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Original Article

Behavior, egg production, and bone strength of commercial laying hens at various cage densities and different cage types

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Abstract

Effects of modified cages with perch and cage density on behavior, egg production, and bone strength were investigated in hens reared either in conventional or modified cages with three densities, i.e. 2, 3, and 4 hens/cage. Neither cage type effect nor their interactions with cage densities were found. Hens in two hens/cage displayed higher percentage of feeding and preening and lower percentage of standing and sham dust-bath with higher body weight change and femur strength than their counterparts ($p<0.05$). Humerus strength of hens in two hens/cage was higher than of those in four hens/cage ($p<0.05$). No differences were apparent between two vs. three hens/cage groups in humerus strength and between three vs. four hens/cage groups in femur strength. An alternative to improve hen welfare in the conventional cages by perch provision is unlikely to be effective as retaining the small group size with optimum area/hen would be more vital.

Keywords: behavior, bone strength, cage density, modified cage, laying hen

1. Introduction

Raising commercial laying hens in cages is currently proved to benefit both economic returns per capita via maximizing egg production per area and health management with considerably well hygienic condition with minimum potential damages of some behavioral problems associated with high density such as cannibalism and feather pecking (Appleby, 1998; Lay *et al.*, 2011). But space allowance in high cage density may limit locomotion and physical activities of the birds (Appleby, Mench & Hughes, 2004) and cause stressful social conditions, ill health and injuries due to impaired and broken bone (Hester *et al.*, 2013) leading to poor hen welfare status (Enneking *et al.*, 2012). Current welfare standards have imposed on changes of hen's housing conditions. 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 to examine the effects of modified cage with various densities on some behavioral expressions, egg production and bone strength in laying hens.

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2. Materials and Methods

2.1 Birds management

Two hundred sixteen Hisex Brown pullets (from 16 to 42 weeks of age) were randomly assigned into either reared in conventional cages or modified cages fitted with perch at Kasetsart University, Bangkok. Each group was further allotted to three 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). Feeding regime (layer diet contained 2,800 kcal/kg ME, 18.00 % CP, 3.50 % Ca and 0.55% available P), lighting program, health and other management followed the Hisex Brown Management Guide. Feed and drinking water were given *ad libitum*. This study was approved by Kasetsart University Animal Ethics Committee (Approval No. ACKU60-AGR-011).

2.2 Housing management

A 2-tier conventional battery cage house of 246 units (41×46 cm.) fitting with eggs trough under feeder in evaporative cooling system was used. The front height of each tier was 43.5 cm. and 38 cm. at the back. Modified cages were fitted a PVC pipe with 1.91 cm thickness**,** 30 cm length, 10 cm height from the floor and 5 cm apart from the back (Figure 1).

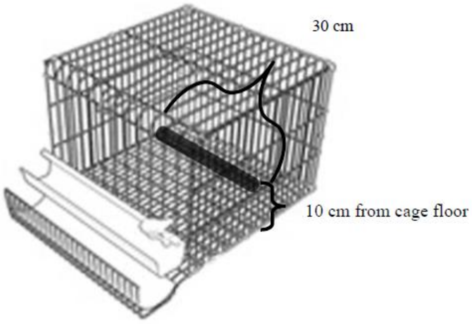

Figure 1. Modified cage with perch.

2.3 Data and sample collection

All birds were observed for 6 h per day, (10.00-12.00 h, 14.00-16.00 h and 18.00-20.00 h) within 10 min intervals at 25, 28, 32, 36, 40 and 42 weeks of age by scanning technique for feeding, drinking, standing, sitting, preening, sham dust-bath and perching, thereafter, percentages of time displayed each behaviour were calculated (Matin & Bateson, 1986). Initial and final body weights of all birds were recorded. Egg production was recorded on hen-day basis while feed intake and feed efficiency were recorded on weekly basis. Ten eggs per replicate were randomly collected every week for egg shell thickness, egg weight and Haugh unit (HU) measurements. At 42 weeks of age, 90 hens (5 hens/replicate) were selected and killed by CO_2 asphyxiation and left humerus, femur, and tibia were prepared for breaking strength (Newton) assessment by a three-point compression test using a bending machine.

