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Feather Pecking of Laying Hens in Different Stocking Density and Type of Cage

Research Article

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ABSTRACT

Both stocking rate and housing systems are main factors influencing the occurrence of feather pecking in laying hens raised in conventional cage system. This study examines the effects of different type of cage and stock density on feather pecking behaviour in hens. Total of 216 Hisex Brown hens at 16 weeks of age were randomly selected and put into 2 types of battery cages: conventional cages and modified cages fitted with perch. Each groups comprised 3 subgroups: 2 hens per cage (943 cm^2/hens), 3 hens per cage (627.7 cm^2/hens), and 4 hens per cage (417.5 cm^2/hens). The feather pecking behavior was observed at 25, 28, 31, 34, 37 and 40 weeks of age using time sampling scanning technique. Feather scoring of the hens was done at 42 weeks of age, neither cage type effect nor their interactions with stock densities on feather pecking behaviour and feather score were evident. The results showed that there were significant effect of stocking density on feather pecking behaviour, and feather score ($P<0.05$). Hens in 3 and 4 hens per cage displayed higher feather pecking bouts than those in 2 hens per cage ($P<0.05$). The feather condition scores in the areas of breast, wing, rump, tail, and belly of the birds in 2 hens per cage were better than those in other groups ($P<0.05$). The hens in 2 hens per cage also had higher body weight change than those in the other densities ($P<0.05$). This study demonstrated that the stock density had considering higher impact on feather pecking behavior than the type of cage. Therefore, using optimum stocking rate would be a potential choice following welfare consideration together with appropriate housing system currently applied.

KEY WORDS feather pecking, housing, laying hen, stocking density.

INTRODUCTION

Conventional cages are the main housing system for laying hen in the industry. This housing system has been criticized for limiting the ability of hens to perform certain behaviors (Moesta *et al.* 2008). In addition, the farmers need to raise their hens at a higher density (<450 cm^2 per hen); in order to reduce the cost of housing. The hens may not express natural behavior, leading to stress, fear and abnormal behavior such as feather pecking and cannibalism behavior (Enneking *et al.* 2012; Dereli Fidan and Nazligul, 2013).

Feather pecking remains an important welfare issue in laying hens (Dereli Fidan and Nazligul, 2013), it increases economic losses due to increased feed consumption and mortality (Rodenburg and Koene, 2007). Pulling out feathers causes pain (Gentle and Hunter, 1990; Sarica *et al.* 2008), increases risk of injuries and can trigger an outbreak of cannibalism (Rodenburg *et al.* 2008). In addition, massive loss of feathers is accompanied by increased heat loss resulting in 10-30% increased food consumption (Glatz, 1998; Rodenburg and Koene, 2007; Dereli Fidan and Nazligul, 2012).

Feather pecking is the important problem that occurs most frequently among domestic hens; of which are reared for egg production (Rodenburg *et al*. 2008; Dereli Fidan and Nazligul, 2012). Feather pecking is a type of abnormal behaviour in poultry that consists of pecking at feathers of other birds, sometimes pulling the feathers out and often eating them (Kjaer, 1999). The target of feather pecks depends on the relative location of the pecking and pecked bird. While standing on the floor birds peck mainly to the belly of other birds, and when the birds are on the perch, they peck more to the neck and rump (Bilaik and Keeling, 2000). Feather pecking is also a multi-factorial problem affected by the genetic background of the birds, their early life history and environmental factors such as nutrition, adequate lighting, housing systems, group size and stocking density (Kjaer, 1999; Rodenburg and Koene, 2007). Under commercial conditions, conventional cage and increase in group size are associated with higher level of feather pecking incidences (Nicol *et al*. 1999; Rodenburg and Koene, 2007). De Jong *et al*. (2013) found that cage design had a significant influence on feather pecking and body plumage. Dereli Fidan and Nazligul (2012) also stated that feather degree was highest in 3 bird density group (16.59 score) and the lowest in 5 bird density group (8.40 score). As a result, the animal welfare committee has reinforced the gradual changes in cage and housing system and appropriate stocking density for laying hen.

The animal welfare committee recommends the move towards free range system, furnished and enriched cage and modified cage systems. Hens in such cages must be provided with 550 cm^2 per bird. Hens in enriched cages must have 750 cm^2 per bird and 250 cm^2 of littered area per hen in alternative system (Broom, 2001; Nicol *et al*. 2006; Council of European Council, 2007). The hens in these systems showed increase locomotive behavior, reduced pecking feather and cannibalism (Moesta *et al*. 2008). Zepp *et al*. (2018) also found that feather pecking could be reduced by reducing the stocking density and providing enrichment in commercial aviary systems.

