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

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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 cm² (T1); 75 sq. inch/484 cm² (T2); 85 sq. inch/548 cm² (T3) and 100 sq. inch/645 cm² (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 cm² 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.
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 eggs). 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, 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. 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. Treatment groups 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 log₂ 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 (Snedenor 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 cm²/bird than any other treatment

| Treatment | Weeks |
|-----------|-------|
|           | 28–31 | 32–35 | 36–39 | 40–43 | 44–47 | 28–47 |
| **T1 (387cm²/bird)** | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR |
| T1 (387cm²/bird) | 81.03±1.38 | 1.58±0.02 | 88.44±0.31 | 1.45±0.01 | 89.95±1.15 | 1.45±0.01 | 91.01±0.76 | 1.45±0.01 | 90.38±0.88 | 1.45±0.01 | 90.1±0.65 | 1.45±0.01 |
| **T2 (484cm²/bird)** | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR |
| T2 (484cm²/bird) | 81.98±0.76 | 1.61±0.01 | 89.58±0.18 | 1.48±0.02 | 90.38±0.88 | 1.46±0.01 | 89.58±0.76 | 1.46±0.01 | 90.1±0.65 | 1.46±0.01 | 89.71±0.59 | 1.47±0.01 |
| **T3 (548cm²/bird)** | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR |
| T3 (548cm²/bird) | 85.04±0.95 | 1.56±0.02 | 88.60±0.91 | 1.77±0.26 | 90.41±0.86 | 1.77±0.26 | 85.28±0.65 | 1.51±0.02 | 89.39±0.65 | 1.50±0.01 | 87.50±0.95 | 1.50±0.01 |
| **T4 (645cm²/bird)** | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR |
| T4 (645cm²/bird) | 84.14±0.88 | 1.57±0.02 | 88.15±0.80 | 1.50±0.01 | 90.15±1.07 | 1.49±0.01 | 85.52±0.65 | 1.51±0.02 | 89.41±0.86 | 1.49±0.01 | 88.25±0.82 | 1.47±0.01 |
| SEM | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR |
| SEM | 0.689 | 0.01 | 0.616 | 0.01 | 0.494 | 0.07 | 0.457 | 0.01 | 0.38 | 0.01 | 0.480 | 0.01 |
| P value | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR | HDEP | FCR |
| HDEP | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| FCR | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |

**, Highly significant at P≤0.001; *, Significant at P≤0.01; NS, Non-significant P>0.05.
groups except the birds reared with floor space 548 cm\(^2\)/bird (83.54\%)
in contrast, the birds received lowest space 387 cm\(^2\) per bird 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). 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 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

| Stocking densities | Cost of production ($/egg) (CP) | Inter relationship of SU×SD×CP |
|--------------------|---------------------------------|-------------------------------|
| T1 (387cm\(^2\)/bird) | 5 2.74±0.02 5305.03±44.20 | **NS** |
| T2 (484cm\(^2\)/bird) | 4 2.62±0.02 5073.55±47.35 |
| T3 (548cm\(^2\)/bird) | 3 2.62±0.02 4301.48±28.32 |
| T4 (645cm\(^2\)/bird) | 3 2.59±0.03 5017.55±65.65 |

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

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 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 cm²/bird) | 6.89±0.14 | 7.89±0.11 | 3.17±0.03 |
| T2 (484 cm²/bird) | 7.44±0.44 | 8.00±0.00 | 3.12±0.07 |
| T3 (548 cm²/bird) | 7.45±0.27 | 8.00±0.00 | 3.16±0.07 |
| T4 (645 cm²/bird) | 8.00±0.00 | 8.00±0.00 | 3.01±0.06 |
| N          | 6            | 6           | 8            |
| SEM        | 0.125        | 0.223       | NS           |
| P value    |             |             | NS           |

(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 cm²/bird. The feather score value was recorded highest in the birds reared with space 645 cm²/bird.

The gait score had no difference in all the treatment groups, 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 log2 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 compromise 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 cm²/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 cm²/bird performed best considering the stocking density (number of bird/cage box), cost of production of egg (₹) and space utilized (cm²/bird) per bird. Hence it is recommended that commercial white leghorn birds may be reared in conventional California cage system by providing 548 cm²/bird (85 sq inch/bird) without compromising production performance, egg quality and welfare of the birds.

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