



Development of innovative scorecard for assessment of welfare and production performance of commercial layer birds reared at different stocking densities in cages

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ABSTRACT

A methodology to assess the welfare of laying birds maintained in cages was developed using innovative scorecard method without compromising the production and economics in Indian scenario. To develop scorecard, specific key parameters such as production, economics, egg quality, welfare and behaviour were considered. The scores for these key parameters were assigned on the basis of the performance of the commercial laying hens maintained in different stocking densities in cages (387, 484, 548 and 645 cm²/b) for an experimental period of 20 weeks. The range for each parameter was decided and based on it four groups were formed and the treatment with the best performance received the highest weightage, that is how scoring of each treatment was done according to the range they fitted in. The scoring, weightage and guidelines were devised by Delphi technique, by a panel of national experts from the academics and experts working in the poultry industry. At the end of the experimental period, laying birds maintained at stocking density of 548 cm²/b scored the highest weightage with 84 out of total 100; 48 weightage for production and economics, 12 weightage for egg quality and 40 weightage for welfare and behaviour. From all above results, it could be summarized that this innovative scorecard can be used to determine the best performance of laying birds taking welfare into consideration.

Keywords: Behaviour, Cage, Layers, Production, Scorecard, Welfare

Welfare of laying hens kept in conventional cages has been a growing concern and a challenge to the Indian poultry industry. Since years, raising layers in confined cages with best management practices has maximized the production capacity but has led to inability to express the behaviour which the birds could do in cage-free systems, thereby compromising welfare of the caged birds.

Under the floor housing system, the EU directives have suggested a layer bird has to be provided with a minimum space of 1100 cm². Presently in USA, layers get 430 cm² spaces but in other countries including India, mostly the laying hens are kept in California cages with space allowances of about 300 cm² to 400 cm² which is much lower than the World average (Widowski *et al.* 2016). The space provided in cages to commercial layer birds is not sufficient to stand, lie down and turn around without touching each other's and sides of enclosure (Chatterjee and Haunshi 2015). Welfare indicators for poultry as suggested in literature are (Backus *et al.* 2014, Rodenburg *et al.* 2008) physical indicators (feather score, gait score, claw length, etc); physiological indicators (corticosterone

level, heterophil:lymphocyte ratio, immune status, etc); vocal and behavioural indicators. Better stocking density, optimum flock size are some of the attempts brought about in a response to the criticism of raising commercial laying hens in conventional battery cages for egg production and provide a sense of welfare. Factors such as physical indicators, physiological indicators, vocal and behavioural indicators exhibit welfare of the laying birds raised in cages is compromised, which attracted the attention of animal welfare society (Bhanja *et al.* 2018). At the latest EU-India Summit in July 2020, the two sides agreed to establish a high-level dialogue at ministerial level "to provide guidance to the bilateral trade and investment relations and to address multilateral issues of mutual interest" (Stephanie 2021).

Indian authorities are currently debating opportunities to phase out battery cages in egg production, as well as introduction of new minimum welfare standards for caged birds. Therefore, it is imperative to study the welfare, behaviour as well as the production performance along with the economics of the layers so as to provide an effective guideline to the Poultry Industry in Indian context. As of now, there is no such tool or methods available for assessing the welfare, behaviour and production performance of caged layers. Therefore, a score card methodology was attempted on the basis of weighted scoring prioritization using numerical scoring to rank the laying birds' welfare,

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behaviour and production economics of rearing. The weighted scoring approach gives quantitative value for each competing parameters to determine which items should be prioritized on welfare roadmap.

MATERIALS AND METHODS

The present study was carried out at Poultry Research and Training Center, Department of Poultry Science, Nagpur Veterinary College, MAFSU, Maharashtra. The biological experiment was conducted on caged commercial laying hens (n= 240; strain BV 300) of 28th week age to evaluate the welfare and production performance. The experiment was conducted for 20 weeks period under standard management practices with four experimental treatments. The laying birds allotted space treatment A: 387 cm²/b or 60 sq.inch/ b; B: 484 cm²/b or 75 sq.inch /b; C: 548 cm²/b or 85 sq.inch /b and treatment D: 645 cm²/b or 100 sq. inch/b. California cage boxes were altered to achieve the required space per bird in each treatment. Each treatment A, B, C and D consists of 18 replicates with specific size cage box to accommodate 5, 4, 3 and 3 birds respectively. The birds were maintained on standard commercial layer feed with 110 gm feed/day/bird. At the end of each week the feed refusals were collected to measure the feed intake of the experimental birds.