In Thailand, as most laying hens are still kept in cages, the better alternative would be to improve conditions within such old types of cages rather than to move towards modern, high welfare standards housing systems which may be too costly. The aim of this study was, then, to re-examine the effects of modified cage with various densities on feather pecking behaviour, feather score and performance.

MATERIALS AND METHODS

Animal, experimental diets and housing

Two hundred sixteen Hisex Brown hens were supplied by Suwanvajokkasikit Farm Kasetsart University and were reared from 16 to 72 weeks without the use of beak trimming.

The hens were randomly assigned to two different housing systems such as conventional battery cages and battery cages with perch (modified cages). Each group was further allotted to 3 cage densities, i.e. 2 (943.0 cm^2/hen; n=48), 3 (627.7 cm^2/hen; n=72) and 4 (417.5 cm^2/hen; n=96) birds/cage (3 replicates with 4 cages per replicate). The hens were randomly assigned to either conventional battery cages or battery cages with perch (modified cages). Feeding, lighting, health management and other practices were the same for both treatments as recommendations by Hisex Brown Management Guide (https://www.hisex.com) (Hindex Genetic, 2015).

The birds had *ad libitum* access to a layer diet containing 3414 kcal metabolizable energy (ME), 17.24% crude protein (CP), 4.34% Ca and 1.36% available P. and drinking water. Feed was added twice a day (08:00 h and 16:30 h). The temperatures and relative humidity were recorded daily.

Weekly date were reported in Table 1. The average temperature was 28 ˚C and average relative humidity (RH) was 72% in during the experimental period. This study was approved by the ethics committee of Kasetsart University (Approval no. ACKU60-AGR-011).

A 2-tier conventional battery cages (41×46 cm) house with evaporative cooling system was used. The front height of each tier was 43.5 cm and 38 cm at the back with sloped floor to the front which fitted with eggs trough under feeder space of 50 cm and via nipple fitted on the top of the cage. There are 4 blocks and each block has 246 cage units. The modified cages were fitted with ¾ inches PVC perch**,** 30 cm in length, 10 cm in height from the cage floor and 5 cm from the back. The birds in 2, 3 and 4 hens/cage had perch area of 15, 10 and 7.5 cm/hen, respectively.

Behaviour observation

Feather pecking was observed when the hens were 25, 28, 31, 34, 37 and 40 weeks of age. The location and behaviour of the birds in all cages were observed twice a week for 2 h in the morning (10.00 - 12.00 hours), 2 h in the afternoon (14.00-16.00 hours) and 2 h in the evening (18.00-20.00 hours). The observer stood in front of the pen about 5 min before observation. Direct visual observations using time sampling scanning technique at 10 min intervals were conducted to record the frequency of feather pecking behaviour of hens. Observations were focused on feather pecking behaviour. Feather pecking is defined as the pecking of the bird's feathers by another bird, and directed to the plumage on any part of the body (Nicol *et al*. 2006). Feather pecking behaviour data within 5 min from all treatments were averaged.

Table 1 The average temperature and relative humidity per week in during the experimental period

Age (weeks)	Temperature (˚C)	Relative humidity (%)	Age (weeks)	Temperature (˚C)	Relative humidity (%)
16	29	71	29	27	75
17	28	70	30	29	75
18	28	75	31	28	72
19	28	74	32	27	72
20	27	72	33	29	72
21	27	72	34	30	74
22	26	73	35	26	75
23	29	75	36	28	72
24	30	73	37	27	75
25	32	72	38	28	74
26	29	75	39	28	72
27	28	62	40	28	72
28	27	72	41	28	74
29	27	75	42	27	74

Feather score

Five birds per replicate (n=60) were randomly selected and assessed for feather loss at 42 weeks of age. Feather loss was determined using the following 4-point scoring system from 7 different areas of the body (comb, neck, belly, wings, rump, tail, and breast): 4= complete feather cover, 3= worn feathers detectable, 2= badly worn feathers detectable or small bare patches and 1= badly worn feathers over most of the area, or mostly devoid of feathers (Nicol *et al.* 2006). Feather scores data for these different body areas were averaged.

Performance

Feed intake data were recorded daily. Feed conversion ratio was calculated weekly. Initial weight, final weights of all birds and mortality rate were recorded.

Statistical analysis

All data were analyzed by 2 × 3 Factorial in Complete Random Design using PROC GLM procedure. If the data were not normally distributed, they were square root transformed prior to analysis. Least squares means were calculated and the means among treatments were compared by the PDIFF option with the Turkey adjustment. Significance level was set at $P < 0.05$.

