linear mixed model (**GLIMM**) with a Poisson distribution and a log link function. The Bonferroni method was used to correct for multiple post hoc comparisons. Significance was set at $P = 0.05$ or $P < 0.05$.

RESULTS

Effect of Pecking Stones

Pecking stone consumption differed between farms; hens in farm B consumed more pecking stone than hens in farm A at week 26 (24.8 ± 6.40 vs. 2.73 ± 0.79 kg/1,000 hens), 36 (21.4 ± 11.1 vs. 6.74 ± 0.75 kg/1,000 hens), and 46 (22.59 ± 8.62 vs. 12.1 ± 1.58 kg/1,000 hens). Pecking stone consumption increased with age (Table 2). In farm A, hens with access to pecking stones had better plumage cover on their wings from 46 wk to 66 wk of age than control hens (pecking stone × age: GLMM, $F_{(5,30)} = 5.01$, $P = 0.002$; Figure 1A). In addition, hens in farm A

Table 2. Effects of pecking stone on egg production and mortality in farms A and B.[1]

	Egg production (%)		Mortality (%)	
Age (A) of hens[2] (weeks)	TRT[3]	Control	TRT	Control
Farm A				
16	NA	NA	0.04 ± 0.02^{d}	0.07 ± 0.06^{d}
26	91.8 ± 1.01^{a}	92.9 ± 1.46^{a}	1.32 ± 0.28^{d}	1.2 ± 0.43^{d}
36	91.2 ± 1.26^{a}	92.2 ± 0.86^{a}	3.90 ± 1.04^{c}	4.93 ± 0.61^{c}
46	89.7 ± 0.84^{b}	87.7 ± 1.73^{b}	4.98 ± 1.32^{b,c}	6.90 ± 1.01^{b,c}
56	85.3 ± 3.81^{b,c}	83.5 ± 3.34^{b,c}	5.61 ± 1.45^{b}	8.38 ± 1.01^{b}
66	78.3 ± 3.85^{c}	75.9 ± 3.80^{c}	9.54 ± 0.95^{a}	11.7 ± 1.71^{a}
TRT	0.783		0.178	
A	<0.001		<0.001	
TRT × A	0.850		0.404	
Farm B				
16	NA	NA	1.28 ± 1.18^{b}	0.08 ± 0.08^{b}
26	66.1 ± 3.93^{b}	67.1 ± 9.05^{b}	7.23 ± 5.54^{a,b}	3.06 ± 1.59^{a,b}
36	61.9 ± 7.04^{a}	57.2 ± 6.70^{a}	20.4 ± 10.1^{a}	10.8 ± 5.28^{a}
46	72.3 ± 1.05^{b}	70.8 ± 3.70^{b}	11.3 ± 0.001^{a,b}	5.61 ± 2.35^{a,b}
TRT	0.931		0.349	
A	<0.001		0.02	
TRT × A	0.836		0.739	

$^{a–c}$The different superscript alphabets within a column indicate a main effect for a measured parameter is different ($P < 0.05$).

[1]Each flock performance data were obtained from the farm manager at each time point.

[2]Age (A) = time point: farm A = 5 replicates of control and treatment evaluated at each time point; farm B, 4 replicates of control and treatment evaluated at 16, 26, and 36 wk of age and 2 replicates of control and treatment evaluated at 16, 26, 36, and 46 wk of age.

[3]TRT = treatment: after every 10 wk, 10 kg pecking stone/1,000 birds were placed in all treatment flocks. A total of 5 control and 5 treatment flocks in farm A and 4 control and 4 treatment flocks in farm B were investigated.

