https://doi.org/10.56093/ijans.v90i9.109494

Indian Journal of Animal Sciences **90** (9): 1300–1304, September 2020/Article

Welfare and performance of commercial laying hens in conventional California cages at different stocking densities

PINKY ROY[1]✉, M M KADAM[2], S K BHANJA[3], N V KURKURE[2], D B BHAISARE[2], J J ROKADE[3] and K K KHOSE[4]

Nagpur Veterinary College, MAFSU, Nagpur, Maharashtra 440 013 India

Received: 20 November 2019; Accepted: 25 February 2020

ABSTRACT

The present experiment was conducted to investigate the effect of different stocking densities on performance and welfare of commercial white leghorn hens (BV 300 strain) reared in conventional California cages. A total of 270 hens were divided into four stocking density groups, viz. 60 sq. inch/387 cm^2 (T1); 75 sq. inch/484 cm^2 (T2); 85 sq. inch/ 548 cm^2 (T3) and 100 sq. inch/645 cm^2 (T4) per bird with 18 replicates in each treatment. The experiment was conducted for a 20 week period under uniform standard management practices with birds fed on commercial layer diet. It was observed T3 and T4 group birds had highly significant ($P<0.001$) percentage of hen day egg production, higher egg weight, better feed conversion ratio, minimum cost of production per egg compared to T2 and T1 at the end of 20 week experimental period. Welfare indicators—Feather score was significantly best in T4 group birds when compared to T1 group, whereas gait score and immunity parameters was non-significant among all the birds reared at different stocking densities. Considering well-being and production performance, the present study confirms that commercial laying hens reared in conventional California cages provided with 85 sq. inch/548 cm^2 space per bird gives better quality egg production without compromising birds welfare.

Keywords: California cages, Egg production, Layer, Stocking density, Welfare

Poultry welfare has become an important issue in recent years since EU banned cage rearing of birds. On the same analogy Indian animal welfare activists increasingly argue that cage rearing of high producing commercial layer birds in intensive system of rearing resulted in some of the welfare and health issues which were not apparent in extensively reared native birds. Ultimately, welfare of the birds reared in conventional cages is compromised. The space provided to commercial birds is not sufficient to stand, lie down and turn around without touching each others and sides of enclosure (Chatterjee and Haunshi 2015). There is a considerable body of morphological, physiological, and behavioural evidence demonstrating that the use of battery cages increases stress in hens due to an overcrowded, barren environment, which can inhibit the hens from performing certain natural behaviours and reduce bone quality (Nicol 1995; Tauson 1999).

Animal Welfare Board of India advised to GOI and State Government [D.O.No.6 (3)310/2017-LC (LS), dated 3rd July 2017] to prohibit the use of battery cages for egg production, so that poultry farms keeping egg laying hens adhere to the provisions of the Prevention of Cruelty to Animals (PCA) Act, 1960 and not confine birds in cages.

In response, The Gazette of India published a draft of the Space allowance for conventional colony enclosures of egg-laying hens for commercial layer production on 29th April 2019 by Ministry of Agriculture and Farmers welfare under G.S.R. 335 (E) indicated that the floor space per bird shall not be less than 550 sq. cm and each cage should accommodate preferably a minimum of 6–8 birds, thus ensuring reasonable space for laying hens for lying down, standing up, flapping wings, turning around and access to feed and water. The use of battery cages is now raising a considerable debate pertaining to the relative effect of the practice on hen well-being. The issue has been raised up to such level that the matter is pending at Honourable High Court, New Delhi (W.P. (C) 9056/2016 and connected matters).

Bird preferences for space are complex and confounded by interactions between group size and stocking density. Reports on poultry welfare are scantly available to form the Indian guidelines, for which we are dependent on European reports. These reports may not be directly applied to Indian poultry farming because of difference in housing, feeding, management and as well as tropical environment. Looking at the current scenario the experiment was designed to examine the differential effects of stocking densities on quality production performance and welfare of commercial layers in most widely used conventional California cage system.