RESULTS AND DISCUSSION

Neither cage type effects nor their interactions with cage densities were detected. The effects of cage density on feather pecking, feather score (breast, wing, rump, tail and belly) and body weight change were detected (Tables 2, 3 and 4). The hens in 2 hens/cage had lower feather pecking behavior than those hens in 3 and 4 hens/cage ($P<0.05$; Table 2). The stocking density has significant effect on feather scores on breast, wing, rump, tail and belly ($P<0.05$; Table 3).

Average feather score of hens in 2 hens/cage was better than those in other groups whereas 3 hens/cage had higher value than those in 4 hens/cage on the area of breast ($P<0.05$). The average scores on the area of wing of hens in 2 and 3 hens/cage were higher than those in 4 hens/cage ($P<0.05$). The average feather scores of hens in 2 hens/cage on the area of rump and belly were highest ($P<0.05$) whereas values for those in 3 and 4 hens/cage were not different ($P>0.05$). The highest average feather scores on the area of tail occurred in 2 hens/cage group were higher than those in 4 hens/cage ($P<0.05$), but not differ from those in 3 hens/cage ($P>0.05$).

There were no significant differences among treatments in feed intake and mortality rate ($P>0.05$), except body weight change ($P<0.05$; Table 3). Hens in 2 hens/cage had higher body weight change than those in the other densities ($P<0.05$).

The main purpose of this study was to determine whether access to perches fitted in cages with various stock densities altered feather pecking behavior, feather score, and performance. Hens have a strong motivation to perch (Appleby and Hughes, 1991) as they perched when it available. Unexpectedly, neither effects of the access to perch in cages nor their interactions with stock densities on any parameters studied were detected. It is possible that it may be due to perch height.

It had been suggested earlier that the height of the perch is an important consideration “as a perch only 5 cm high above the cage floor is not considered as a perch and has no attractive nor repulsive value” to the birds (Scientific Veterinary Committee, 1996). In aviary system, perching space guidelines are frequently based on the hen’s body width to ensure accommodation of all hens, with 15 cm/hen being the common recommendation (Campbell *et al.* 2016). In this study, perch space per hen for those in 2 hens/cage would rather be sufficient according to the above recommendation.

Table 2 Average number of pecks per bird per 5 minutes in different housing and stocking density

Items	Feather pecking (LSM±SD)
Housing system (H)	
Cage	1.17±0.58
Cage with perch	0.91±0.35
Stocking density (S)	
2 hens/cage (943 cm^2/hen)	0.62±0.35^b
3 hens/cage (627.7 cm^2/hen)	1.25±0.43^a
4 hens/cage (417.5 cm^2/hen)	1.25±0.40^a
P-value	
H	0.1073
S	0.0298
H × S	0.7809

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
LSM: least square mean and SD: standard deviation.

Table 3 Plumage condition scores of hens in different of housing and stocking density (n=60) (Mean±SD)

Items	Comb	Neck	Breast	Wing	Rump	Tail	Belly
Housing system (H)							
Cage	3.81±0.13	3.38±0.36	3.11±0.53	3.81±0.24	3.67±0.28	3.17±0.25	3.81±0.21
Cage with perch	3.91±0.25	3.22±0.51	2.98±0.74	3.79±0.38	3.56±0.53	3.14±0.28	3.89±0.13
Stocking density (S)							
943 cm^2/hen	3.92±0.13	3.54±0.33	3.67±0.26^a	3.79±0.29^a	3.96±0.10^a	3.33±0.13^a	4.00±0.00^a
627.7 cm^2/hen	3.97±0.31	3.33±0.44	2.96±0.33^b	3.75±0.27^a	3.50±0.42^b	3.17±0.30^{ab}	3.79±0.19^b
417.5 cm^2/hen	3.98±0.10	3.04±0.43	2.46±0.46^c	3.29±0.33^b	3.38±0.41^b	2.96±0.19^b	3.75±0.16^b
P-value							
H	0.8336	0.3887	0.3434	0.0622	0.5286	0.8068	0.2442
S	0.7659	0.1307	0.0003	0.0026	0.0393	0.0523	0.0241
H × S	0.1906	0.2841	0.3787	0.2704	0.6186	0.6555	0.6186

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SD: standard deviation.

Table 4 Performance of hens in different cage density (Mean±SE)

Items	Cage density (cm^2/hen)			P-value
	943	627.7	417.5	
Body weight change (kg)	0.71±0.06^a	0.64±0.03^{ab}	0.57±0.07^b	0.0064
Feed intake (g/bird)	107.29±4.43	106.72±9.33	105.75±3.31	0.9185
Mortality rate (%)	0.00±0.00	2.78±1.30	3.13±1.42	0.1623

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SE: standard error.

