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The effect of group size and stocking density on the welfare and performance of hens housed in furnished cages during summer

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Abstract

The aim of this study was to investigate the effect of group size and stocking density on the welfare and performance of hens housed in furnished cage systems during summer. A total of 924 Hy-Line Brown hens were assigned to three housing systems: a standard battery cage system (control, 4 hens per cage and 398 cm² per hen), two furnished systems (including perches and nest); one with a small (SFC, 21 hens per cage; 586 cm² per hen) and one with a large group size (LFC, 48 hens per cage; 543 cm² per hen). The results showed that hens housed in SFC and LFC had a higher feed intake and a poorer feed efficiency compared to control hens. Laying rate and egg weight were not significantly affected by housing systems. Hens housed in LFC and SFC systems showed less sitting and more walking behaviours than control hens. SFC hens showed more nesting and less perching behaviours than LFC hens. Hens kept in SFC systems showed fewer signs of heat stress during summer, with less panting activity than LFC or control hens, and a relatively lower rectal temperature than controls. The rectal temperature of LFC hens did not differ from the SFC hens and controls. Blood concentrations of luteinising hormone, follicle-stimulating hormone and oestradiol were not significantly influenced. In conclusion, group size and stocking density in furnished cages have an effect on behaviour and performance of hens. The furnished cage systems with small group sizes were favourable for hen welfare without markedly affecting performance. Group size should be considered in the development of furnished cage systems.

Keywords: *animal welfare, furnished cage, group size, laying hens, performance, temperature*

Table 1 Housing facilities in three cage systems.

	Control	SFC	LFC
Group size (hens per cage)	4	21	48
Stocking density (cm^2 per hen)	398	586	543
Feeder space (cm per hen)	11.2	12.4	7.7
Drinker	0.25	0.28	0.29
Perch space (cm per hen)	–	17.1	8.8
Hen-to-nest ratio	–	0.38	0.25

SFC = furnished cage with small group size; LFC = furnished cage with large group size.

density and group size as it is a common practice to vary stocking density by adjusting the number of hens in a fixed space. Hence, the effect of group size and stocking density of furnished cages needs to be investigated further. We hypothesised that group size and stocking density may play a role in the behaviour, welfare, and performance of hens in furnished caging systems.

Further, climate may also affect performance and welfare of laying hens in conventional and furnished cages. The detrimental effects of heat stress on egg production and eggshell quality of laying hens have been well studied (Marsden & Morris 1987; Al-Saffar & Rose 2002). Moreover, high environmental temperature causes depressed immune function, and disordered endocrine and metabolic systems (Lin *et al* 2002, 2004, 2008; Mashaly *et al* 2004; Rozenboim *et al* 2007). However, the effect of group size and stocking density in furnished cage systems on the thermal regulation of hens during a hot season remains unclear.

In the present study, the effects of housing within a conventional battery cage, or within one of two furnished cage systems, on laying performance, behaviour, blood parameters and thermoregulation were compared during summer. In the design of the two furnished cage systems, it was intended to have one group size double the other, with the same space allowance per bird, but logistics (cage materials) prevented that aim being achieved precisely. Two furnished cage systems, equipped with perch and nest, were therefore designed to provide different group sizes (21 vs 48 hens per cage) while keeping stocking density similar (543 vs 586 cm^2 per hen).

Materials and methods

Study birds and housing conditions

Day-old Hy-Line Brown chicks were obtained from a local hatchery. The chicks were housed in cages (50 birds per cage) measuring 190 × 60 × 45 cm (length × width × height) located in an environmentally controlled building. Each cage provided five watering nipples and 185-cm feeder spaces. Management procedures (temperature and lighting programme) were in accordance with the recommendations of the *Hy-Line Brown Management Guide*.

