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Effects of floor space area in battery cages on the bird weight and egg production of olympia black layers

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ABSTRACT

The impact of varying floor space area in battery cages have been evaluated on the weight and egg production of olympia black laying birds. The experiment was carried out using battery cages with varying floor spaces area of 300 mm by 300 mm, 380 mm by 380 mm and 460 mm by 460 mm also stocked with 2 and 3 birds per cage cell. The experimental birds used were 45 Olympia black layers, which are seventeen weeks old and the experiment lasted for twelve weeks. The birds' weights were measured while egg production was determined on weekly bases. Design expert software 6.0.8 version was used for experimental design and analysis of the experiment. The results obtained shows that Cage cells 380 mm × 380 mm with 2 birds gave the optimum weight of birds to be 1.46 kg and also gave the optimum egg production of 7 eggs per bird per week while cage cells (300 mm × 300 mm) with 3 birds gave the lowest productivity with egg production 4 eggs per bird per week. There was a significant effect of stocking density on the weight of bird and egg production at $P < 0.05$. The study was able to established a template for the development of battery cage, which caters for maximum productivity and welfare of laying birds

Keywords: Stocking density, battery cages and egg production.
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1. Introduction

Poultry production methods involving large number of birds living in a controlled environment under the supervision of a farmer; the houses are expected to provide everything the birds need to maintain their welfare and performance. Generally, environmental factors such as temperature and humidity have high effect on livestock production(Baxter, 1994). However, poultry production highly depends on the temperature and humidity of their immediate environment. The significance of stocking density in poultry performance was established at the beginning of the development of industrial poultry production (Škrbić *et at.,* 2009). In the design of livestock housing, an adequate floor space area is a good requirement for optimum production. This is to ensure good ventilation, high productivity and maximum profit accuracy of the business. Poultry welfare has been regarded as a controversial topic in modern animal agriculture because of the discrepancy of opinions regarding how animals should be treated and maintained (Iyalabani, 2015). There are numbers of minimum standard of stocking density employed in temperate regions (NAWAC, 2012), Duncan (2004) reported that commercial battery cages stocking densities decreases the welfare of the birds which has negative impact on the productivity of the birds, while too much floor space area is un-economical. In temperate countries an important effect of poultry welfare legislation was to reduce stocking density (Elson and Tauson, 2011). In the design of livestock housing, adequate floor space area is a good requirement for healthy and optimum production of poultry farms. This is to ensure good ventilation, high productivity and hence, maximum profit of the business. Traditional battery cage are not sufficiently high enough to provide allowance for the hen, which means that hens are crowded together. Zehra *et al.,* (2006) found out that cage height, width and feeder space affect productive performance of layers. Factors such as feeding rate, types of feed and so on, account for variation in the number of eggs produced per bird per day (Zehra *et al.,* 2006). Duncan (2004) also reported that commercial battery cage densities used in the North America (300-350 cm^2 per bird in the United States and 450 cm^2 in Canada) decreased the welfare of the birds. In developed countries an important effect of poultry welfare legislation was to reduce stocking density (Elson and Tauson, 2011). However many researches have been carried out on hen stocking density in temperate region but very few in South-South, Nigeria. Hence there are no enough data on stocking density of birds in Southwestern Nigeria. The stocking density employed by poultry farmers and indeed by the cage manufacturers are the standard from temperate countries. It is therefore necessary for researchers in the tropical region of the world (particularly Nigeria) to carry out experiments with a view to investigate the stocking density that will be relevant to determine and establish a minimum standard that can be adopted and serve as template for development of battery cages in our own environment. It is in this view, that this study focused on the effects of floor space area in battery cages on bird weight and egg production of olympia black layers