Present address: [1]Department of Poultry Science, MAFSU, Nagpur; [2]Nagpur Veterinary College, MAFSU, Nagpur 440 013; [3]ICAR-CARI, Izatnagar, Bareilly; [4]COVAS, Parbhani, Maharashtra. ✉Corresponding author e-mail: ingewarpin@gmail.com

MATERIALS AND METHODS

The biological experiment was conducted using 270 commercial white leghorn birds (BV 300 strain) for a period of 20 weeks during 28–47 weeks age of birds. All the experimental birds were reared in elevated layer cage house which had 3-tier conventional California cages over a dropping pit. Well in advance of two week before the start of the experiment the birds were randomly shuffled into four different treatments group of cage floor space 387 (60 sq. inch), 484 (75 sq. inch) 548 (85 sq. inch) and 645 (100 sq. inch) square centimeter per bird. Each treatment group was sub divided into 18 replicates (cage boxes of depth 15″, height 16″ and front length of 20″). Each cage box with floor space 387, 484, 548 and 645 square centimeter per bird accommodated 5, 4, 3 and 3 birds per treatment respectively. The conventional cages used for the experiment were modified to obtain the exact space per bird as per treatment stocking densities. Birds fed on standard commercial layer diet and maintained under uniform standard management practice as per BV 300 Manual, except the variation in the cage floor space.

Daily egg production, feed offered record was noted to calculate the weekly feed intake and feed conversion ratio (per dozen egg). The cost of production per egg considering recurring expenditure and inter relationship among space utilization (SU), cost of production of egg (CP) and stocking density (SD) was calculated at the end of the experimental period. Egg quality parameters (egg weight, shape index, albumen and yolk index, Haugh unit, yolk score, yolk weight) were recorded twice a month during entire experimental period. The immunity of the birds were measured during the start (28th week), mid (38th week) and end (47th week) of the experimental period. Eight birds per treatment group were randomly selected and marked for blood collection to test the humoral immune response against New Castle Disease virus (NCDV). Haemagglutination test (HA) was performed to calculate the 4HA unit titer. Later Haemagglutination inhibition (HI) test was performed to observe the titer against commercial strain of NCDV when used as antigen. The results were expressed as $\log_2$ of the highest serial dilution showing complete inhibition of 4HA unit of test antigen. The same birds were used for immunological study. The blood samples were collected in an EDTA coated tubes and centrifuged at 3,000 rpm/15 min. to separate serum which was kept in –18°C until the assays.

Feather and gait score was measured at the end of the experiment on 47th week. The test hens were put into a dark and quiet room for observation and recording the gait score. Feather score was recorded as per method suggested by Abrahamsson *et al.* (1996)**.** Assigned score was 8, 6, 4 and 2 on full feather cover, worn feather detectable, small as well large bare patches and no feather cover to the most of the body respectively. Similarly gait score was assigned with marks of 8, 6, 4 and 2 to sound birds with no detectable impairment, bird moving with significant or serious deficiency, birds that barely able to move and total inability birds to move respectively as suggested by Kestin *et al.* (1992).

Data emerged from the different treatments were analyzed for statistical significance using completely randomized design (CRD) by following standard methods (Snedecor and Cochran, 1989). All data were statistically analyzed using SPSS software package (version 13).

RESULTS AND DISCUSSION

The present investigation was carried out to evaluate the growth performance, quality egg production, economics, immunity and well-being of laying hens kept in different stocking density. Statistical analysis of data on hen day egg production per cent showed significant (P<0.001) difference between treatment groups throughout the experimental period (Table 1). Hen day egg production (90.72%) was significantly higher (P<0.001) in birds provided with highest floor space of 645 cm^2/bird than any other treatment

Table 1. Per cent hen day egg production (HDEP) and feed conversion ratio (FCR) of commercial layers reared at different stocking densities during 28 to 47 week of age Hen Day Egg Production% and Feed Conversion Ratio (per dozen of eggs)

Treatment		Weeks					
		28–31	32–35	36–39	40–43	44–47	28–47
T1 (387cm^2/bird)	HDEP	81.03^{c}±1.38	81.98^{c}±0.76	85.04^{d}±0.95	84.14^{c}±0.88	85.52^{bc}±0.65	83.54$^{c±}$0.73
	FCR	1.58^{a}±0.02	1.61^{a}±0.01	1.56±0.02	1.57 ^{a}±0.02	1.55 ^{a}±0.01	1.58 ^{a}±0.01
T2 (484cm^2/bird)	HDEP	88.44^{ab}±1.31	89.58^{b}±1.08	87.60^{c}±0.91	88.15^{ab}±0.80	87.50^{ab}±0.95	88.25$^{b±}$0.82
	FCR	1.45 ^{b}±0.01	1.48 ^{b}±0.02	1.77±0.26	1.50^{b}±0.01	1.51^{ab}±0.02	1.50 ^{b}±0.01
T3 (548cm^2/bird)	HDEP	89.95^{ab}±1.15	90.38 ^{ab}±0.88	88.26^{c}±0.71	90.41^{a}±0.86	89.39^{a}±0.65	89.71^{ab}±0.59
	FCR	1.45 ^{b}±0.01	1.46 ^{b}±0.01	1.49±0.02	1.46^{b}±0.01	1.48^{bc}±0.01	1.47 ^{b}±0.01
T4 (645cm^2/bird)	HDEP	91.01^{a}±1.65	91.14^{ab}±1.70	90.6^{b}±0.98	90.68^{a}±1.17	90.15^{a}±1.07	90.72^{a}±1.09
	FCR	1.44 ^{b}±0.01	1.46 ^{b}±0.03	1.46±0.02	1.46^{b}±0.02	1.47 ^{c}±0.02	1.46^{b}±0.02
SEM	HDEP	0.689	0.616	0.494	0.457	0.480	0.422
	FCR	0.01	0.01	0.07	0.01	0.01	0.01
P value	HDEP	**	**	**	**	**	**
	FCR	**	**	NS	**	**	**