A total of 924 hens with similar bodyweight, aged 18 weeks, were used. The hens were randomly assigned to three different housing systems: conventional battery cages (384 hens), furnished cages for small group size (252 hens) and furnished cages for large group size (288 hens). All the hens were housed in the same house with the same ventilation and lighting regimen. All the replicates of the three cage systems were randomly located in the building. Lighting time increased by 1 h per week until 16 h (from 0500 to 2100h) at 24 weeks of age and maintained as such during the whole experimental period. The experiment was conducted in August, 2010 when the experimental hens were 33 weeks of age. The mean room temperature was 28.5 (± 1.6)ºC and mean relative humidity (RH) was 75 (± 7)% during the 4-week experimental period. A layer diet based on a corn-soybean meal (containing 16% CP, 2,750 kcal ME, 3.6% Ca and 0.4% available P) was used. The present study was approved by Shandong Agricultural University and carried out in accordance with the *Guidelines for Experimental Animals of the Ministry of Science and Technology.*

Housing systems

Conventional cage (control)

The conventional battery cages (45.5 × 35 × 37 cm; length × width × height), with four hens per cage, were used as the control group (Table 1). The floor area was 398 cm^2 per hen. In the conventional cage system, a set of 16 cages housing a total of 64 hens comprised one replicate. Six replicates of this system were employed.

Furnished cage with small group size (SFC)

The furnished cage was designed by our research group to house 21 hens with a floor area of 586 cm^2 per bird (not including the nest area). The cage dimensions were 192.4 × 93.0 × 41.5 cm (length × width × height). Each furnished cage was equipped with three perches (120 × 5; length × width) at a height of 10 cm. Two wooden nests containing four boxes each (93 × 30 × 41 cm; length × width × height) were located at two sides of the cage, providing 265 cm^2 nest area per hen; Table 1). In order to achieve a similar number of experimental birds across treatments, two cages of 21 hens served as one replicate and there were six replicates in total.

Furnished cage for large group size (LFC)

The furnished cage was designed to house 48 hens with a floor space of 543 cm^2 per hen (not including nest area). The cage was furnished with three perches located in front of the nestboxes. The cage measured 185.5 × 140.5 × 60 cm (length × depth × height). A wooden nest with 12 boxes (30 × 40 × 30 cm; length × depth × height) was located at one side of the cage and 40 cm above floor, providing 300 cm^2 nest area per hen (Table 1). One furnished cage of 48 hens served as one replicate, and there were six replicates in total.

Measurement

Performance and egg quality

Egg production was recorded daily. Feed intake (FI) was recorded weekly and feed efficiency was calculated. Egg breakage, defined as the number of intact eggs with cracks, was recorded daily. Meanwhile, the broken eggs (unintact ones) were checked, recorded and removed daily. The egg breakage % was reported as the percentage of intact eggs with cracks and unintact eggs in total egg numbers. At the fourth week of the experiment, 30 eggs were collected from each treatment and used for the measurement of egg quality. Eggshell thickness without membranes (mean of three pieces of eggshell from equator and two ends) and shape index (length-to-width ratio) were measured.

Behavioural observations

Behavioural observations were performed during the fourth week of the experimental period for four consecutive days using scanning techniques. In each treatment, 12 marked hens in each replicate were used. The observation was conducted at a 1-min interval for 15 min in the period from 1400 to 1600h. A scan consisted of scoring the number of chickens eating, drinking, standing, walking, sitting, pecking, panting, nesting, perching and others (Bubier 1996; Maria *et al* 2004; Table 2). During observations over six days, four observers were respectively responsible for the cages in front of them. The cages observed by each observer were altered systematically each day to minimise any possible influence of observers. Hens were accustomed to the presence of the observer in the first two days and the data of the last four days were used for the analysis.

Rectal temperature

At 36 weeks of age, two hens close to the mean body size were selected from each replicate. Ten hens (1,670 [± 6] g) were used (the heaviest and lightest ones were not used) for the measurement of rectal temperature for four consecutive days. Mean air temperature: 31.5 (± 0.8)ºC, RH: 74 (± 4)%. Rectal temperature was measured with a thermometer at 0900h in all the four measuring days to avoid diurnal variation.