2.4 Statistical analysis

All data were analyzed by PROC GLM procedure using complete random design in a 2×3 factorial arrangement except perching data that was analyzed using simple complete random design. Least squares means were calculated and the means among treatments were compared by the PDIFF option with the Turkey adjustment. Bone strength data were transformed to $\log_{10}$ prior to analysis. Significance was set at P<0.05.

3. Results

Neither cage type effects nor their interactions with cage densities were detected. The effects of cage density on behavioral expression, body weight change and humerus and femur strength were detected (Table 1, 2, and 3). Hens in two hens/cage displayed higher percentage of feeding and preening and lower percentage of standing and sham dust-bath with higher final body weight, body weight change and femur strength than their counterparts (p<0.05). The effects of cage density on performance and egg quality were not significant differences among treatments (p>0.05). Humerus strength of hens in 2 hens/cage was higher than of those in 4 hens/cage (p<0.05). No differences were apparent between two vs. three hens/cage groups in humerus strength and between three vs. four hens/cage groups in femur strength (Table 3).

Table 1. Effect of cage density (group size and area/hen) on behavioral expression (%) in laying hens (mean ± standard error of mean).

Behavior (%)	Cage density (hens/cage; cm^2/hen)			P-value
	2; 943	3; 627.7	4; 417.5	
Standing	$9.11^c \pm 6.13$	$20.41^b \pm 3.58$	$22.21^a \pm 2.63$	<0.0001
Sitting	$8.70^b \pm 2.98$	$10.83^{ab} \pm 1.97$	$11.80^a \pm 3.12$	0.0223
Feeding	$36.06^a \pm 9.66$	$32.63^b \pm 8.70$	$25.03^c \pm 4.80$	0.0341
Drinking	6.64 ± 1.71	7.22 ± 0.90	7.82 ± 2.67	0.2301
Preening	$39.06^a \pm 7.14$	$27.53^b \pm 7.32$	$29.66^b \pm 7.09$	<0.0001
Sham dust bath	$0.43^b \pm 0.23$	$1.15^b \pm 0.27$	$3.28^a \pm 0.22$	0.0405
Perching*	0.19 ± 0.10	0.23 ± 0.13	0.20 ± 0.05	0.8545

[a,b] Least squares means within a row with no common superscript are different between groups (*p*<0.05). * Cage fitted with perch.

Table 2. Performance and egg quality of hens in different cage density (group size and area/hen; mean ± standard error of mean).

Items	Cage density (hens/cage; cm^2/hen)			P-value
	2; 943	3; 627.7	4; 417.5	
Initial body weight (kg)	1.24±0.03	1.25±0.02	1.24±0.03	0.8721
Final body weight (kg)	$1.98^a \pm 0.05$	$1.88^{ab} \pm 0.07$	$1.81^b \pm 0.04$	0.0241
Body weight change (kg)	$0.70^a \pm 0.06$	$0.63^{ab} \pm 0.03$	$0.56^b \pm 0.70$	0.0064
Hen-day egg production (%)	92.57±5.74	91.78±3.28	90.94±5.50	0.5540
Egg weight (g)	61.31±3.90	60.30±5.32	60.17±4.06	0.3931
Feed intake (g/bird)	107.29±4.43	106.72±9.33	105.75±3.31	0.9185
Feed efficiency (g egg/feed)	1.74±0.20	1.76±0.14	1.75±0.13	0.1286
Eggshell thickness (mm)	0.389±0.21	0.386±0.25	0.381±0.20	0.1214
Haugh unit	89.94±0.25	88.86±0.18	88.51±0.18	0.6686

[a,b] Least squares means within a row with no common superscript are different between groups (*p*<0.05).

Table 3. Bone strength (N) of hens in different cage density (group size and area/hen; n=90).

Bone	Cage density (hens/cage; cm²/hen)			P-value
	2; 943	3; 627.7	4; 417.5	
Humerus	104.83^{a}±1.03	92.00^{ab}±1.38	82.50^{b} ±1.95	0.0318
Femur	186.00^{a}±1.33	158.33^{b}±2.36	149.67^{b}±1.55	0.0467
Tibia	188.00±3.13	183.50±3.09	180.83±3.05	0.4002

^{a,b} Least squares means within a row with no common superscript are different between groups (p<0.05). Mean ± standard error of mean.