Egg production, feed intake, and FCR was calculated. On the basis of recurring expenses, cost of production per egg (CPPE) was calculated, whereas, on the basis of space utilization, cost of production per egg was estimated. To calculate CPPE on basis of space utilization, the below formula was used:

$$\text{CPPE (on the basis of space utilization)} = \frac{\text{CPPE (on the basis of recurring expenses)} \times \text{space allowance per bird (inches)} \times \text{number of birds}}{\text{space allowance per bird (inches)} \times \text{number of birds}}$$

Egg production was recorded daily and egg weights were noted once in a week for each replicate. All the treatment eggs were visually graded to check the cracks and dirtiness of the egg. During laying process, the eggs get contaminated with faecal material and blood smears on the shell, those eggs were noted to calculate the percentage of dirty and cracked eggs.

The immune responsiveness of layers birds maintained in different stocking densities were analyzed by humoral immune response by estimating haemagglutination inhibition titre against New Castle Disease virus (NCDV) during start, mid and end of the 20 week experimental period (O.I.E. 1992). To obtain heterophil to lymphocyte ratio (Gonzales *et al.* 2003) and corticosterone level (ELISA kit), eight birds from each treatment were randomly selected for the blood collection at 28th (start of experiment), 37th (mid of experiment) and 47th (end of experiment) weeks of age.

Physical indicators of welfare like feather score and gait score was measured using a modified eight point scoring system for plumage score (Kestin *et al.* 1992, Abrahamsson 1996).

All the state and event behavioural activity of the birds

were video recorded in CCTV camera for 24 hr during the entire experiment and studied the behaviour pattern of the laying birds at different stocking density Martin and Bateson (2007). From the 24 hours recording, an activity chart or ethogram was prepared and the time devoted (01 min) to each activity was expressed. The time budgets for feeding, drinking, standing, sleeping, sitting, walking, investigation, perching, feather pecking, wing flapping, scratching and preening on the perches were calculated as the mean proportion of birds performing.

Scorecard was developed considering welfare, behaviour and performance of caged laying hens on the basis of production, egg quality, immunity, stress response economics, welfare and behaviour of the birds. On the basis of Delphi technique (Balamurugan *et al.* 2019) performance scorecard, weightage and guidelines were developed by panel of national level experts of academics, scientist and poultry industry. The opinions from different panels (statutory student advisory comprising scientists from ICAR-Central Avian Research Institute, Bareilly, College Academic Advisory, University board of studies comprising well known poultry industry representative were invited, collated, discussed and summarized for the preliminary score card. During the discussion, the experts were asked to comment on the parameter to be undertaken for evaluation, scoring pattern, and weights to be assigned. On the basis of consensus, specific marks weightage was given to each parameter (Table 1). The finalized performance scorecard was discussed and approved through college Animal ethical committee too. Parameters that were considered while preparing the score card were production and economics with a weightage of 48%, followed by almost equal weightage for stress, immunity, welfare and behaviour with weightage of 40% and the remaining 12% weightage were allotted to egg quality. While allotting the scores for the various parameters, the scores were divided into four groups (ranges) and the treatment with the best performance received the highest weightage that was scored in each treatment according to the range it fit in, the details are provided in Table 1.

RESULTS AND DISCUSSION

The experimental layer birds reared in California cages for 20 weeks at four different stocking densities were assessed for hen day egg production (HDEP %), FCR (per dozen eggs) and the cost of production (per egg) was calculated on basis of recurring expenses and space utilization (Table 2). It was observed that the layer birds reared at treatment D (645 cm²/b) and treatment C (548 cm²/b) scored highest 16 marks followed by the birds reared at space 484 cm²/b (treatment B) received 12 marks and 4 marks for the birds reared at 387 cm²/b. The non-significant difference of means for HDEP (89.71 vs 92.70 %) between the birds reared at space 548 and 645 cm²/b was observed (Table 3), similarly non-significant observations was recorded for the birds reared at 548 and 484 cm²/b. There was significantly high difference in egg production

Table 1. Score card to evaluate welfare and production performance of cage reared commercial layers