Blood variables

At 36 weeks of age, another 12 hens close to mean body size were selected from each treatment (two hens in each replication). At 0900h, a blood sample was obtained from the wing vein using a heparinised syringe and collected in chilled tubes. Plasma was obtained after centrifugation at 400 g for 10 min at 4°C and stored at –20°C for further analysis.

Plasma concentrations of glucose, uric acid, triglyceride (TG), cholesterol (CHO), high density lipoprotein (HDL), low density lipoprotein (LDL), creatine kinase (CK) and non-esterified fatty acid (NEFA) were measured with commercial diagnostic kits (Jiancheng Bioengineering Institute, Nanjing, China). The levels of luteinising hormone (LH), follicle-stimulating hormone (FSH) and oestradiol (E_2) in plasma were measured by radioimmunoassay as previously described (Krishnan *et al* 1993; Bacon & Long 1996).

Table 2 Description of behaviours of laying hens.

Behaviour	Description
Eating	Pecking the feed from the food trough continuously
Drinking	Ingestion of water from drinking nipples continuously
Standing	Standing still posture or alert in one place
Walking	Taking at least one step in any direction
Sitting	Sitting with head retracted and eyes open or closed
Pecking	Pecking at feathers, neck, head, tail, claw of another bird; gentle pecks aimed at beak, at particles in the body of another bird; pecking at the cages, trough and perches
Panting	Pant in any posture
Others	Preening, flapping and stretching wing, lying and severe aggression
Nesting	All behaviours performed in the nest
Perching	All behaviours performed on the perch

Statistical analysis

For the variables laying rate, feed intake, feed efficiency, egg weight and egg breakage during the four-week experimental period, repeated measurement option of the GLM procedure with the least squares means statement (Version 9.1, SAS Institute 2009) was conducted with six replicates for each housing system. The main effects of housing system, time and their interaction were estimated. The behavioural data were subjected to arc-sin transformation prior to analysis (Wall *et al* 2004). Plasma variables were analysed by a one-way ANOVA using a GLM procedure with the data from 36 individual chickens (12 from each housing system), and the main effect of housing system was estimated. Behavioural variables were analysed similarly to the plasma variables but using the data from 72 individual chickens. When the main effect was significant, multiple comparisons among treatments were conducted by Duncan's multiple comparison test. Probability levels < 0.1 were reported as were significance differences at $P < 0.05$.

Results

Laying performance and egg quality

Housing system had no significant effect ($P > 0.05$) on laying rate and egg weight (Table 3). In contrast, hens housed in LFC and SFC had a higher feed intake ($P < 0.05$, $F_{2,15} = 4.97$) and poorer feed efficiency ($P < 0.01$, $F_{2,15} = 10.96$) than that of controls (Table 3). Moreover, the SFC hens had a higher ($P < 0.05$, $F_{2,15} = 5.92$) level of egg breakage compared to the control group. Housing system had no significant effect ($P > 0.05$) on egg-shape index and eggshell thickness. A significant time effect was observed on feed intake ($P < 0.0001$, $F_{3,13} = 51.38$) and feed efficiency ($P < 0.0001$, $F_{3,13} = 34.11$), but not in laying rate and

Table 3 Effects of different cage systems on performance of laying hens.