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2. Materials and Method

The study work evaluates the effects of floor space area in battery cages on bird weight and egg production of olympia black layers. The experiment lasted for twelve weeks between January and April, 2014, the climatic condition of the study site falls into the late dry season and early raining season, the experiment was carried out in Ogbomoso, Oyo State located in South-West geopolitical zone of Nigeria, with characteristic features of a savanna (longitude 8.9° N and latitude 4.15° E). The experiment was carried out using battery cages with varying floor spaces area and stocking density. The recommended floor dimensions adopted for the study were 300 mm × 300 mm, 380 mm × 380 mm and 460 mm × 460 mm respectively. The choice of these dimensions was based on the responses from a preliminary interview conducted to justify what is obtainable with the local farmers. A constant cage cell of 300 mm × 300 mm was divided into two rolls making a total of six cells; the first row was stocked with 2 birds per cage cell while the second row was stocked with 3 birds respectively. The reason for the stocking density was based on the local content adopted for rearing of birds in the study area. The same procedure was repeated for 380 mm × 380 mm and 460 mm × 460 mm respectively. The total sum of cages constructed for this research work was six, with each cage containing three cells. The cages were placed in an open space which is fenced against predator attack and sheltered with polyvinyl sack to protect the birds from direct sun radiation. The choice of housing is made to provide equal environmental condition to the birds. The experimental animals used were 45 Olympia black layer birds at their 17th week of age; they were introduced to the battery cage as recommended by Midwest Plan Service (1983). The feed given to the birds was purchased from Premier Feed Mills Co. LTD. RC 791117. The composition of feed and metabolized energy of the feed is given in Table1. The choice of feed was based on recommendation from local poultry farmers and Awoniyi (2003). Measurement of weight of birds and weight gained was done using a measuring scale with ranges between 0-20kg and sensitivity of (± 0.1). The initial weight of the birds was taking while subsequent weight was taking on weekly basis for the whole time of the research while the egg production were determined on weekly basis**.** The design layout for the study was two numerical factor which was Floor space (three levels) and Stoking density (two levels) which was replicated three times as shown in Table 2. Response Surface Methodology (RSM) was adopted for the study using historical data, the total runs of the experiments were 18 and its design model was linear Design expert software 6.0.8 version was used for analysis of the effects of floor space area in battery cages on bird weight and heat production of olympia black layers.

Table 1: Feed Composition

Ingredient	Mass constituent in (Kg)
Crude protein	16.50
Fats (oil)	5.00
Calcium	6.00
Available phosphorus	3.60
Lysine	0.45
Methionine	0.80
Kcal/Kg Metabolized Energy	2500

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Table 2: Design Layout

	2 Birds (L_1			3 Birds (L_2)		
300 ×300 mm (S_1)	S_1L_1	S_1L_1	S_1 L_1	S_1L_2	S_1L_2	S_1L_2
380 ×380 mm (S_2)	S_2L_1	S_2L_1	S_2L_1	S_2L_2	S_2L_2	S_2L_2
460 ×460 mm (S_3)	S_3L_1	S_3L_1	S_3L_1	S_3L_2	S_3L_2	S_3L_3

3. Results and discussion

3.1 Effect of floor space on weight of birds

Table 3 shows the weight of birds taken for twelve weeks from which the average weight of birds showed that the cage cell stocked with two birds gained more weight than others in the last weeks of the study which is between 8th and 12th weeks. The cage cell 460 mm × 460 mm with two stocking density gained an average weight of 1.48 kg and 1.46 kg at the end of 8th and 12th weeks respectively, which was the highest weight gained. At the end of 8th and 12th weeks, cage cell 380 mm × 380 mm stocked with two birds gained 1.46 kg and 1.42 kg weight respectively, which came close comparing it with highest weight gained. It showed that the weight gained by these birds over the weeks of the study is dependent on the floor space area of the cage cell. Taking a look at the cage cell 300 mm × 300 mm stocked with 3 birds, weight gained by birds at the 12th was 1.41 kg and this weight gained is higher compared to others of the same floor space area with 2 stocking density. The tabulated results indicated that the cage floor space area has effects on the weight of birds. Also there is fluctuation in the weight of the birds' week in, week out, when the birds start dropping eggs. Table 4 indicated that floor space area is significant. The Model F-value of 898.14 implies the model is significant, R^2 is given as 0.9948 while the "Pred R^2" of 0.9905 "Adj R^2" of 0.9937 shows the fitness of response surface model; floor space area has significant effect on the weight of the birds ($p < 0.0500$). Figure 1 is the shape of three dimensional surface response plot it shows the material balance between the response which is the weight of birds in kg and the two factors which are floor space area and stocking density. The maximum wieght of birds 15.56 kg were obtained at the highest floor space area of 460 mm × 460 mm and the lowest 14.21 kg also obtained at 300 mm × 300 mm which was the lowest floor space area, while cage cell stocked with three birds gained less weight of 14.21 kg.

