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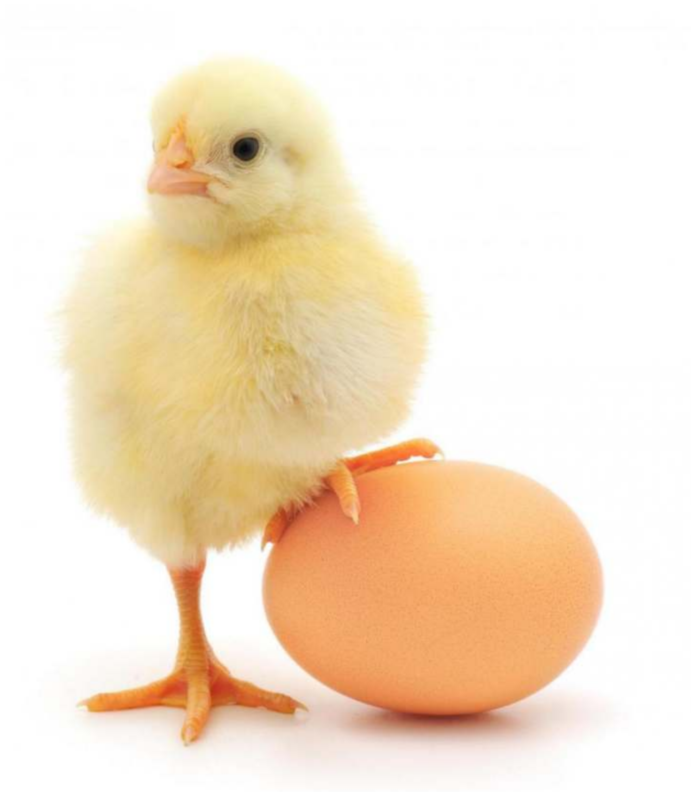

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Building Environment and Interaction of Population Density and Position and Their Relationship to Layer Performance

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Abstract: In this study it was aimed to determine the effects of hen age, cage position and cage density on egg production and quality characteristics in laying hens. One thousand and thirty six 25 wk old Isa Brown layers, at the beginning of laying period, were used in experiment. Two cage bateries which were parallel to the long axis were selected as the study material. Cage densities were four, and five birds per cage, respectively. Different egg production and egg quality parameters were measured for different hen age, cage position and densities for 11 weeks. Egg samples were collected from the cages to define the egg quality characteristics once a week. Indoor environmental conditions such as temperature and humidity were fairly affected by cage density ($P<0.01$). However, they did not differ among cage positions. Hen age had a significant effect on hen-day egg production (HDEP), feed consumption (FCS), feed conversion (FCV), and egg quality characteristics ($P<0.01$). The weekly observations showed that cage position and cage density did not have major influence on HDEP, FCS and FCV. On the other hand, HDEP and FCS were higher for four birds per cage on the window side. No egg quality characteristics were impacted by cage position and cage density. Differences between hen age for mortality were significant ($P<0.01$). Even though the cage position effect on mortality was not significant, the highest mortality was observed on corridor side. The mortalities were differed ($P<0.05$) among cage densities. Mortality in lower cage density was less than higher cage density. The study concluded that the interactions among hen age, cage position and cage density were significant for some variables.

Key words: Laying hens, cage position, cage density, egg production, egg quality

Introduction

Cage systems provide transition to the automation, and facilitate the management in the laying hens production. Furthermore, in this husbandry system cage density per unit floor area is higher and laid eggs can be easily controlled. However, investment cost for cage systems is higher than other systems, and high cage density adversely affects the hen behaviors. Additionally, animal lover associations contravene these systems. The performance of caged hens is influenced by many factors such as genotype, cage position, cage size, cage density, lighting regime (Grover *et al.*, 1972), and indoor temperature and humidity (Charles, 1994).

Many producers believe that the increasing cage density improves the profitibality. However, it has been reported that higher cage density decreases egg production, feed consumption, feed conversion (Adams and Craig, 1985, Lee and Moss, 1991) and increases mortality (Sandoval *et al.*, 1991, Anderson *et al.*, 1995, Carey *et al.*, 1995). Some early studies indicated that hen age has a known effect on egg production and quality characteristics. Pandey *et al.* (1990) reported that hen age increases the egg weight. Egg quality characteristics such as shape index, shell thickness, albumen index, yolk index and Haugh Units reduce with the hen age (Delgado *et al.,* 1990; Arafa *et al.*, 1982 and Rossi and Pompei, 1995). Thus, the objective of this article is to determine the effects of building environment (temperature and humidity), hen age, population density and position on layer performance (egg production and egg quality).