	Control	SFC	LFC	Means	Probability
Laying rate* (%)					
1 week	91.33 (± 0.54)	87.93 (± 2.61)	85.40 (± 3.56)	88.22	Treat: ns
2 weeks	89.81 (± 0.98)	87.59 (± 2.98)	81.66 (± 2.04)	86.35	Time: ns
3 weeks	89.43 (± 0.55)	86.45 (± 2.27)	84.23 (± 2.17)	86.70	Treat × time: ns
4 weeks	88.84 (± 0.51)	85.43 (± 3.37)	87.85 (± 2.50)	87.37	
Means	89.85	86.85	84.78		
Feed intake* (g per day)					
1 week	105.5 (± 1.1)	109.1 (± 1.3)	108.3 (± 3.6)	107.6[y]	Treat: 0.0221
2 weeks	103.8 (± 1.2)	112.5 (± 1.7)	104.2 (± 3.2)	106.9[y]	Time: < 0.0001
3 weeks	115.8 (± 2.6)	120.1 (± 2.5)	119.1 (± 2.9)	118.3[x]	Treat × time: 0.0105
4 weeks	90.7 (± 3.6)	106.7 (± 3.3)	106.2 (± 3.2)	101.1[z]	
Means	104.0[b]	112.1[a]	109.4[a]		
Feed: Egg* (g g^{-1})					
1 week	1.96 (± 0.02)	2.12 (0.006)	2.39 (± 0.01)	2.07[z]	Treat: 0.0012
2 weeks	1.96 (± 0.02)	2.22 (± 0.06)	2.37 (± 0.13)	2.18[y]	Time: < 0.0001
3 weeks	2.19 (± 0.03)	2.37 (± 0.04)	2.44 (± 0.06)	2.33[x]	Treat × time: 0.00171
4 weeks	1.73 (± 0.08)	2.15 (± 0.06)	2.08 (± 0.05)	1.99[z]	
Means	1.96[b]	2.21[a]	2.25[a]		
Egg weight* (g)					
1 week	58.87 (± 0.48)	58.86 (± 0.20)	57.84 (± 0.75)	58.52	Treat: ns
2 weeks	58.92 (± 0.43)	58.22 (± 0.48)	58.07 (± 0.81)	86.35	Time: ns
3 weeks	59.05 (0.57)	58.66 (± 0.40)	58.07 (± 0.45)	86.60	Treat × time: ns
4 weeks	59.02 (± 0.56)	58.15 (± 0.36)	58.20 (± 0.23)	87.37	
Means	58.89	58.47	58.04		
Egg breakage* (%)					
1 week	0.74 (± 0.19)	1.34 (± 0.30)	0.92 (± 0.21)	0.99[xy]	Treat: 0.0127
2 weeks	0.62 (± 0.28)	1.34 (± 0.20)	1.13 (± 0.47)	1.03[xy]	Time: ns
3 weeks	0.55 (± 0.20)	0.89 (± 0.26)	0.65 (± 0.27)	0.70[y]	Treat × time: ns
4 weeks	0.88 (± 0.31)	2.10 (± 0.44)	0.81 (± 0.37)	1.26[x]	
Means	0.70[b]	1.42[a]	0.88[b]		
Egg-shape index**	1.29 (± 0.01)	1.28 (± 0.01)	1.28 (± 0.01)		Treat: ns
Eggshell thickness** (mm)	0.34 (± 0.01)	0.33 (± 0.01)	0.34 (± 0.01)		Treat: ns

* Data are presented as means (± SEM) (n = 6); ** Data are presented as means (± SEM) (n = 30); [a,b] Means with different superscripts within the same row differ significantly ($P < 0.05$); [x,y,z] Means with different superscripts within the same column differ significantly ($P < 0.05$).

egg weight ($P > 0.05$). A significant interaction of time and cage system was detected for feed intake ($P < 0.05$, $F_{6,26} = 3.56$) and feed efficiency ($P < 0.05$, $F_{6,26} = 3.21$).