Table: 3 Summary of average weight of birds on four weeks interval

Cage cell	From day one to 4th week (kg)	From 4th week to 8th week (kg)	From 8th week to 12th week (kg)
A1L1	0.96	1.25	1.29
A2L1	1.21	1.44	1.38
A3L1	1.14	1.37	1.30
B1L2	1.2	1.48	1.46
B2L2	1.09	1.3	1.21
B3L2	1.08	1.32	1.36
C1L1	1.02	1.28	1.34
C2L1	0.98	1.3	1.34
C3L1	1.11	1.45	1.35
D1L2	1.1	1.26	1.31
D2L2	1.16	1.46	1.42
D3L2	1.1	1.38	1.37
E1L1	0.94	1.21	1.16
E2L1	0.94	1.21	1.16
E3L1	1.08	1.36	1.41
F1L2	1.08	1.16	1.25
F2L2	1.14	1.34	1.3
F3L2	1.14	1.29	1.29

A = 460 mm by 460 mm
B= 460 mm by 460 mm
C = 380 mm by 380 m
D= 380 mm by 380 mm
E = 300 mm by 300 mm
F= 300 mm by 300 mm
L_1 = 3 birds
L_2 = 2 birds

Table 4: ANOVA Analysis of the effect of floor space area on bird weight

Source	Sum of Squares	DF	Mean Squares	F-Value	Prob > F
Model	3.39	3	1.13	898.14	< 0.0001 significant
A	2.62	1	2.62	2085.56	< 0.0001 significant
B	0.76	1	0.76	608.07	< 0.0001 significant
Residual	0.018	14	1.258E-003		
Lack of Fit	3.472E-003	2	1.736E-003	1.47	0.2677 not significant
Pure Error	0.014	12	1.178E-003		
Cor Total	3.41	17			

Significant at $p < 0.05$, Std. Dev. 0.035, R^2 0.9948, Mean 14.88, AdjR^2 0.9937, C.V. 0.24, Pred R^2 0.9905, PRESS 0.032 and Adeq Precision 80.591 A = Floor space area, B = Stocking Density,

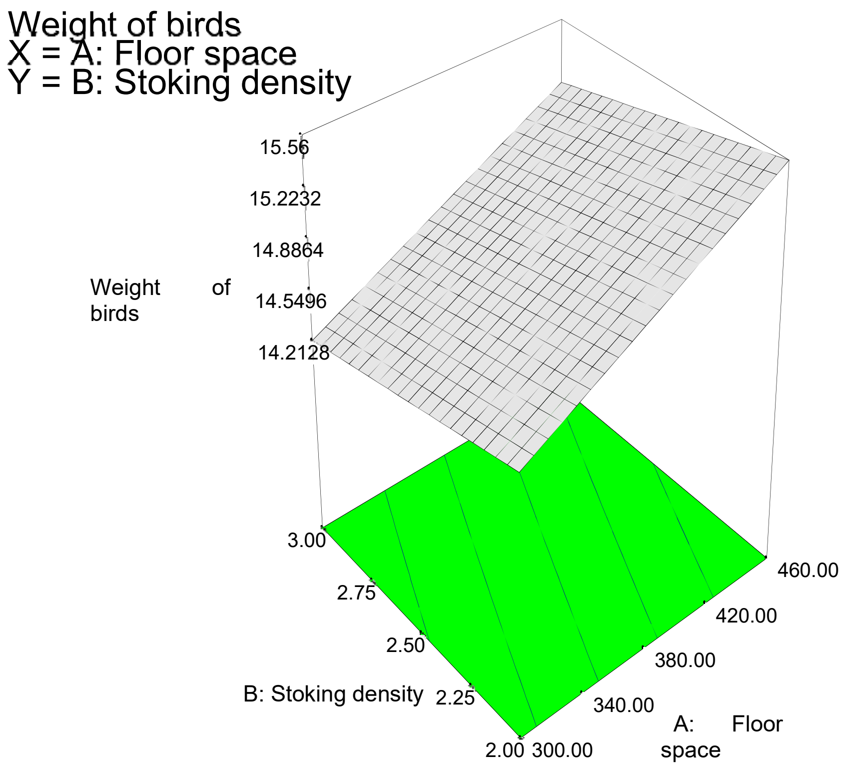

Figure 2: Response Surface Plot of Weight of Birds as Function of Stocking Density and Floor Space Area