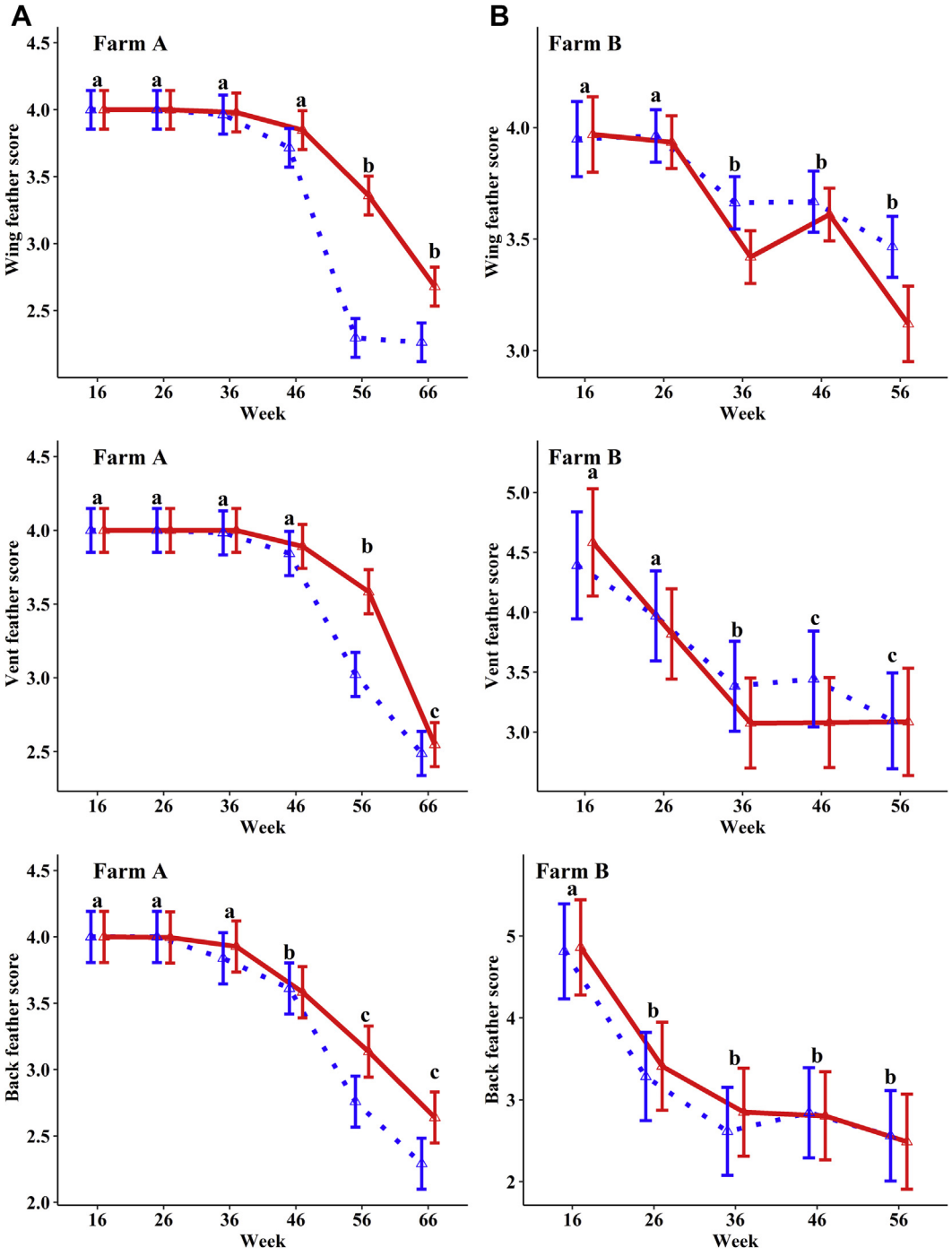

Figure 1. Feather score of different body parts (wing, vent, and back) of hens at (A) a commercial fixed shed farm (farm A) and (B) a commercial mobile shed farm (farm B) at different weeks of age. The "abc" represents significant difference between the age group. There was no difference between the treatment groups in any of the parameters. Levels not connected by the same letter are significantly different. There was no significant difference between the farms at any weeks of age. Red line represents treatment group (pecking stone provided) and blue dotted line represents control group without pecking stone.

that were offered pecking stones tended to have higher feather scores on their vents at 56 wk of age than control hens (GLMM, $F_{(5,31)} = 2.42$, $P = 0.058$; Figure 1B). Mortality increased with age in both farm A and B ($F_{(1,47)} = 2.251$, $P = 0.0240$, and $F_{(1,47)} = 4.397$, $P = 0.0234$, respectively), but no significant effect of pecking stone was observed (Figure 2 and Table 2). Details about the lack of significance of pecking stone or its interaction with age for all other parameters including beak length are presented in Table 3.