4. Discussion

The primary aim of this study was to determine if access to perches fitted in cages with various cage densities altered behavior, egg production and bone strength. Laying hens have a strong motivation to perch (Appleby & Hughes, 1991) as hens displayed perching during the day if available. Unexpectedly, neither effects of the access to perch in cages nor their interactions with cage densities on any parameters studied were detected. It was evident that providing opportunity for hens to perform their natural perching behavior and stimulates their activities, leading to improved musculo-skeletal health due to exercise (Enneking *et al.*, 2012; Yan, Hester, & Cheng, 2014). However our data were not in line with this statement, while cage densities had significant impacts on humerus and femur strength. It is possible that the differences found were due to perch height, as 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). Perch access in the small cage designs with fixed cage height and perch height in this study, therefore, may not be physically efficient to improve hen welfare. Thus, not only should perches be offered, but perches should be elevated (Schrader & Muller, 2009).

The normal behavior of hens comprises ancestral behavior patterns exhibited when access to adequate space and diverse resource (Appleby *et al.*, 2004) with an absolute amount of three-dimensional space in order to be able to perform basic body movements (Widowski, Caston, Hunniford, Cooley, & Torrey, 2016). Spatial restriction of movement will cause hens to display mainly standing and sitting behavior (Mench & Blatchford, 2014). In fact the hens in 943 cm²/hen group displayed different time budget as compared to the counterparts. Higher space available allowed them to display less idle, spent more time feeding and preening with less sham dust-bath. Low cage density with more space may also allow the hens to perform more preening, indicating more comfort behavior and less sham dust-bathing (Moesta, Ute, Briese, & Hartung, 2008).

Group size is usually confounded with cage density, the function of space allowance and numbers of hen in cage, and with fixed cage size, which both has independent effects on the birds (Appleby & Hughes, 1991). Stress increases linearly with group size (Mashaly, Webb, Youtz, Roush, & Graves, 1984) and small group size is advantageous: in battery cages small groups showed higher egg production and decreased aggression, hysteria and other behavioral problems compared with larger groups (Rodenburg & Koene, 2007). Our results confirm that cages which retain similar small group sizes gave some similar advantages in behavioral expression but not in egg production and quality. Hens in high cage density spent less time feeding, indicating that feeding is associated with feeding space and also hen/cage (Thogerson *et al.*, 2009). Lower competition for feeder space and more active of hens in low cage density may allow them to perform higher feeding behavior thus higher feed intake (Saki, Zamani, Rahmati & Mahmoudi, 2012).

Increased space allowance or decreased cage density significantly enhanced egg production with no impact on external egg quality traits e.g. egg weight, specific gravity, shell breaking resistance, shell weight and shell thickness (Sarica, Boga, & Yamak. 2008). In this study, both feed intake and egg production were similar among treatments. In fact, previous study reported no consistent effect of cage density on feed intake (Brake & Peebles, 1992).

In this study, humerus and femur strength were influenced by increasing cage density with no differences in either egg production or quality. Again, this may link with more space allowance and more exercise or movement in lower cage density group. When providing more space as in a cage-free aviary system, skeletal loading provided by activities within this housing resulted in structural and material changes that improved the load-bearing capability and stiffness to the tibia and humerus (Regmi *et al.*, 2015). In contrast, the strength of tibia was similar. Possibly, the hens in cages may perform less locomotive behavior than those in cage-free system. Mechanism by which more space in cage improves bone strength requires further investigation.

5. Conclusions

The effects of cage types and their interactions with cage densities were not evident. Cage density (i.e. group size and area/hen) had impacts on some behavior, body weight change and bone strength. Thus, optimizing stocking density would be a potential choice according to welfare considerations together with appropriate housing systems currently applied. Alternative approach to improve hen welfare in such old types of housing may not likely to be modified cage system fitted with only perch while retaining the small group size and optimum area/hen would be more vital.

References

Appleby, M. C. (1998). Modification of laying hen cages to improve behavior. *Poultry Science*, *77*, 1828–1832.

Appleby, M. C. & Hughes, B. O. (1991). Welfare of laying hens in cages and alternative systems: Environmental, physical and behavioural aspects. *World's Poultry Science Journal*, *47*, 110-128.

Appleby, M. C., Mench, J. A. & Hughes, B. O. (2004). *Poultry behaviour and welfare*. Wallingford, England: CAB. International.