The intercept between the two factors is 14.88 kg; this plot can be use to navigate the design of floor space area against the stocking density. This result is in line with the result obtained by Sarica *et al*. (2008) who observed that live weight of birds were moderately higher in hens allowed more space compared to those kept at lower space allowances; and also the high live weight of birds could be explained by higher feed comsumption and water intake during the experiment period. Onbasilar and Aksoy (2005) also found out that increased stocking density by increasing the number of hens per cage from 1 to 5, decreases the live weight of HY-Line Brown genotype. However Jalal *et al*. (2006) find significant effect of space allowance on the weight of hens in cages having 690 cm^2, 516 cm^2, 413 cm^2 and 372 cm^2 per hen.

3.2 Effect of floor space area on egg production

The effect of floor space area on egg production was illustrated in table 5. Table 5 is a Summary of average egg production per bird on Four weeks interval an average four weeks, egg layed by the birds in the cell cage at the first four weeks of introduction to the battery cage cell only birds with two stocking density starts production. This result clearly showed that stocking density is a key player in productivity of a laying hen. This result shows that irrespective of the cage floor space the birds that are stocked two are the once that begin to lay at the fourth week of introduction to cage. At the last four weeks making it twelveth week, the performance of the birds in the cage cell shows that the best performance was obtained from cage cells with two stocking density the best of all is cage cell 380×380 mm with an average number of 7 eggs per bird per week in the cage cell. The lowest record was 4 eggs per cage cell per week and it is common among cage cells with 3 stocking density. This implies that the egg production is affected by the increase in stocking density irrespective of the floor spaace area.

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Table 5: Summary of Average Hen-House Egg Production Per Bird Per Four weeks

Cell cage	From day one to 4th week	From 4th week to 8th week	From 8th week to 12th week
A1L1	0	12	16
A2L1	0	20	20
A3L1	0	12	16
B1L2	2	20	24
B2L2	1	12	20
B3L2	0	20	16
C1L1	0	8	12
C2L1	0	8	20
C3L1	0	8	24
D1L2	2	24	28
D2L2	1	16	24
D3L2	0	16	24
E1L1	0	12	16
E2L1	0	12	16
E3L1	0	4	24
F1L2	2	12	20
F2L2	0	12	16
F3L2	2	24	24

A = 460 mm by 460 mm E = 300 mm by 300 mm

B = 460 mm by 460 mm F = 300 mm by 300 mm

C = 380 mm by 380 mm L1 = 3 Birds

D = 380 mm by 380 mm L2 = 2 Birds

Table 6 showed that only stocking density is significant on the experiment, that is the hen day production is only affected significantly at $P \leq 0.05$. while the floor space area has no significant effect on the egg production at $P \geq 0.05$. Figure 1 is a 3D surface response graph showing that there was decrease in hen week production has the stocking density increases and on the other hand the egg production remain contant as the floor space increases. The best performance was obtained at stocking density of two. During the present study, hen house egg production increase with decrease in the cage stocking density for Olympia black layers. Cage stocked with two birds has higher egg production compared to cage stocked with three birds in the cage been experimented. This result is in line with the expectation that cage related stress and density related social stress would be more in densely populated cages and less in cages sparsely populated (Baxter, 1994). The reason for this is that immediately before laying is stimulated there is high flock uniformity within the birds in high density cages as they compete for both feed and water compared to sparsely populated cages (Zehra *et al.,* 2006). Decrease egg production was shown to be attributable to the reduced feeding area per bird, cannibalism (Nicol *et al.,* 2006; Adams and Craig, 1985). Anderson et al., (2004) found out that high cage stocking density from HY- line W36 and Dekalb XL commercial layer genotypes decreased hen egg production. They reported a decrease in egg production from 82.3% to 77.4% because of increase in the cage stocking density from 482 cm^2 to 361 cm^2 per hen. Onbasilar and Aksoy (2005) determined hen day egg production as 94.1%, 89.3% and 78.5% at the respective stocking density 1968, 656 and 393.8 cm^2 per hen with statistical significance ($p<0.050$).