However, perch access in small cage designs with fixed cage height and ineffective perch height and length may not be able to efficiently improve hen welfare by reducing aggressive and pecking behaviour. These unexpected results, therefore, suggested that not only should perch be made available with enough area per bird, but it should be elevated (Schrader and Muller, 2009).

In contrast, housing system affects feather pecking activities and aggressive behaviour of chickens (Dereli Fidan and Nazligul, 2013; Hartcher *et al*. 2015; Huo and Na-Lampang, 2016). Cage design had significant impact on feather pecking and body plumage conditions (De Jong *et al*. 2013).

Appleby *et al*. (2004) also stated that housing conditions such as conventional cage, which limits movement, can lead to stress and feather pecking behaviour, but increased complexity within housing and cages, such as non-cage, furnished and enrich system, can reduce feather pecking in laying hens.

An appropriate housing design, resulting in no competition or increased activity at feeders, drinkers and nest boxes, and the availability of perches may prevent feather pecking (Savory, 1995). Our results are inconsistent with above findings. This may be due to the differences in cage design, area per bird and perch height. This inconsistence of the results also gives an evidence for modified cage design that is useful for commercial cage fitted with perch design in the future.

Feather pecking behavior

This study examines the effects of different type of cages (conventional cages and modified cages) and stock densities (2 hens/cage; 943 cm^2/hen, 3 hens/cage; 627.7 cm^2/hen and 4 hens/cage; 417.5 cm^2/hen) on feather pecking and feather score. Surprisingly, this result demonstrated that stocking density had considerably higher impact on feather pecking and feather score than the effect of housing system in laying hens.

It is evident that higher stocking density can lead to higher levels of damaging behaviours, and increased fearfulness and stress in poultry (Rodenburg *et al*. 2008). Feather damage, caused by abrasion against other birds at high density or against equipment in the system or the side of cages, has also been found to facilitate and accelerate outbreaks of feather pecking (Savory and Mann, 1997; McAdie and Keeling, 2002). These findings are supported by the results presented by Nicol *et al*. (1999); De Haas *et al*. (2014) and Yin *et al*. (2017) found that group size and stocking density are related to feather pecking. Increasing group size (Keeling, 1995) or increasing stocking density (Appleby, 1998; Savory and Mann, 1999) has been linked with an increase in feather pecking behaviour. In fact, group size and stocking density are confounded as the role of each individual factor cannot be distinguished (Nicol *et al*. 1999; Savory and Mann, 1999).

In this experiment, hens in 3 hens per cage (627.7 cm^2/hen) and 4 hens per cage (417.5 cm^2/hen) displayed higher feather pecking than 2 hens per cage (943 cm^2/hen). It's possible that hens in high stocking density and group size (3-4 hens per cage) did not have adequate space to display feeding and drinking behaviour (Sarica *et al*. 2008; Dereli Fidan and Nazligul, 2012). As a result, hens had displayed aggression by fight for resources, lead to increased feather pecking behavior (Hansen and Braastad, 1994). Similar to Onbasilar (2003); Sarica *et al*. (2008) and Dereli Fidan and Nazligul (2012) who stated that decreasing feeder allowance for each bird related to increasing cage density, increasing trend in pecking and feather pecking and stress could have accelerated the loss of feather. It had been shown that stocking density and feather pecking are related. Zepp *et al*. (2018) suggested that feather pecking could be reduced by reducing the stocking density and providing enrichment in commercial aviary systems. These results indicate and may imply that the cage and modified cage with perch can increase space area, leading to more display of normal behavior expression(s) and decrease abnormal behavior.

In addition, it would be possible that high stocking density which has been criticized for limiting the ability of hens to perform certain behaviour (Moesta *et al*. 2008), causes hens to display aggressive behavior, feather pecking and cannibalism behaviour (Gibson *et al*. 1988). Zepp *et al*. (2018) suggested that the birds possibly could not keep the preferred inter individual distances and their need for space was unsatisfied. This may have led to frustration and therefore to feather pecking. Space availability can be limited not only by the cage size per se, but also by the stocking density, and individual size. Animal welfare is ultimately determined by the ongoing social interactions among the birds and physical space limitations (Leone and Estévez, 2008). High group size and density are expected to increase conflicts between birds, leading to increased stress, which can also increase fearfulness, higher glucocorticoid levels, and cause a decrease in bursa weight (Ravindran *et al*. 2006). Similar to Rhim (2013) founded that body and head pecking were higher in small cages compared to medium and large cages. This seems most likely because pecking behavior is performed at small inter individual distance. Sarica *et al*. (2008) also suggested that most feathers pecking in the cage of 500 cm^2 per hen densities compared 667 cm^2, 1000 cm^2 and 2000 cm^2 per hen. The greatest increase in feather pecking behavior was observed in higher stocking density. Our results confirmed this contention. In addition, it is evident that higher stocking density can lead to higher levels of damaging behaviours and increased fearfulness and stress in poultry (Rodenburg *et al*. 2008). Thus, low stocking density would be the choice to minimize feather pecking behavior in hens.