Brake, J. D. & Peebles, E. D. (1992). Laying hen performance as affected by diet and caging space. *Poultry Science*, *71*, 945–950. doi:10.3382/ps.0710945

Enneking, S. A., Cheng, H. W., Jefferson-Moore, K. Y., Ein stein, M. E., Rubin, D. A. & Hester, P. Y. (2012). Early access to perches in caged White Leghorn pullets. *Poultry Science*, *91*, 2114-2120. doi:10.33 82/ps.2012-02328

Hester, P. Y., Enneking, S. A., Haley, B. K., Einstein, M. E., Cheng, H. W. & Rubin, D. A. (2013).The effect of perch availability during pullet rearing and egg laying on musculoskeletal health of caged White Leghorn hens. *Poultry Science*, *92*, 1972-1980. doi: 10.3382/ps.2013-03008

Lay, Jr., D. C., Fulton, R. M., Hester, P. Y., Karcher, D. M., Kjaer, J. B., Mench, J. A., . . . Porter, R. E. (2011). Hen welfare in different housing systems. *Poultry Science*, *90*, 278–294. doi:10.3382/ps.2010-00962

Martin, P. & Bateson, P. (1986). *Measuring Behavior: An Introductory guide*. Cambridge, England: Cambridge University Press.

Mashaly, M. M., Webb, M. L., Youtz, S. L., Roush, W. B. & Graves, H. B. (1986). Changes in serum corticosterone concentration of laying hens as a response to increased population density. *Poultry Science*, *63*, 2271-2274.

Mench, J. A. & Blatchford, R. A. (2014). Determination of space use by laying hens using kinematic analysis. *Poultry Science*, *93*, 794-798. doi:10.3382/ps.2013-03549

Moesta, A., Ute, K., Briese, A. & Hartung, J. (2008). The effect of litter condition and depth on the suitability of wood shavings for dust-bathing behavior. *Applied Animal Behavior Science*, *115*, 160-170. doi:10.1016/j.applanim.2008.06.005

Regmi, P., Deland, T. S., Steibel, J. P., Robison, C. I., Haut, R. C., Orth, M. W. & Karcher, D. M. (2015). Effect of rearing environment on bone growth of pullets. *Poultry Science*, *94*, 502-511. doi:10.3382/ps/peu 041

Rodenburg, T. B. & Koene, P. (2007). The impact of group size on damaging behaviours, aggression, fear and stress in farm animals. *Applied Animal Behaviour Science*, *103*, 205-214. doi:10.1016/j.applanim.20 06.05.024

Saki, A. A., Zamani, P., Rahmati, M. & Mahmoudi, H. (2012). The effect of cage density on laying hen performance, egg quality, and excreta minerals. *The Journal of Applied Poultry Research*, *21*, 467–475. doi:10.3382/japr.2010-00318

Sarica, M., Boga, S. & Yamak, U. S. (2008). The effects of space allowance on egg yield, egg quality and plumage condition of laying hens in battery cages. *Czech Journal Animal Science*, *53*, 346–353.

Schrader, L. & Muller, B. (2009). Night-time roosting in the domestic fowl: The height matters. *Applied Animal Behaviour Science*, *121*, 179-183. doi:10.1016/j. applanim.2009.09.010

Scientific Veterinary Committee. (1996). *Report on the welfare of laying hens.* Brussels, Belgium: Commission of the European Communities Directorate-General for Agriculture VI/B/II.2.

Thogerson, C. M., Hester, P. Y., Mench, J. A., Newberry, R. C., Pajor, E. A., & Garner, J. P. (2009). The effect of feeder space allocation on behavior of Hy-Line W-36 hens housed in conventional cages. *Poultry Science*, *88*, 1544–1552. doi: 10.3382/ps.2009-00011

Widowski, T. M., Caston, L. J., Hunniford, M. E., Cooley, L., & Torrey, S. (2017). Effect of space allowance and cage size on laying hens housed in furnished cages, Part I: Performance and well-being. *Poultry Science, 96*, 3805–3815. doi: 10.3382/ps/pex197

Yan, F. F., Hester, P. Y. & Cheng, H. W. (2014). The effect of perch access during pullet rearing and egg laying on physiological measures of stress in White Leghorns at 71 weeks of age. *Poultry Science*, *93*, 1318–1326. doi:10.3382/ps.2013-03572