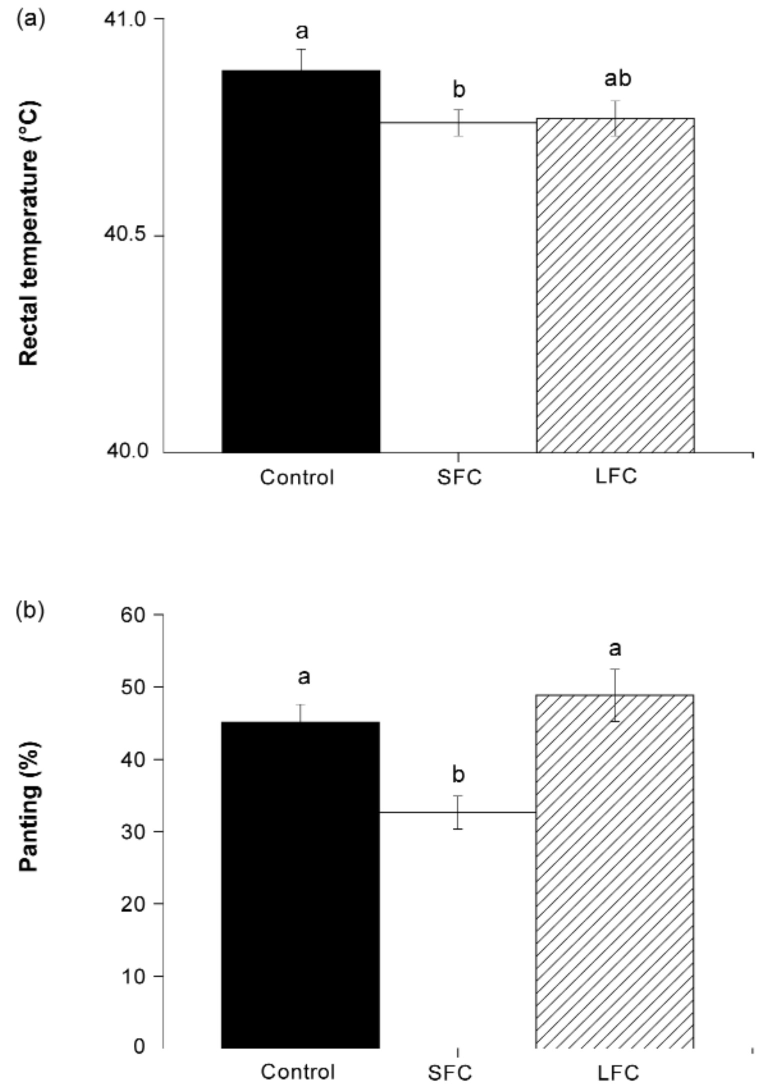
Hens kept in the SFC cage tended to have a lower rectal temperature ($P = 0.0677$, $F_{2,117} = 2.76$) than that of controls, whereas there was no significant difference between LFC and control or SFC hens (Figure 1[a]).

Behaviours

The hens spent most time eating and standing in all three housing systems (Figure 2). Compared to hens kept in SFC or LFC, controls had a higher frequency of sitting ($P < 0.0001$, $F_{2,67} = 26.49$) and lower frequency of walking ($P < 0.0001$, $F_{2,68} = 21.91$). SFC hens showed a lower frequency of sitting ($P < 0.0001$, $F_{2,67} = 26.49$) and perching

Figure 1

Effects of different cage systems on (a) rectal temperature and (b) incidence of panting behaviour of laying hens. Data are presented as means (± SEM) (n = 40);
[a,b] Means with different superscripts differ significantly ($P < 0.05$).



($P < 0.01$, $F_{1,38} = 10.99$) behaviours compared to birds in LFC. In contrast, the SFC hens showed a higher frequency of nesting compared to the LFC treatment (20.4 vs 2.2%, $P < 0.0001$, $F_{1,45} = 112.7$). No significant ($P > 0.05$) differences were found in pecking, feeding, drinking and standing between different treatments (Figure 2). Moreover, the proportion of hens displaying other behaviours (preening, flapping wing, lying and severe aggression) was small in all of the three housing systems.

The frequency of panting was lower ($P < 0.001$, $F_{2,67} = 9.61$) in hens housed in SFC than those housed in control or LFC (Figure 1[b]).

