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Effect of Cage Density on the Performance of 25- to 84-Week-Old Laying Hens

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ABSTRACT

Three experiments were carrie out to evaluate the influence of cage density on the performance of 25- to 84-week-old laying hens. Forty hundred Lohmann-LSL layers were distributed in cages (100x40x 45x50cm) according to a completely randomized experimental design with split plot in time.Three treatments (10, 12, or 14 hens per cage, corresponding, to 450, 375, and 321cm^2/bird, respectively), with 15 assessment periods (four weeks each), and eight replicates per treatment were applied. Considering that layer`s production cycle is affected by age, three experimental trials (25 to 44; 45 to 64 and 65 to 84 weeks of age) were carried out, and the data collected in each trial was individually analyzed. Increasing cage density significantly reduced feed intake in all phases studied. Increasing birds/cm^2 significantly decreased feed intake and improved feed conversion at all stages of study, and egg production was only affected in 45-week-old birds. The number of birds per cage should be reduced as birds age in order not to affect their performance. Birds with more cage space in the presented higher feed intake; however, this did not result in higher egg production or lower mortality. These results suggest that up to 45 weeks of age, 375 cm^2 per layer results in the best performance, and from then on, 450 cm^2 per bird is required to maintain egg production and to reduce hen mortality.

INTRODUCTION

High bird density is often used in layer production to reduce housing and equipment costs per bird. However, this may influence flock performance, as it may cause significant bird stress, impairing bird welfare. Excessive reduction of cage space as well as feeder and drinker space may have negative impact on layer growth and performance, as feed intake may be reduced, with consequent decrease in live weight, and in muscle and skeletal development. Body weight and feed intake are essential factors when assessing bird's development, as well as egg production, egg size, and feed conversion ratio.

A common practice in Brazil and in the United States is to increase the number of birds per cage to reduce production costs. At the same time, the layer strains currently available in the market have been submitted to continuous genetic improvement. Layers have become increasingly lighter and more productive, and therefore, further studies on bird density are warranted. Few studies have been conducted on the effects of bird density during the growing period on bird performance this phase and the next rearing phase. Due to the intensification of the production process in industrial scale, with reduced income per housed bird and lower profit margins, cage density has become a factor of great economic importance.

This study aimed at evaluating the effect of bird density in cages during lay (25 to 84 weeks of age) on layer performance.

MATERIAL AND METHODS

The experiment was carried out at the Poultry Sector of the Federal University of Lavras (Universidade Federal de Lavras). Four hundred (400) 18-week-old Lohmann-LSL layers from the same flock were purchased. Upon arrival at the experimental facilities, birds were weighed and distributed according to three different bird densities:10, 12, or 14 birds per cage (100 cm wide x 45 cm deep x 40 cm high height, with a 50 cm partition), which corresponded respectively to 450, 375, and 321 cm^2/bird. Two hundred and eighty eight (288) birds out of the 400 were utilized; the remaining 112 birds were, housed at the same experimental densities in order to replace any possible bird that died during the experimental period. Birds were housed a 20 m long x 6 m wide poultry house measuring 20 m long by 6 m broad, where the metal cages, equipped with nipple drinker and a trough feeder, were placed. A completely randomized experimental design in split plot in time was applied. Each plot (treatment) consisted of three cage densities of eight replicates each, and the subplots included fifteen production periods (25 to 28; 29 to 32; 33 to 36; 37 to 40, and 41 to 44 weeks of age in the first trial; 45 to 48; 49 to 52; 53 to 56; 57 to 60; and 61 to 64 weeks of age in the second trail and 65 to 68; 69 to 72; 73 to 76; 77 to 80 and 81 to 84 weeks of age in the third trial). Bird mortality and egg production were daily recorded in proper forms. Dead birds were replaced by the birds housed in the replacement cages at the same density equal to that of the plot where death occurred. All birds were fed twice daily with the same diet, formulated according to the recommendations of the strain's manual (1999). A lighting program of 16 of light per day was applied. Feed intake, egg production, and mortality were weekly recorded.

The collected data were analyzed using SISVAR statistical package (Ferreira, 2000). The following parameters were evaluated: feed intake, egg production, average egg weight, feed conversion per kg (kg feed/ kg eggs), feed conversion per dozen (kg feed/dozen eggs), and mortality.