Feather score

In this study, feather scores of all areas in low stocking density were better than those in higher stocking densities. The results in current study regarding the losing feather score in high stocking density are in agreement with other studies that reported most feather damage in the high stocking densities (Nicol *et al*. 2006; Sarica *et al*. 2008; Dereli Fidan and Nazligul, 2013). Previous studies also support this result as Hansen and Braastad (1994) found that a low stocking density of 6.5 animals per m^2 had a positive effect on the plumage condition during the rearing and laying periods and reduced feather pecking during the rearing period. In this experiment, the 3 and 4 hens/ cage (627.7 cm^2/hen, 417.5 cm^2/hen) had increased feather lose score on breast and wing regions than in 2 hens/cage (943 cm^2/hen). It's possible that high density groups showed more disturbed activity which was visually observed at times when the hens had their breast through the vertical wire bars over the feeder troughs at the front of the cage (Humber-Eicher and Audige, 1999; Sarica *et al*. 2008; Yamak and Sarica, 2010). Nicol *et al*. (1999) examined the effect of different stocking densities of 6, 14, 22, or 30 animals per m^2 on the plumage condition from 14 to 30 weeks of age. They found that the flock with the lowest stocking density (6 animals per m^2) had the best plumage condition and increasing stocking densities caused the opposite. In addition, feather damages of rump, tail and belly were higher of hens in high stocking density than those in low stocking density in the current study. Appleby *et al*. (2004); Dereli Fidan and Nazligul, (2013) suggested that the conditions of feather at body of rump, tail and belly as larger and distinctive point, which may link with more and easy subjecting to feather score.

Performance

High stocking density rate has been previously reported to reduce growth rate, feed intake, viability, feed efficiency, egg production and egg quality in laying hens (Sarica *et al*. 2008; Guo *et al*. 2012; Saki *et al*. 2012; Dereli Fidan and Nazligul, 2012; Abudabos *et al*. 2013; Qaid *et al*. 2016). Lower feed intake was a response to the higher cage density, which was related to the higher competition for feeder and drinker space and the lower activity, which caused lower feed intake, leading to decrease egg production, egg weight and increase mortality (Leeson and Summers, 1984; Saki *et al*. 2012; Dereli Fidan and Nazligul, 2012). In addition, Yamak and Sarica (2010) founded that large amounts of feather loss due to feather pecking, feather discharge or other factors can cause a deterioration of the natural heat insulation of the layer, increasing the amount of heat loss from the body of the bird and causing the layer to compensate for this heat loss by consuming additional feed. Massive loss of feathers is accompanied by increased heat loss resulting in 10-30% increased food consumption (Glatz, 1998; Rodenburg and Koene, 2007; Dereli Fidan and Nazligul, 2012). Our results are inconsistent with above contentions except mortality data. This may be due to the differences in feeding technique, feed allowance and the physical environment of the barn. In this study, feed intake was similar among treatments. In fact, previous study reported no consistent effect of cage density on feed intake (Brake and Peebles, 1992; Anderson and Adams, 1992; Saki *et al*. 2012) and increase mortality (Keeling *et al*. 2003; Jalal *et al*. 2006; Yamak and Sarica, 2010). However, in this study body weight change of hens has increased by low stocking density in contrary to report by Jalal *et al*. (2006) who found significant effect of cage space per hen (342, 413, 516 and 690 cm^2/hen) on body weight changes.

CONCLUSION

The effect of stocking density, in this case as the interactions of both numbers of birds per cage and space availability, had significant impact on feather pecking and feather score. Hens in 2 hens per cage group had significant lower number of pecks per bird and higher feather score on the areas of breast, wing, rump, tail and belly than those in other groups. Thus, hens expose to adequate space for display normal behavior, lead to less feather pecking behavior and better feather score. But access to perch within the conventional cage had no effect on either feather pecking or feather score.

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