Parameter	Weightage (%)	Sub-division of weightage (%)	Sub-division of parameters	Marks distribution	
Production and Economics	48	24	16	a) Per cent Egg Production	Treatment achieving the highest egg production will be given maximum 16 marks and subsequent treatment as 12, 08 and 04.
			08	b) Feed Conversion Ratio per egg	Treatment achieving the best FCR will be given the highest 08 marks, followed by 06, 04 and 02 for the other treatments.
		24	16	a) Cost of production per Egg in relation to Recurring expenses.	Treatment group with the minimum cost of production would be assigned score 16, followed by 12, 08 and 04.
			08	b) Cost of production per Egg in relation to Space Utilization.	Treatment group with the maximum space utilization will score 08, followed by 06, 04 and 02.
Egg Quality	12	12	04	a) Egg weight	Treatment with highest egg weight will receive maximum 04 marks followed by 03, 02, 01 for the subsequent treatments.
			04	b) Percentage of broken egg	Treatment conforming to the less broken eggs will have the maximum 4 marks followed by other group as 03, 02, 01.
			04	c) Percentage of clean eggs	Treatment group producing cleanest eggs among the treatments will have the highest 04 marks followed by subsequent groups as 03, 02, 01.
Immunity, Stress, Welfare and behaviour (Behaviour data collected with the help of CCTV)	40	12	04	a) HI Titre	Depending on the best titre, the treatment groups would be assigned score from 04 to 01
			04	b) Heterophil/Lymphocyte Ratio	Depending on the H/L, the treatment groups would be assigned score from 04 to 01.
			04	c) Corticosterone level	Depending on the corticosterone, the treatment groups would be assigned score from 04 to 01
		16	08	Physical condition of bird- Feather Scoring	Depending on the feather scoring suggested by Abrahamsson (1996) at the end of the trial marks will be assigned from 8, 6, 4 and 2 for full feathers cover, worn feathers, detectable small and large bare patches to no feather most of the body.
			08	Gait scoring	Gait performance as described by Kestin <i>et al.</i> 1992 at the end of the trial observed marks would be assigned from 8, 6, 4 and 2 to treatment groups having sound birds with no detectable impairment, bird moving fast with flight, significant or serious deficiency and birds that are barely able to move or have total inability to walk.
		12	06	a) State behaviour (standing, walking, sleeping, etc)	The activity number for state behaviours would be calculated for each treatment and group with the highest activity were offered highest score of 06, followed by others 04, 02 and 00.
06	b) Event behaviour (feather pecking, drinking, feeding, preening, etc)		The activity number for event behaviours would be calculated for each treatment and group with the highest activity were offered highest score of 06, followed by others 04, 02 and 00.		
Total	100				

(92.70%) performance among the birds reared at treatment D (645 cm²/b) and the treatment A (387 cm²/b); B (484 cm²/b). Negative effect on egg production percentage with increasing stocking density similar to this experiment

was reported by Onbasilar and Aksoy (2005), Jalal *et al.* (2006), Sarica *et al.* (2008) and Rajendran *et al.* (2013). The layer bird reared at space 548 and 645 cm²/b received the maximum weightage of 8 for the FCR per dozen eggs

Table 2. Evaluation of production performance of commercial layers on the basis of developed scorecard method

Parameter	Sub-group of parameters	Total score	Range	Score allotment	Scores of treatment			
					A 387 cm ² /b	B 484 cm ² /b	C 548 cm ² /b	D 645 cm ² /b
Production and Economics (₹)	Egg Production (HDEP) %	16	1) 83.54 to 85.34	04	04			
			2) 85.3 to 87.14	08				
			3) 87.15 to 88.94	12		12		
			4) 88.95 to 90.74	16		16	16	
	FCR (per dozen eggs)	08	1) 1.46 to 1.49	08			08	08
			2) 1.5 to 1.53	06		06		
			3) 1.54 to 1.57	04				
			4) 1.58 to 1.60	02	02			
	Cost of production per egg in relation to recurring expenses	16	1) 2.59 to 2.63	16		16	16	16
			2) 2.64 to 2.68	12				
			3) 2.69 to 2.73	08				
			4) 2.74 to 2.78	04	04			
	Cost of production per egg in relation to space utilization	08	1) 667.20 to 706.02	08			08	
			2) 706.03 to 744.85	06				
			3) 744.86 to 783.68	04		04	04	
			4) 783.69 to 822.49	02	02			
Sub-total	48			12	38	48	44	

as it was ranging between 1.46 to 1.49. The birds (B group) reared at space 484 cm²/b scored 6 marks and the birds reared at highest stocking density (387 cm²/b) gained weightage of 2 marks. The FCR was observed significantly better for lower stocking density of 645, 548, and 484 cm²/b than the birds kept in highest stocking density of 387 cm²/b. In accordance to present study better space better FCR values observed by Davami *et al.* (1987) and Lee and Moss (1995). The cost of production per egg (CPPE) was realized on the basis of recurring expenses and space utilization. The CPPE on the basis of recurring expenses was observed significantly better for lower stocking density of 645, 548, and 484 cm²/b than the birds kept in highest stocking density of 387 cm²/b. Hence, on the basis of score card the treatment D, C and B scored 16 marks and the treatment group A recorded 4 marks.