**, Highly significant at P≤0.001; *, Significant at P≤0.001; NS, Non-significant P>0.05.

groups except the birds reared with floor space 548 cm^2/bird (89.71%). In contrast, the birds received lowest space 387 cm^2 per bird recorded significantly lesser (P<0.001) hen day egg production (83.54%) among all the treatment groups. The birds received space 484 and 548 cm^2/bird recorded non-significant difference of hen day egg production among the treatment group, similar non-significant observations were recorded in the birds which received space 548 and 645 cm^2/bird. Space allowance significantly affect the per cent hen day egg production as observed during overall experiment with higher or lower cage floor space allowance per bird and increased or decreased stocking density. These finding are in agreement with observations of Anderson *et al.* (2004), Benyi *et al.* (2006), Sarica *et al.* (2008) and Rajendran *et al.* (2013), who recorded lower egg production with decreasing floor space. Similarly, Onbasilar and Aksoy (2005) determined hen-day egg production as 94.1, 89.3 and 78.5% at the respective stocking densities of 1968, 656 and 393.8 cm^2/hen with statistical significance (P<0.05). Decreasing egg production was shown to be attributable to the reduced feeding area per hen, cannibalism, (Onbasilar and Aksoy 2005; Jalal *et al.* 2006; Nicol *et al.* 2006) and stocking density (Adams and Craig 1985). A constant feed amount of 110 g/bird was offered as per strain (BV300) recommendation; therefore, feed refusal was measured at the end of the each month. During entire experimental period the birds reared at highest stocking density with minimum space area of 387cm^2/bird showed significantly (P<0.001) poor (1.58/dozen of egg) feed conversion ratio (FCR) compared to all the treatment groups. There was no significant (NS) difference in FCR among the birds provided with space 484, 548 and 645 cm^2/bird. The best FCR (1.46/dozen of egg) was recorded in the birds reared with space 645 cm^2/bird (Table 1). Similar result was noticed by Mangnale *et al* (2019) and Lee and Moss (1995) with significant improvement in FCR as density level decreased or space allowance increased while in contrast Benyi *et al.* (2006) observed poorer feed efficiency as stocking density decreased, the findings indicated that FCR was mostly dependent on egg production rate.

Egg quality parameters were measured after each two weeks (Table 2). Albumen and yolk index was found significantly (P<0.001)better in the birds reared with minimum space 387cm^2/bird, similar findings on albumen index and Haugh Unit was reported by Onbasilar and Aksoy (2005), whereas the egg weight (55.88 g) recorded best in the birds provided with higher space allowance 548 cm^2/bird with stocking density of 3 birds in each cage box. Though the treatment birds with the maximum space allowance was 645 cm^2/bird but the difference in egg weight (1.21 g) among treatment group 548 and 645 cm^2/bird was non-significant, which is in contrast with the findings of Rajendran *et al* (2012) and Onbasilar and Aksoy (2005), that as space allowance higher egg weight is more. Lee and Moss (1995) reported egg weight to be unaffected by population density. The birds reared in 387 cm^2/bird with

Table 2. Egg quality parameters of commercial layers reared at different stocking densities during 28 to 47 week of age

Group	Egg weight	Albumen index	Yolk index	Shell thickness
T1 (387cm^2/bird)	52.44^{b}± 0.34	0.118^{a}± 0.00	0.394^{a}± 0.00	0.414± 0.01
T2 (484cm^2/bird)	54.48^{ab}± 0.49	0.113^{b}± 0.00	0.396^{a}± 0.00	0.413± 0.00
T3 (548cm^2/bird)	55.88^{a}± 0.98	0.112^{b}± 0.00	0.386^{b}± 0.00	0.418± 0.01
T4 (645cm^2/bird)	54.67^{a}± 0.46	0.113^{b}± 0.00	0.383^{b}± 0.00	0.416± 0.01
N	12	12	12	12
SEM	0.32	0.00	0.00	0.00
P Value	**	*	*	NS