RESULTS AND DISCUSSION

Table 1 shows the results obtained for, the phase of 25 to 44 weeks of age.There was no effect of the cage density ($p>0.05$) on egg production or egg weight. These results are consistent with those obtained by Marks *et al*. (1970), who evaluated, three cage densities (1,125, 562,or 450 cm^2/bird) and did not find any, differences in egg production. Other authors, such as Dorminey & Arscott (1971), Wells (1971), Craig & Milliken (1989), Lee (1989), and Carey *et al*. (1995), also did not observe any effect of cage density on egg production. However, opposite findings were reported by Cunningham *et al*. (1988), who verified 2.1% egg production reduction when cage density was increased from 406 to 316 cm^2/ bird. Garcia *et al*. (1993), Adams & Craig (1985), Davami *et al*. (1987) and Okpokho *et al*. (1987) also found that increasing cage density and reduction of feeder space/bird caused a decline in egg production. Egg weight results obtained in the present study were similar to those obtained by Al Rawi *et al*. (1976), Goodling (1984), Mench *et al*. (1986), Lee (1989), and Carey *et al*. (1995), who also did not find any effect of cage density on egg weight, whereas Roush *et al*. (1984), observed a trend of increasing egg weight as cage area per bird was reduced. Davami *et al*. (1987) found that egg weight decreased in the treatment of highest density. Cunningham (1982), however, reported that the densities of 483.87 and 387.09 cm^2/bird, in the "deep" cages, and of 484.15 and 387.32 cm^2/bird in the shallow cages did not reduce egg weight.

Period of lay ($p<0.01$) influenced average egg production and egg weight (Table 1). Egg production followed the curve described in the strain's manual, reaching a plateau, and declining thereafter. The increase in egg weight is related to the increase in feed intake by the birds according to their normal growth cycle.

Feed intake results (Table 1) were significantly influenced by the, interaction ($p<0.01$) between period of lay and cage density, with increasing feed intake in each cage density as a function of bird age. A significant difference ($p<0.01$) in feed intake was determined within the studied periods among cage densities, with birds housed at the density of 321 cm^2/ bird presenting the lowest feed intake. These results are similar to these obtained by Hill (1977), who housed layers at, densities of 310, 38, and 464 cm^2/bird and, found that those housed at the density of 310 cm^2/ bird consumed less feed than those housed at 387 and 464 cm^2/bird.

There was a significant effect of the interaction ($p<0.01$) between period of lay and cage density on feed conversion per kg. The only density affected by period was 375 cm²/bird ($p<0.01$), increase in feed intake was not accompanied by increase in egg weight as layers aged. Feed conversion ratio relative to cage density in periods 4 and 5 are consistent with those observed by Hill (1977), who found an improvement in feed conversion per kilogram when cage density increased from 464 to 310 cm²/bird. On the other hand, Adams & Craig (1985), Davami *et al*. (1987), Cunningham & Ostrander (1982), and Garcia *et al*. (1993) observed an improvement in feed conversion per dozen and per kilogram of produced eggs as the, available space per bird in the cage increased (lower density).

Mortality is controversial when associated to housing density, because it is believed that mortality increases with increasing density, as observed in the present experiment, which mortality rates were of 1.25, 1.05, and 6% as cage density increased.

The results of the period of 45 to 64 weeks are presented in Table 2. There was no effect of cage density ($p>0.05$) egg weight or feed conversion ratio (FCR kg/dz). However, cage density influenced feed intake ($p<0.05$), egg production, and FCR (kg/kg). Feed intake increased as the number of birds pen cage decreased, with the lowest feed intake observed at the density of 14 birds per cage (321cm²/bird).

Birds housed at the lowest density presented the highest egg production, whereas the egg production of those housed at intermediate density was not different from the others.

FCR per kg was negatively affected by the lowest cage density, that is, the highest density (321cm²/bird) presented the poorest FCR.

These results are opposed to those verified by Lee (1989) and, Carey *et al*. (1995), who did not observe any effect of cage density on egg production/bird/day or per bird housed. On the other hand, results similar to the present study were reported by Cunningham *et al*. (1988), who observed 2.1% reduction in egg production/bird/day when density was increased from 406 to 316 cm²/bird. Garcia *et al*. (1993) and Okpokho *et al*. (1987) also found that increasing cage density and reducing feeder space/bird decreased egg production.

Egg weight results of the present study were similar

Table 1 - Egg production (%), feed intake (g/bird/day), egg weight (grams), feed conversion (g/g) and feed conversion per dozen (g/dz) of Lohmann-LSL layers between 25 to 44 weeks of age as a function of, period of lay and cage density (birds/cage).