The Effect of Age

All feather scores decreased (worsened) with age ($P = 0.003$; Table 3). The beak length of hens housed in farm A at 16 wk of age was shorter than that of hens at 36, 46, 56, and 66 wk (GLMM, $F_{(5,27)} = 10.50$, $P < 0.001$; Table 3). Similarly, hens housed in farm B had shorter beaks at 16, 26, and 36 wk of age than at 56 wk of age (GLMM, $F_{(4,16)} = 26.70$, $P < 0.001$; Table 3). Toe nail length of hens housed in farm A at

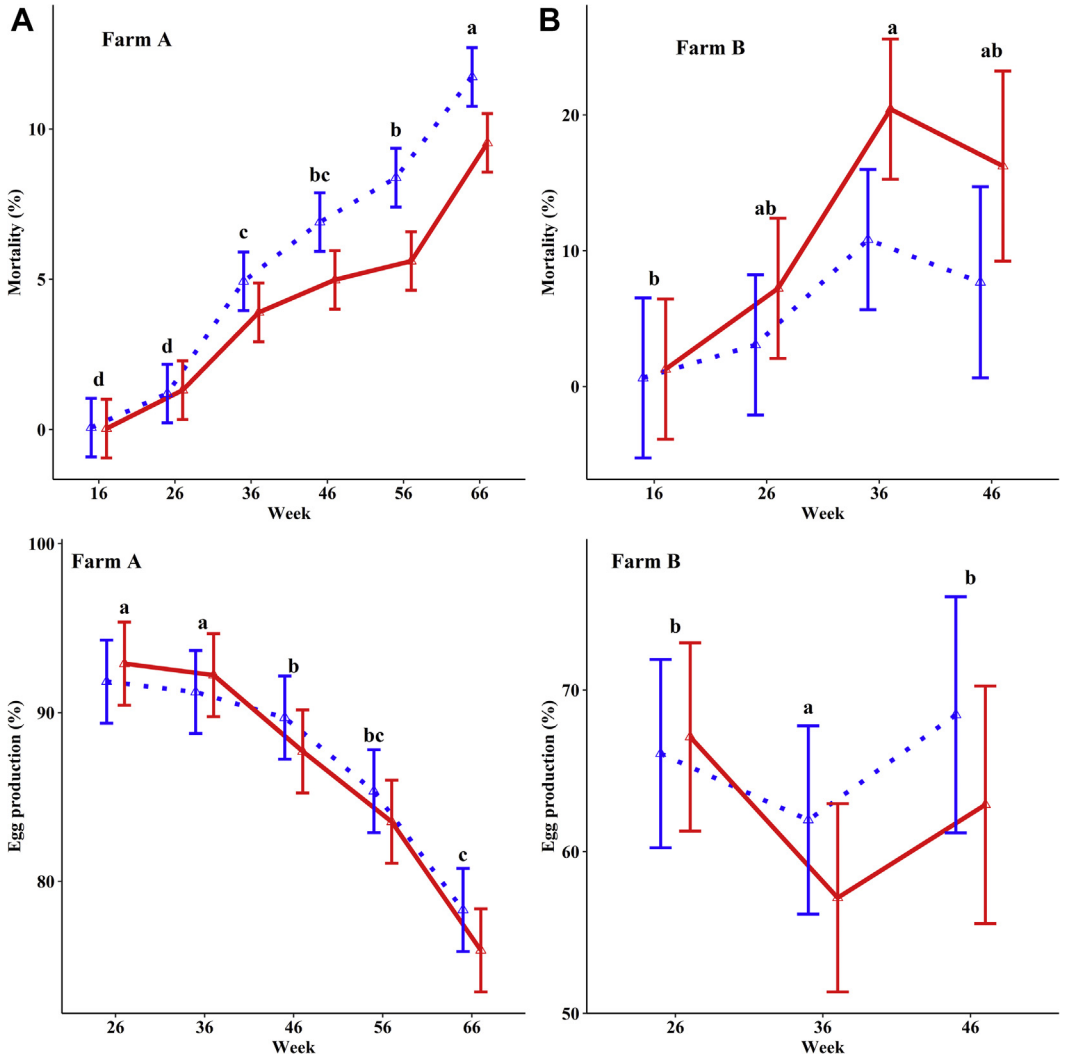

Figure 2. Percentage egg production and percentage mortality at (A) a commercial fixed shed farm (farm A) and (B) a commercial mobile shed farm (farm B) at different weeks of age. The "abc" represents significant difference between the age group. Levels not connected by the same letter are significantly different. There was no difference between the treatment groups in any of the parameters. There was no significant difference between the farms at any weeks of age. Red line represents treatment group (pecking stone provided) and blue dotted line represents control group without pecking stone.

the age of 16 wk was shorter than that at 26, 36, 46, 56, and 66 wk of age (GLMM, $F_{(5,35)} = 5.65$, $P = 0.01$; Table 3). There was no effect of age on toe nail length in farm B ($P > 0.05$).