The CPPE on the basis of space utilization realized with best score card values (8) in the treatment birds reared at

484 and 645 cm²/b, whereas the birds received the space 548 cm²/b recorded 4 score card figure. The layer birds reared at highest stocking density (387 cm²/b) gave poor value of 2 in term of space utilization.

Egg weight, percentage of broken eggs and clean eggs were recorded for egg quality with a total score allotted 12; each of the subgroup was allotted 4 marks. The birds reared in the group A with highest stocking density (387 cm²/b) laid significantly smaller egg ($P < 0.01$) as compared to birds reared at space 548 and 645 cm²/b. On the basis of score card, the birds reared at 548 cm²/b obtained the highest score 4, due to the maximum egg weight of 55.88 g followed by the treatment group D (645 cm²/b) and B (484 cm²/b) with 3 marks each and lowest mark scored was 1 by treatment group A with highest stocking density. The effect of stocking density was observed by Onbasilar and Aksoy (2005) and Rajendran *et al.* (2013) while others like Craig and Milliken (1989), Lee and Moss (1995) and Sarica

Table 3. Effect of stocking density on egg production and economics of commercial laying hens

Cage space allotted (cm ² /b)	Hen day egg production % (HDEP)	Feed conversion ratio (FCR)	CPPE on the basis of RE (₹)	CPPE on the basis of SU*
A (387)	83.54 ^a ± 0.73	1.58 ^a ± 0.01	2.74 ^a ± 0.02	822.49 ^a ± 6.85
B (484)	88.25 ^b ± 0.82	1.50 ^b ± 0.01	2.62 ^b ± 0.02	786.19 ^b ± 7.34
C (548)	89.71 ^{ab} ± 0.59	1.47 ^b ± 0.01	2.62 ^b ± 0.02	667.20 ^c ± 4.39
D (645)	90.72 ^a ± 1.09	1.46 ^b ± 0.02	2.59 ^b ± 0.03	777.91 ^b ± 10.18
SEM	0.422	0.01	0.01	7.799
P-value	**	**	**	**

RE, Recurring expenses; *CPPE on the basis of RE × space allowance per bird in inches × number of birds; SU, Space utilization.

^{a, b, c} means not followed by the same superscript are significantly different ($P < 0.05$) along the row. Mean values ± SEM.

Table 4. Evaluation of egg quality of commercial layers on the basis of developed score card method

Parameter	Sub-group of parameter	Total score	Range	Score allotted	Scores of treatment			
					A 387 cm ² /b	B 484 cm ² /b	C 548 cm ² /b	D 645 cm ² /b
Egg quality	Egg weight (g)	04	1) 52.44 to 53.29	01	01			
			2) 53.3 to 54.15	02				
			3) 54.16 to 55.01	03		03		03
			4) 55.02 to 55.87	04			04	
	Broken egg (%)	04	1) 0.19 to 0.25	04			04	04
			2) 0.26 to 0.32	03		03		
			3) 0.33 to 0.39	02				
			4) 0.40 to 0.46	01	01			
	Clean egg (%)	04	1) 99.16 to 99.32	01		01	01	
			2) 99.33 to 99.49	02	02			
			3) 99.50 to 99.66	03				
			4) 99.67 to 99.83	04			04	
Sub-total	12			04	07	09	11	

et al. (2008) found no difference on egg weight because of stocking density. There was no significant difference found in broken and dirty eggs similar finding observed by Sarica *et al.* (2008) and Windowski *et al.* (2017). On adding up the scores obtained by various treatment for the egg quality, a linear trend was observed, as the stocking density improved the egg quality score improved 04, 07, 09 and 11 for treatment group A, B, C and D respectively (Table 4).

Stress and immune status of caged birds was determined by estimating the H/L ratio and corticosterone level (ng/ml), HA, HI during the start, mid and end of the experiment. The average values, of the treatment were used for scoring. A total score for stress and immunological parameters by various treatment groups A,B,C,D were 06, 10, 09 and 05 for the treatment group A, B, C and D respectively. The birds reared with highest stocking density of 387 cm²/b showed highest level of corticosterone and H/L ratio value, whereas, lowest values were observed in the birds reared at 548 cm²/b (Table 5). Mashaly *et al.* (1984) observed significant changes in serum corticosterone at different stocking density. Cheng and Muri (2004) findings support the present experiment for plasma corticosterone. This was explained by the fact that elevated concentration of corticosterone in blood causes an increase in heterophil