**, Highly significant at P≤0.001; *, Significant at P≤0.001; NS, Non-significant P>0.05.

stocking density 4 birds in each cage box produced each egg for ₹ 2.74, which was highest among all the treatment groups. There was no significant (NS) difference in cost of production per egg among the birds provided with space 484, 548 and 645 cm^2/bird. The lowest cost of production of egg ₹ 2.59 was noted in the birds reared with space 645 cm^2/bird (Table 3). Mangnale *et al* (2019) reported higher net profit per egg in birds maintained at more space allowance (or lesser stocking density) in California cages, indicating lower cost of production similar to present experiment.

Interestingly, when number of birds in each cage box (number of bird), cost of production per egg (₹) and space (cm^2/bird) utilized by each bird was interrelated (number × cost × space), it was observed that the best lowest figure (4,301.48) generated by the birds reared with space 548 cm^2/bird followed by 645, 484 and 387 cm^2/bird (Table 3).

At the end of the experiment the birds reared at minimum space 387 cm^2/bird showed significantly (P<0.01) poor feather score compared to all the treatment group birds

Table 3. Inter relation of cost of production stocking densities and space utilized by commercial layers reared during 28 to 47 week of age

Space utilized	Stocking densities (SD) in each cage box	Cost of production (₹) per egg (CP)	Inter relationship of SU×SD×CP
T1 (387cm^2/bird)	5	2.74^{a}±0.02	5305.03^{c}±44.20
T2 (484cm^2/bird)	4	2.62^{b}±0.02	5073.55^{b}±47.35
T3 (548cm^2/bird)	3	2.62^{b}±0.02	4301.48^{a}±28.32
T4 (645cm^2/bird)	3	2.59^{b}±0.03	5017.55^{b}±65.65
N	18	18	
SEM	0.01	50.42	
P Value	**	**	

**, Highly significant at P≤0.001; *, Significant at P≤0.001; NS, Non-significant P>0.05.

Table 4. Welfare parameters of commercial layers reared at different stocking densities during 28 to 47 week of age

Treatment	Feather score (28th week)	Gait score (47th week)	Immunity titer		
			Initial phase (28th week)	Mid phase (38th week)	End phase (47th week)
T1 (387 cm^2/bird)	6.89^{b}±0.14	7.89±0.11	3.17±0.03	3.08±0.06	3.03±0.09
T2 (484 cm^2/bird)	7.44^{ab}±0.44	8.00±0.00	3.12±0.07	2.98±0.10	3.03±0.07
T3 (548 cm^2/bird)	7.45^{ab}±0.27	8.00±0.00	3.16±0.07	2.90±0.06	3.06±0.14
T4 (645 cm^2/bird)	8.00^{a}±0.00	8.00±0.00	3.01±0.06	2.88±0.10	2.99±0.12
N	6	6	8	8	8
SEM	0.125	0.223	0.030	0.040	0.136
P value	*	NS	NS	NS	NS

(Table 4). Craig *et al.* (1986) conducted experiment for thirty weeks and observed that there was significant differences in scores 8.3, 6.3, and 3.4 for hens in single-, 4- and 6-bird cages, respectively. Feather damage and loss increased step-wise and significantly with increased stocking density, Sarica *et al.* (2008), Apply by *et al.* (2002). The poorer feather score of densely populated cages may be caused by abrasion against cage wire or other hens. There was no significant difference in feather score among the birds provided with space 484, 548 and 645 cm^2/bird. The feather score value was recorded highest in the birds reared with space 645 cm^2/bird.

The gait score had no difference in all the treatment group birds, may be because of the 20 week period was too short to bring a significant difference in their gait. Li *et al.* (2015) observed a poorer welfare condition in hens maintained in conventional cages in terms of feather condition score, gait score and tonic immobility duration.

Immune response to known antigen is another parameter that has been widely used in assessing the stress level of birds and indirectly to welfare of birds. The antibody titers reported as $\log_2$ of the highest dilution yielding significant agglutination were non-significant among all the treatments (Table 4) tested at different time period, indicating that stocking density did not compromised the immunity of the bird. This is in agreement with Patterson and Siegel (1998) and Heckert *et al.* (2002) who observed that cage density treatments had no significant effect on hemagglutinin titers to SRBC.