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Table 6: Anova Analysis of the Effect of floor space area and Stocking Density on the Hen House Egg Production

Source	Sum of Squares	DF	Mean Square	F-Value	Prob > F
Model	720.97	2	360.49	6.16	0.0112significant
A	24.08	1	24.08	0.41	0.5309
B	696.89	1	696.89	11.90	0.0036
AB	14.08	1	14.08	0.23	0.6402
Residual	878.14	15	58.54		
Lack of Fit	126.14	3	42.05	0.67	0.5861notsignificant
Pure Error	752.00	12	62.67		
Cor Total	1599.11	17			

Significant at $p < 0.05$, Std. Dev. 7.65, R^2 0.4509, Mean 33.22, Adj R^2 0.3776, C.V 23.03, Pred R^2 0.2077, PRESS 1266.93 and Adeq Precision 4.891 A = Floor space area, B = Stocking Density,
A = Floor space area, B = Stocking Density,

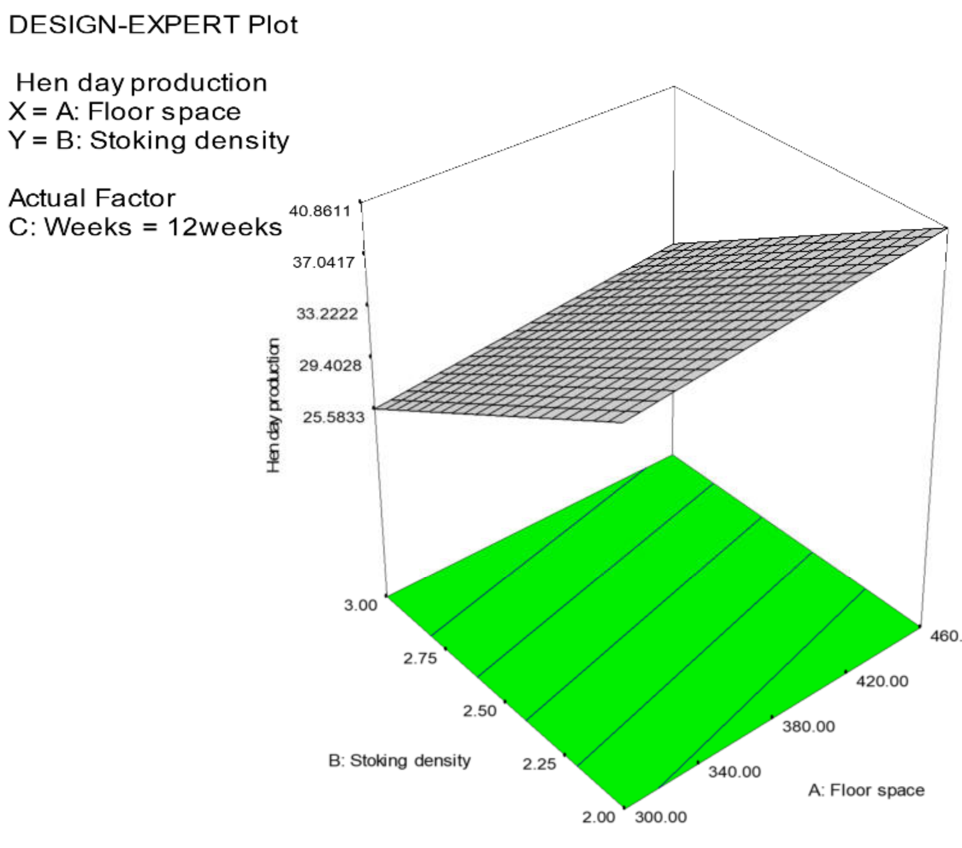

Figure 2: Response Surface Plot of Egg Production as Function of Stocking Density and Floor Space Area

4. Conclusions

The floor space area in battery cages has significant effect on the weight of the birds, and the cage cells with the best weight gain, is cage cell with two birds. The best performance on individual cage cell showed that cage cell 460 mm × 460 mm with 1.46 kg and 380 mm × 380 mm 1.42 kg gained the highest weight within the period of the experiment. Also floor space area in battery cages shows to have significant effect on the bird weight and egg production of the hen. The result obtained shows that only cage cells with two stocking density started egg production earlier and the cage cell with the optimum egg production as cage cell 380 mm × 380 mm with an average of 7 eggs per bird in the last four weeks, it birds shows consistency in hen day production during the last for weeks of the experiment than others.

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