Parameter	Density	Periods[1,2] 1	2	3	4	5	Mean[3]
Feed intake (g/bird/day)							
CV% = 2.51	10	107Ab	111 Aa	113 Aa	112 Aa	113 Aa	111.2
	12	100 Bc	107 Ab	109 Aab	112 Aa	112Aa	108.0
	14	102 Bab	99 Bb	102 Bab	105 Ba	105 Ba	102.6
	Mean	103	105,6	108	109.6	110	
Egg production (%)							
CV% = 2.68	10	95.03	95.64	97.26	94.77	94.33	95.41
	12	94.42	95.64	95.87	93.39	91.88	94.23
	14	95.19	92.69	95.06	92.40	92.46	93.56
	Mean	94.88	94.66	96.06	93.52	92.87	
Egg weight (g)							
CV% = 1.70	10	62.77	63.47	65.38	66.08	66.47	64.83
	12	62.37	63.56	65.37	66.14	66.69	64.82
	14	62.95	63.95	65.21	67.14	67.69	65.39
	Mean	62.69	63.66	65.32	66.45	66.95	
Feed conversion,g/dz							
CV% = 7.20	10	1.38	1.45	1.44	1.53	1.48	1.45a
	12	1.32	1.37	1.40	1.47	1.48	1.41ab
	14	1.31	1.28	1.29	1.44	1.44	1.35b
	Mean	1.34	1.36	1.38	1.48	1.46	
Feed conversion,g/g							
CV% = 3.17	10	1.76	1.80	1.77	1.79	1.78	1.78a
	12	1.70	1.76	1.74	1.81	1.83	1.77a
	14	1.70	1.72	1.70	1.72	1.72	1.71b
	Mean	1.72	1.76	1.74	1.77	1.78	

1 - Means followed by capital letters in the same column are statistically different by Tukey's test ($p<0.01$). 2 - Means followed by different small letters in the same row are statistically different by Tukey's test ($p<0.01$). 3 - Means followed by different small letters in the same column are statistically different by Tukey's test ($p<0.01$).

Table 2 - Egg production (%), feed intake (g/bird/day), egg weight (grams), feed conversion (g/g) and feed conversion per dozen (g/dz) of Lohmann-LSL layers between 45 to 64 weeks of age as a function of, period of lay and cage density (birds/cage).

Parameter	Density	Periods 1	2	3	4	5	Mean[1]
Feed intake (g/bird/day)							
CV% = 3.73	10	115.88	111.72	105.21	109.71	110.92	110.68 b
	12	112.23	109.68	106.27	108.66	107.77	108.92 b
	14	110.32	106.74	102.06	100.52	100.27	103.98 a
	Mean	112.81	109.38	104.51	106.25	106.32	
Egg production (%)							
CV% = 3.64	10	94.33	93.48	91.65	92.41	92.86	92.94 b
	12	91.11	92.45	91.67	91.67	91.48	91.67 ab
	14	92.00	90.18	90.02	89.64	88.54	90.07 a
	Mean	92.48	90.03	91.11	91.24	90.96	
Egg weight (g)							
CV% = 1.54	10	66.48	67.00	66.23	67.19	67.17	66.81
	12	66.69	66.77	66.25	67.40	65.92	66.60
	14	67.70	67.61	67.09	67.38	67.01	67.35
	Mean	66.95	67.12	66.51	67.32	66.70	
Feed conversion, g/dz							
CV% = 4.09	10	1.48	1.43	1.38	1.42	1.44	1.43
	12	1.48	1.42	1.39	1.42	1.41	1.42
	14	1.44	1.42	1.36	1.35	1.36	1.38
	Mean	1.46	1.42	1.37	1.39	1.40	
Feed conversion, g/g							
CV% = 4.03	10	1.85	1.78	1.73	1.77	1.78	1.78 b
	12	1.85	1.78	1.75	1.76	1.79	1.78 b
	14	1.77	1.75	1.69	1.67	1.70	1.71 a
		Mean 1.82	1.77	1.72	1.73	1.75	

1 - Means followed by different small letters in the same row are statistically different by Tukey's test ($p<0.05$).

to those obtained by Lee (1989) and Carey *et al*. (1995), who also did not find any effect of density on egg weight, as opposed to Roush *et al*. (1984), who observed a trend of increasing egg weight as cage area per bird was reduced. Davami *et al*. (1987) verified that egg weight was reduced in the treatment with the highest cage density. Cunningham (1982), however, reported that densities of 483.87 and 387.09 cm^2/bird in deep cages and of 484.15 and 387.32 cm^2/bird, in shallow cages did not influence egg weight.

The results obtained from 65 to 84 weeks are presented in Table 3. There was no effect of cage density ($p>0.05$) on egg weight or feed conversion per kg eggs. However, a significant effects ($p<0.05$) were detected on egg production, FCR per dozen and feed intake. The highest bird density (14 birds/cage or 321cm^2/bird) negatively influenced egg production as compared to the densities of 10 or 12 birds per cage. This may be explained to the lower stress to which birds housed at the lowest density were submitted. Also, there was a linear effect ($p<0.05$) of age, with decreasing in egg production as birds aged.

In terms of egg weight and FCR per kg eggs, there was linear effect ($p<0.05$) of period of lay, with increase in egg weight and a stability after the second period. Also, FCR per dozen and per kilogram eggs linearly increased with bird age, which may explained by the fact that egg production is reduced and egg weight is stabilized as layers age .