Plasma variables

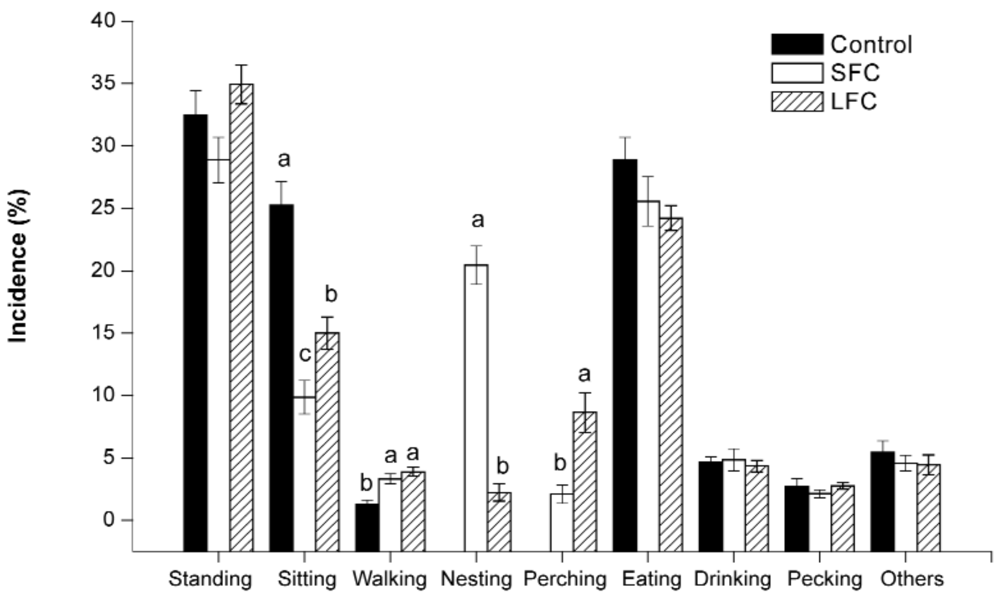
The plasma CK concentration was lower ($P < 0.01$, $F_{2,33} = 5.96$) in hens of SFC and LFC compared to the control hens (Table 4). In contrast, plasma level of NEFA was higher ($P < 0.01$, $F_{2,32} = 5.57$) in LFC hens compared to the control or SFC hens. LFC hens had a lower level of E_2 compared to SFC and control hens ($P = 0.098$, $F_{2,31} = 2.51$). The different cage systems had no significant effect on the concentrations of glucose, CHO, HDL, LDL, urate, TG, FSH and LH (Table 4).

Discussion

In the present study, the effect of furnished cage systems with different group sizes on laying performance and behaviour was investigated during summer. The results indicate that group size together with stocking density has an effect on the welfare of laying hens and should be considered in the development of furnished cage systems.

In an earlier study, the laying rate of hens housed in furnished cages did not differ from birds reared in conventional cages (Pohle & Cheng 2009b). In line with these

Figure 2



Effects of different cage systems on behavioural incidence of laying hens. Data are presented as means (± SEM) (n = 24); [a,b,c] Means with different superscripts differ significantly ($P < 0.05$).

Table 4 Effects of different cage systems on plasma parameters of laying hens.

Plasma parameters	Control	SFC	LFC	Probability
Glucose (mmol L^{-1})	10.46 (± 0.29)	11.01 (± 0.23)	10.33 (± 0.15)	ns
Cholesterol (mmol L^{-1})	1.55 (± 0.17)	1.87 (± 0.15)	1.70 (± 0.12)	ns
Triglyceride (mmol L^{-1})	6.73 (± 1.07)	8.66 (± 1.11)	8.22 (± 0.81)	ns
HDL (mmol L^{-1})	0.36 (± 0.02)	0.37 (± 0.02)	0.36 (± 0.04)	ns
LDL (mmol L^{-1})	0.33 (± 0.05)	0.42 (± 0.03)	0.42 (± 0.04)	ns
NEFA (mmol L^{-1})	1.84 (± 0.20)^{b}	1.73 ± (0.17)^{b}	2.48 (± 0.14)^{a}	0.008
Urate (μmol L^{-1})	148.0 (± 17.4)	156.2 (± 24.6)	137.4 (± 14.3)	ns
Creatine kinase (U ml^{-1})	1.11 (± 0.14)^{a}	0.72 (± 0.06)^{b}	0.56 (± 0.12)^{b}	0.007
LH (mIU ml^{-1})	4.03 (± 1.12)	9.27 (± 5.02)	13.33 (± 7.78)	ns
FSH (mIU ml^{-1})	6.95 (± 2.19)	7.53 (± 3.30)	14.46 (± 4.41)	ns
E_2 (pg ml^{-1})	57.86 (± 5.90)	60.08 (± 8.19)	42.63 (± 4.08)	0.098