count and a decline in lymphocyte count. This indicates that the birds reared at 548 cm²/b received comparatively stress free environment than any other stocking density reared birds. While, the HI values did not show any significant difference among any of the stocking density reared birds. Onbasiler and Akshoy (2005) observed significant changes for ratio of heterophils to lymphocytes. Similarly non-significant effect of stocking density on immune-competence was reported by Mench *et al.* (1986) when compared the micro-hemagglutination log₂ values to SRBC for stocking densities of 1394 and 697 cm²/hen. There was non-significant differences in the gait score for the birds maintained in different stocking densities, while the feather score values were significantly (P<0.05) better in stocking density 484, 548 and 645 cm²/b than the birds reared at 387 cm²/b group.

A total score for welfare and behavior including feather score, gait score, state and event behavior obtained by various treatments groups were 10, 18, 18, 22 for Treatment A, B, C and D respectively (Supplementary Table 1) out of 28 weightage. The birds reared at 548 cm²/b spent 12% time on standing state which was significantly (P<0.005) lower than the other treatment group birds. Hence we can say that the birds spent maximum time on the activity (Supplementary Table 2). The treatment group birds

Table 5. Effect of stocking density on egg quality, stress, immune status and welfare

Parameter	387 cm ² /b	484 cm ² /b	548 cm ² /b	645 cm ² /b	SEM	P-value	Significance
Egg weight	52.44 ^b ± 0.34	54.48 ^{ab} ± 0.49	55.88 ^a ± 0.98	54.67 ^{a±} 0.46	0.32	0.00	**
Broken egg (%)	0.44 ± 0.14	0.26 ± 0.13	0.20 ± 0.08	0.19 ± 0.09	0.057	>0.05	NS
Dirty egg (%)	0.67 ± 0.00	0.84 ± 0.34	0.71 ± 0.29	0.22 ± 0.08	0.125	>0.05	NS
H/L ratio	0.34 ^a ± 0.05	0.27 ^{ab} ± 0.03	0.22 ^b ± 0.01	0.22 ^b ± 0.01	0.011	0.041	*
Corticosterone level	2.21 ^a ± 0.28	1.08 ^{ab} ± 0.16	0.91 ^c ± 0.10	1.65 ^b ± 0.07	0.128	0.000	**
HI values	3.01 ± 0.10	3.05 ± 0.09	3.17 ± 0.13	3.02 ± 0.16	0.059	0.793	NS
Feather score	6.67 ^b ± 0.30	7.44 ^{ab} ± 0.44	7.45 ^{ab} ± 0.27	8.00 ^{a±} 0.00	0.170	0.037	*
Gait score	7.89 ± 0.11	8.00 ± 0.00	8.00 ± 0.00	8.00 ± 0.00	0.028	0.413	NS

Means bearing superscript within a column differ significantly. NS, Non-significant; *, P<0.05; **, P< 0.01.

(548 cm²/b) spent significantly higher time (25%) on sleeping state which indicates that birds were in enough in state to spend maximum time on sleeping activity. The similar group birds spent only 7% time on investigation behavior which shows the birds were well verse with the feeding and watering system and there was no as such competition among birds to get feed and water. The total of the state and event behaviors comprised of various activities as charted in Supplementary Table 2 was non-significant, though the most individual activity showed significant differences. As expected, behavioural activities like grooming and preening, wing flapping, walking was significantly ($P < 0.001$) poor at stocking density of 387 cm²/b compared to the rest of the treatments because of less space per bird and also, similar was found by various experimental trials of Nicol (1987), Huges and Black (1974) and Anderson *et al.* (2004). The birds reared at space 548 cm²/b and 645 cm²/b exhibited significantly ($P < 0.005$) better wing flapping and less feather pecking as compared to other stocking density groups. If different activities are clubbed as total state or total event it would be more or less equal, for example a bird spending more time on walking would have less of standing, similarly a particular group showing more of state behaviors would have less of total event behavior resulting in score of either the maximum 06 or the minimum 00 on the scorecard.

The total scores obtained by the various treatment groups, with emphasis on production, economics, egg quality and welfare in the scorecard weightage system were 32, 73, 84 and 82% for the birds maintained in stocking density of 387, 484, 548 and 645 cm²/bird

It could be summarized that, in context to Indian conditions, scorecard method is developed which can be used to evaluate production, economics and welfare of cage reared commercial layers.

As per the score card method, the birds reared in conventional California cage system with space allowance 548 cm²/bird (85 sq. inch/b) achieved highest marks (84%) with optimum weightage to production performance, egg quality and welfare of the birds.

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