On the basis of the above results, it is concluded that the commercial white leghorn birds reared in conventional California cage system with floor space 548 and 645 cm^2 / bird recorded non-significant difference in hen day egg production (%), quality of egg, feed conversion ratio and welfare parameters. However, the birds reared with cage floor 548 cm^2/bird performed best considering the stocking density (number of bird/cage box), cost of production of egg (₹) and space utilized (cm^2/bird) per bird. Hence it is recommended that commercial white leghorn birds may be reared in conventional California cage system by providing 548 cm^2/bird (85 sq inch/bird) without compromising production performance, egg quality and welfare of the birds.

ACKNOWLEDGEMENTS

The authors greatly acknowledge the Maharashtra Animal and Fishery Sciences University, Nagpur for providing all infrastructural facilities to carry out this research work.

REFERENCES

Abrahamsson P. 1996. Furnished cages and aviaries for laying hens. Effects on production, health and use of facilities. Dissertation. Report 234, submitted to Department of Animal Nutrition and Management, SLU, 75007 UPPSALA, SWEDEN

Adams A W and Craig J V. 1985. Effect of crowding and cage shape on productivity and profitability of caged layers: a survey. *Poultry Science* **64**(2): 238–42.

Anderson K E, Davis G S, Jenkias P K and Corroll A S. 2004. Effect of bird age, density and molt on behavioural profiles of two commercial layer strains in cages. *Poultry Science* **83**: 1–23.

Appleby M C, Walker A W, Nicol C J, Lindberg A C, Freire R, Hughes B O and Elson H A. 2002. Development of furnished cages for laying hens. *British Poultry Science* **43**: 489–500.

Benyi K, Norris D and Tsatsinyane P M. 2006. Effect of stocking density and group size on the performance of white and brown Hyline layers in semi-arid conditions. *Tropical Animal Health Production* **38**: 619–24.

Chatterjee R N and Haunshi S. 2015. *Welfare Concerns in Poultry Production*. Lead papers presented in 32nd Annual conference of IPSA held at College of Avian Sciences and Management, Palakkad, Kerala from 19–21 Nov 2015, pp 89–94 (in Souvenir) DADF, GOI, 204, Livestock Censes (www.dahd.nic.in)

Craig J V, Craig J A and Vargas J V. 1986. Corticosteroids and Other Indicators of Hens well-being in four laying-house environment. *Poultry Science* **65**: 856–63

Heckert R A, Estevez I, Russek-Cohen E and Pettit-Riley R. 2002. Effects of density and perch availability on the immune status of broilers. *Poultry Science* **81**: 451–57.

Jalal M A, Scheideler S E and Marx D. 2006. Effect of bird cage space and dietary metabolizable energy level on production parameters in laying hens. *Poultry Science* **85**: 306–11.

Lee K and Moss C V. 1995. Effect of population density on layer performance. *Poultry Science* **74**: 1754–60.

Li X, Chen D, Li J and Bao J. 2015. Effects of furnished cage type on behavior and welfare of laying hens. *Asian-Australasian Journal of Animal Science* **29**(6): 887–94.

Mangnale G A, Desai D N, Ranade A S and Avari P E. 2019. Study of production performance of layers in different types of cages with different stocking densities. *International Journal of Livestock Research* **9**(2): 190–96

Nicol C J, Brown, S N, Glen E, Pope S J, Short F J, Warriss P D, Zimmerman P H and Wilkins L J. 2006. Effects of stocking density flock size and management on the welfare of laying hens in single-tier aviaries. *British Poultry Sci*ence **47**: 135–46.

Onbasilar E E and Aksoy F T. 2005. Stress parameters and immune response of layers under different cage floor and density conditions. *Livestock Production Sci*ence **95**: 255–63.

Patterson P H and Siegel H S. 1998. Impact of cage density on pullet performance and blood parameters of stress. *Poultry Science* **77**: 32–40.

Rajendran K, Edwin S. C, Amutha R, Moorthy M and Shamsudeen P. 2013. Influence of cage stocking density on egg production and egg weight in commercial White leghorn Layers. *Indian Veterinary Journal* **90**(8): 57–58.

Sarica M, Boga S and Yamak U S. 2008. The effect of space allowance on egg yield, egg quality and plumage condition of laying hens in battery cages. *Czech Journal of Animal Science* **53**(8): 346–53.

Snedecor G W and Cochran W G. 1989. *Statistical Methods*. 8th Edn. Iowa State University Press, Ames, Iowa, Reprinted in 1994. East-West Press Pvt. Ltd., New Delhi.

Tauson R, Wahlstromand A and Abrahamsson P. 1999. Effects of two floor housing systems and cages on health, production and fear response in layers. *Applied Poultry Research* **8**: 152–59.