Data are presented as means (± SEM) (n = 12); [a,b] Means with different superscripts within the same row differ significantly ($P < 0.05$); E_2 = oestradiol; FSH = follicle-stimulating hormone; HDL = high density lipoprotein; LDL = low density lipoprotein; LH = luteinising hormone; NEFA = non-esterified fatty acid.

results, the laying rate of hens was not significantly different among housing systems, although the laying rate of LFC hens was lower than that of control hens (–5.6%). This result indicates that group size may play a role in the laying performance of hens. A higher egg breakage (intact eggs with cracks) were observed in SFC hens. According to our observations, the relative higher egg breakage in SFC hens was because of the lower proportion of eggs laid in nests (SFC, 73.0 vs LFC, 98.9%). Indeed, the proportions of eggs laid in nests in SFC hens was lower than expected. For example, Abrahamsson *et al* (1996) reported that birds laid 92 to 94% eggs in nests. The lower proportion of eggs laid in the nest in the present study could have been related to the design of the nest and the lines of layers used (Wall *et al* 2002). The percentage of broken eggs was higher in furnished cages compared to standard cages, whereas the difference between these two rearing systems was reduced considerably when only the eggs laid in the nest were considered in the furnished cages (Guesdon & Faure 2004). Similarly, the average differences in eggshell quality between the furnished cage and non-cage systems were negligible (De Reu *et al* 2009). The narrow nests of furnished cages without egg saver and the relatively low frequency of manual egg collection were suggested to be the main factors responsible for the hair-cracked eggs (Guesdon *et al* 2006). The nest area in SFC was smaller than that of LFC (SFC, 265 cm^2 per bird vs LFC, 300 cm^2 per bird). The results imply that the size of the nesting area may be at least partially responsible for the decreased eggs in nests. Moreover, the SFC hens had higher frequency of nesting activity compared with LFC hens (SFC, 20.44 vs LFC, 2.22%). The result suggests that a long-time stay of hens in nests is involved in the decreased eggs in nests. Further investigation is needed into whether the reduced number of eggs laid in nests in furnished cage systems was associated with nest design, group size or both.

In the present study, control hens housed in conventional cages had the highest laying performance, whereas the LFC hens had the poorest performance, indicating large group size is not favourable for the laying performance of hens. In conventional cages, small group size meant lower stocking density. A lower density or smaller group size (2, 3 or 4 hens per cage and 1,100, 733 or 550 cm^2 per hen, respectively) resulted in heavier eggs (Benyi *et al* 2006). Craig *et al* (1986) reported that chickens in a larger group size (six hens per cage) had a higher mortality level and reduced egg production. Plasma corticosterone concentrations were consistently higher in the serum of birds housed five per cage than in birds housed three or four per cage (Mashaly *et al* 1984). Hence, these results suggest that decreased stocking density or group size in conventional cage systems is beneficial for the laying performance and welfare state. In the alternative cage systems, group size is related to development of a stable hierarchical social structure and tolerant social behaviour (Keeling *et al* 2003). Hens in the intermediate groups of 30 experienced social disruption because groups were too large for a stable hierarchy to develop yet too small for a tolerant social system to occur (Keeling *et al* 2003). The result suggests that group sizes should be considered together with stocking density in alternative cage systems.