Cage density significantly influenced FCR per dozen eggs, with the density of 10 birds per cage presenting the poorest FCR due to their highest feed intake, whereas the other densities (12 and 14 birds per cage) presented no differences for this parameter.

There was significant effect of the interaction ($p<0.05$) between period of lay and cage density on feed intake. During the first period, layers housed at the density of 10 birds per cage consumed more feed than those maintained at the other evaluated densities, which did not present different feed intake. As for the second period, feed intake was different only between the densities 10 and 14 birds per cage, with birds at the lowest density (10 birds/cage) presenting higher feed intake both during the fourth and the fifth periods (77 to 80 and 81 to 84 weeks of age) as compared to those housed at higher densities. This may be explained by higher feeder space per bird, allowing them easier access to the feeder during the day, thereby increasing their feeding frequency. There was a quadratic effect of period within each cage density on feed intake,

Table 3 - Egg production (%), feed intake (g/bird/day), egg weight (grams), feed conversion (g/g), and feed conversion per dozen (g/dz) of Lohmann-LSL layers between 65 to84 weeks of age as a function of period of lay and cage density (birds/cage).

Parameter	Density	Periods[1]					Mean[1]
		1	2	3	4	5	
Feed intake (g/bird/day)							
CV% = 3.04	10	112.96B	111.74 B	109.41A	109.88B	114.10 C	111.61
	12	107.13A	107.37AB	106.22A	107.86B	108.60B	107.43
	14	103.33A	104.95 A	107.72A	100.56A	101.48A	103.60
	Mean	107.86	108.02	107.76	106.10	108.06	
Egg production (%)							
CV% = 3.15	10	89.60	86.56	85.80	79.46	76.79	83.64 a
	12	88.84	86.90	84.15	82.14	78.79	84.16 a
	14	86.64	85.68	81.79	78.89	72.39	81.07 b
	Mean²	88.36	86.34	83.91	80.16	75.99	
Egg weight (grams)							
CV% = 1.78	10	67.97	68.34	68.34	68.34	68.34	66.26
	12	66.77	67.34	67.34	67.34	67.34	67.22
	14	67.68	68.87	68.87	68.87	68.87	66.63
	Mean	67.47	68.18	68.18	68.18	68.18	
Feed conversion,g/dz							
CV% = 4.61	10	1.51	1.55	1.53	1.66	1.79	1.60 b
	12	1.45	1.48	1.51	1.58	1.66	1.53 a
	14	1.44	1.47	1.58	1.53	1.68	1.54 a
	Mean	1.46	1.50	1.54	1.59	1.71	1.56
Feed conversion, g/g							
CV% = 5.20	10	1.86	1.89	1.87	2.03	2.18	1.96
	12	1.81	1.84	1.88	1.96	2.05	1.90
	14	1.77	1.78	1.92	1.86	2.04	1.87
	Mean ²	1.81	1.83	1.89	1.95	2.09	1.91

1 - Means followed by different small letters in the same column are statistically different by Tukey's test (p<0.01).

which was completely unexpected, as layers tend to increase their feed intake as they age.

Similar results were reported by Cunningham *et al*. (1988), who verified a 2.1% reduction in egg production/bird/day when increasing bird density from 406 to 316 cm²/ bird. Garcia *et al*. (1993), Adams & Craig (1985), Davami *et al*. (1987), and Okpokho *et al*. (1987) also found that increasing bird density and reducing feeder space /bird resulted in lower egg production.

Opposite egg weight results were reported by Roush *et al*. (1984), who observed an increase in egg weight as cage area per bird decreased. Cunningham (1982), however, reported that densities of 483.87 and 387.09 cm²/bird, in deep cages and of 484.15 and 387.32 cm²/bird in shallow cages did not affect egg weight.

Similar FCR results were reported by Hill (1977), who found an improvement of feed conversion per kilogram when increasing bird density from 464 to 310 cm²/bird. On the other hand, Adams & Craig (1985), Davami *et al*. (1987), Cunningham & Ostrander (1982), and Garcia *et al*. (1993) found better feed conversion per dozen and per kilogram eggs yielded with increasing available cage space per bird (lower density).

The results obtained in the present study show that the highest density increased bird mortality, which is an important factor when production cycles are analyzed. Therefore, as only feed intake and FCR per kg results of the intermediate density of 12 birds per cage (375cm²/bird) were significantly different from the other evaluated densities, this suggests that this bird density makes the best use of the facilities, and therefore it is the most adequate for egg production under the conditions in which the present study was carried out.

CONCLUSIONS

The results of the present study indicate that 375 cm²/bird up to 45 weeks of age and 450 cm²/bird after 45 weeks of age are the best suited densities to maintain layer production parameters and livability.

Although cage density influenced feed intake, egg production, and feed conversion ratio, egg weight was not affected by reducing cage space per bird.

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