Hens housed in farm A produced fewer eggs per hens present at the age of 66 wk than at 26, 36, and 46 wk of age (GLMM, $F_{(5,32)} = 51.66$, $P < 0.001$; Table 2). Hens housed in farm B produced fewer eggs at the age of 36 wk than at 26 and 46 wk of age (GLMM, $F_{(3,13)} = 91.04$, $P < 0.001$; Table 2). In farm A, higher mortality was observed at the age of 66 wk than at 16 wk of age (GLIMM, $F_{(5,47)} = 2.53$, $P = 0.041$). In farm B, mortality was lower at the age of 16 than at 36 wk (GLIMM, $F_{(3,15)} = 28.2$, $P < 0.001$; Table 2).

DISCUSSION

Hens in farm A that were provided with pecking stones had lower mortality. These results suggest that the reduction in mortality seen in hens that were provided with pecking stones in farm A was related to severe feather pecking and cannibalism. These results are in line with previous reports in which higher hen mortality has been shown to be associated with feather pecking and cannibalism, especially in the absence of any disease (Hughes and Duncan, 1972; Allen and Perry, 1975; Appleby and Hughes, 1991; Guesdon et al., 2006). The effects of the pecking stones were absent in farm B, although the hens had poorer feather cover and higher mortality than farm A, and pecking stone consumption was greater. In fact, the cumulative mortality in farm B was nearly twice as high compared with that in control flocks (Table 2), leading to inconclusive results regarding hen mortality. One major difference between farm A and farm B was that beaks of hens in farm B were nontrimmed, and as such, it may provide evidence that pecking stones may only be effective in beak trimmed hens. Although we were not able to quantify the cause of mortality in farm B, non–beak-trimmed hens are known to be subject to higher

Table 3. Effects of pecking stone (TRT) on age on beak length, toe nail length, and feather score compared to hens that were not provided with pecking stones (control) across 2 study sites (farm A and farm B).[1]

	Beak length (mm)		Toe nail length (mm)		Feather scoring[3]											
					Neck		Back		Vent		Breast		Wings		Tail	
Age (A) of hens[2] (weeks)	TRT[4]	Control	TRT[4]	Control	TRT[4]	Control	TRT[4]	Control	TRT[4]	Control	TRT[4]	Control	TRT[4]	Control	TRT[4]	Control
Farm A																
16	13.0^{a}	12.7^{a}	1.52^{a}	1.52^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}
26	13.5^{a,b}	13.5^{a,b}	1.66^{b}	1.67^{b}	4.00^{a}	4.00^{a}	3.99^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.90^{b}	3.82^{b}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}
36	14.1^{b}	14.1^{b}	1.68^{b}	1.74^{b}	4.00^{a}	3.95^{a}	3.93^{a}	3.84^{a}	4.00^{a}	3.98^{a}	3.04^{b}	2.96^{b}	3.98^{a}	3.96^{a}	3.96^{a}	3.90^{a}
46	14.5^{c}	14.4^{c}	1.72^{b}	1.76^{b}	3.72^{a,b}	3.33^{a,b}	3.58^{b}	3.61^{b}	3.89^{a}	3.84^{a}	2.56^{b}	2.17^{b}	3.84^{a}	3.71^{a}	3.58^{a}	3.61^{a}
56	14.8^{c}	14.6^{c}	1.70^{b}	1.73^{b}	3.20^{b}	2.26^{b}	3.14^{c}	2.76^{c}	3.58^{b}	3.02^{b}	1.46^{b}	1.26^{b}	3.36^{b}	2.29^{b}	3.12^{b}	2.58^{b}
66	14.3^{c}	14.9^{c}	1.70^{b}	1.78^{b}	2.86^{b}	2.15^{b}	2.64^{c}	2.29^{c}	2.55^{c}	2.48^{c}	1.32^{b}	1.17^{b}	2.68^{b}	2.26^{b}	2.47^{b}	2.18^{b}
SEM	0.278		0.057		0.263		0.205		0.163		0.186		0.149		0.217	
P value																
TRT	0.978		0.568		0.258		0.608		0.517		0.311		0.061		0.575	
A	<0.001		0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
TRT × A	0.472		0.927		0.227		0.310		0.058		0.914		0.002		0.149	
Farm B																
16	15.4^{a}	16.1^{a}	1.65	1.67	4.00^{a}	3.98^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.81^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}
26	15.1^{a}	15.3^{a}	1.70	1.74	3.98^{a}	3.98^{a}	3.41^{b}	3.28^{b}	3.82^{a}	3.97^{a}	3.85^{b}	3.82^{b}	3.93^{a}	3.96^{a}	3.99^{a}	3.79^{a}
36	15.8^{a}	15.7^{a}	1.60	1.67	3.82^{a}	3.84^{a}	2.85^{b}	2.61^{b}	3.07^{b}	3.38^{b}	3.09^{b}	3.40^{b}	3.42^{b}	3.66^{b}	3.01^{b}	2.77^{b}
46	16.4^{a,b}	16.5^{a,b}	1.69	1.64	3.87^{a}	3.87^{a}	2.80^{b}	2.80^{b}	3.08^{c}	3.21^{c}	2.66^{b}	2.76^{b}	3.61^{b}	3.65^{b}	2.87^{b}	2.61^{b}
56	17.5^{b}	17.5^{b}	1.65	1.84	3.74^{b}	3.74^{b}	2.75^{b}	2.57^{b}	2.99^{c}	3.30^{c}	2.31^{b}	2.53^{b}	3.09^{b}	3.36^{b}	2.21^{b}	2.39^{b}
SEM	1.036		0.053		0.067		0.475		0.353		0.186		0.115		0.399	
P value																
TRT	0.898		0.357		0.674		0.962		0.719		0.707		0.227		0.862	
A	<0.001		0.157		0.023		0.002		0.019		<0.001		<0.001		0.003	
TRT × A	0.337		0.199		0.999		0.971		0.930		0.581		0.730		0.942	