Compared to control birds, the hens kept in LFC and SFC used more feed and had a poorer feed efficiency. Hens housed in LFC and SFC walked more while control birds spent more time sitting (Figure 2), which was in line with the observation of Shimmura *et al* (2007). The result suggests that the increased physical activity in furnished cages should be at least partially responsible for the poor feed efficiency.

In accordance with previous studies (Tauson *et al* 1999; Shimmura *et al* 2007; Sogunle *et al* 2008; Pohle & Cheng 2009b), housing system had no significant effect on shell thickness and egg-shape index. However, increased egg breakage was observed in SFC hens. The results indicate that furnished cages did not result in an improvement in egg quality during the hot season.

At high temperatures, heat production decreases while heat dissipation increases. The lower rectal temperature in hens kept in SFC cages compared to the control indicated the facilitating effect of thermoregulation in hens subject to hot weather. For the chickens housed in cages, birds tend to distance themselves from each other and let their wings droop and lift from their body to maximise sensible heat loss (Etches *et al* 1995). The results suggest that the availability of more space in the furnished cages allow hens to better express their thermoregulatory behaviour, which contributes at least partially to the maintenance of body temperature. The lower frequency of thermal panting behaviour (Figure 1[b]) in SFC layers compared with both control and LFC hens indicates the lower heat load in SFC hens. The results suggest that furnished cage systems with suitable group sizes and stocking density are favourable for the thermoregulation of birds under hot weather.

Housing system can strongly influence the behaviour of hens. Battery cages limit the expressions of birds' natural behaviours (Appleby 1993; Craig & Swanson 1994; Vestergaard *et al* 1997). In line with previous studies, the hens kept in conventional cages showed more sitting and less walking behaviour compared to FSC and LFC treatments (Figure 2). In furnished cage systems, group size may also have an effect on the behaviour of hens (Lay *et al* 2011). Chickens in appropriate groups show less aggressive behaviour (Croney & Newberry, 2007). It was observed that most feather-pecking activity of hens housed in floor pens occurred in the largest group size (120 birds) and there was evidence of an increasing frequency of aggressive pecks with increasing group size (Bilcík & Keeling 2000). In contrast to previous studies, no significant difference in the frequency of pecking behaviour between SFC and LFC treatments indicated that group size had no significant effect on the feather-pecking behaviour in the present experimental conditions. Conflicting evidence for the relationship between group size and aggression may be related to the type and nature of hens' acts of aggression (Pagel & Dawkins 1997). In hens housed in large groups, certain types of aggression associated with 'establishment fights' were less frequent, whereas other kinds of aggression associated with 'resource fights' were more common (Pagel & Dawkins 1997). Moreover, the influence of the scan-sampling method used in the present study on the observation of feather-pecking and aggressive-pecking behaviours cannot be excluded. Nevertheless, the results indicate that group size may affect the behaviour of hens.

The blood parameters related to metabolic and endocrinological responses were measured to evaluate the effect of different cage systems. Although higher levels of plasma NEFA and CK were detected in LFC and control hens, respectively, all the other blood metabolites and hormones were not altered by housing systems (Table 3), indicating that housing systems had no significant effect on hormonal and metabolic status. This result was in line with the work of Nicol *et al* (2006), who reported no clear effect of flock size on the physiological indicators of welfare in hens from a commercial single-tier aviary system. However, as the blood was sampled in the morning, the possible influence of oviposition and egg formation cannot be excluded.

Animal welfare implications and conclusion

In conclusion, furnished cage systems improved the welfare of laying hens. Group size and stocking density in furnished cage systems had an effect on the behaviour and performance of hens. Furnished cage systems with small group sizes (around 20 hens) were favourable for the thermal balance during summer. The result suggests that furnished cage systems with small group sizes are favourable for hens' welfare without affecting performance.

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