[a–c]Different superscript letters within a column indicate a main effect ($P < 0.05$).

[1]In each flock, 50 birds were randomly selected at 5 different places of house every 10 wk; results are reported as mean values.

[2]Farm A = 5 replicates of control and treatment evaluated at each time point; farm B = 4 replicates of control and treatment evaluated until 46 wk and 2 replicates of control and treatment evaluated until 56 wk of age on farm B.

[3]Feather scoring was performed by scoring individual hen on a 1–4 scale with 1 being no feather cover and 4 being full feather cover.

[4]TRT = treatment: after every 10 wk, 10 kg pecking stone/1,000 birds were placed in all treatment flocks. A total of 5 control and 5 treatment flocks in farm A and 4 control and 4 treatment flocks in farm B were investigated.

mortality (Guesdon et al., 2006). Although gentle feather pecking is predominantly directed toward wing and tail feathers, the significant better cover of this area in hens offered with pecking stones in the present study may rather reflect an impact of pecking stones on gentle feather pecking (Daigle, 2017).

Differences on the impact of pecking stones in farm B and farm A may have been due to the various housing and management conditions between the farms, including the use of beak-trimmed hens, flock size, range management, and stockmanship. Infrared beak trimming of hens in farm A may have reduced the overall pecking activity and minimized the need for further shortening of the already short beaks (Desserich et al., 1983). In addition, the lower use of pecking stones by infrared beak-trimmed hens may have been due to painful exposure of the sensory innervation of the beak, which may have also altered the overall pecking behavior (Hartcher et al., 2015a). Infrared beak-trimmed hens are known to alter their feeding behavior, which may indicate that their pecking stone consumption may also be affected (Iqbal et al., 2019).

Better plumage cover indicated by higher feather score of hens that were provided with pecking stones in farm A is in agreement with the previous reports of reduced feather pecking when hens were exposed to polystyrene blocks or foraging material (Huber-Eicher and Wechsler, 1998). However, the lack of consistent response to pecking stones on beak length and overall feather score in the present study may be related to the time that the pecking stones were initially placed in the house. Early life experience is important in developing pecking behavior (Huber-Eicher and Sebö, 2001b). As such, the critical age of chicks to learn pecking a substrate is when they reach the age of 10 days (Vestergaard and Baranyiova, 1996). Exposing pullets during rearing to a new pecking substrate may redirect pecking behavior from flock mates toward substrate pecking and prevent feather pecking in adult hen flocks (Vestergaard and Baranyiova, 1996). Using environmental enrichment during rearing can encourage birds to develop their exploring behavior (Glatz and Runge, 2017; Daigle, 2017). Further research is warranted to examine the effects particular of range use and individual exploratory behavior on feather pecking.

CONCLUSION

The results of the present study are of direct relevance to the industry and demonstrate evidence that pecking stones may improve feather plumage of certain body areas and mortality within flocks. However, these results were not consistent across both study sites and especially mortality results lead to ambivalent findings. Further investigations are warranted to determine the factors that may impact hen interactions with pecking stones and the subsequent benefit for hen welfare.

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