Materials and Methods

At the beginning of the trial period, when the birds were 25 weeks old, one thousand and thirty six Isa Brown birds were assigned to two treatments (windows and corridors). The trial was conducted between July 2003 and January 2004 in a mechanically ventilated layer house.

Throughout the 11-week experiment, the birds were housed in individual layer cages of three tiers wire blocks in a complete randomized design. Twelve rows of 222 wire cages, with 50x45x40cm dimensions were used. Six rows of the cages were located on the each window sides, and the others were on the corridor sides. Five and four birds were allocated to each cage randomly in each row on both sides.

A minimum of 16 hours of light per day was provided during the laying period by natural and artificial means. All of the birds received the same feed as starter, layer grower, pre layer and layer diet.

Cage temperature and humidity were recorded during the study. Temperature and humidity in the house, were recorded using digital thermohygrometer, thermohygrograph and electronic thermometer for 24 h period.

The daily performance of the birds were determined by measuring the feed intake, feed conversion ratio, egg production and mortality. Egg quality was estimated by measuring weight, shape index, shell thickness, albumen index, yolk index and Haugh Unit of each egg obtained on the seventh day of every week from each row on both sides of the cage in different bird densities. Data were analyzed using the general linear models procedure of Minitab (1998). Significant treatment effects were detected by Duncan's multiple range test. Results were expressed as means with their standard errors.

Results and Discussion

The average indoor temperatures and humidities and mortality for cage positions and densities were summarized in Table 1. The average temperature obtained for window side (WS) and corridor side (CS) were 22.41°C, 22.74°C, respectively. Also, for cage density (four and five hens per cage), the average temperature were 22.16°C, 22.98°C, respectively. The average indoor humidities for cage positions were 63.14% (WS) and 63.62% (CS) while average indoor humidities for four and five hens per cage were 64.5% and 62.18%, respectively. Cage position did not have a significant effect on indoor temperature and humidity (Table 1), while the cage density has a significant impact on these variables. Indoor temperature for five birds/cage density was significantly greater ($P<0.01$) than four birds/cage density while the indoor humidity was significantly higher ($P<0.01$) for four birds/cage. It assumed that ventilation played an important role in indoor temperature and humidity. Average indoor temperature for five birds/cage might be greater than that of experimental conditions if the ventilation was poorer. Webster (1994) stated that production temperature could be between 19°C and 24°C, with an optimum ambient temperature of 21°C for caged layers. Muiruri and Harrison (1991) found that high environmental temperatures had deleterious effect on productive performance of laying hens. Furthermore, heat stress depresses body weight (Scott and Balnave 1988), egg production (Whitehead *et al.*, 1998), egg weight (Balnave and Muheereza, 1997) and shell thickness (Mahmoud *et al.,* 1996) in layers.

Average mortalities observed in different cage positions and densities, and the effects of hen age, cage position and cage density on mortality were represented in Table 1. It was determined that mortality was not significantly changed due to weeks. The highest mortality was observed in 29 wk of age due to the heat stress with the higher indoor temperature (30.47°C). Since the environmental conditions was relatively close to the thermoneutral zone for laying hens less mortality observed between 46 and 48 wk of age. Cage position significantly affected ($P<0.05$) mortality. Mortality was greater for hens located corridor side than the window side. Uncomfortable indoor temperature and inadequate ventilation in corridor side might be the reason for higher mortality. This is conflict with the findings of Ipek *et al.* (2002), who reported that cage position had not a significant effect on mortality in spite of large differences among window and corridor side.

Table 1: Means of average temperature and humidity and mortality for week of study different cage position and cage density (Mean±SE)

Parameters	Temperature (°C) Average	Humidity (%) Average	Mortality (%) Average
Week	**	**	N.S.
25	29.19 ± 0.828^{b}	48.55 ± 1.292^{c}	0.85 ± 0.177
26	29.43 ± 0.851^{b}	48.79 ± 1.281^{c}	0.58 ± 0.466
27	28.43 ± 0.828^{c}	42.27 ± 1.135^{f}	1.22 ± 0.546
28	29.73 ± 0.862^{b}	44.89 ± 1.206^{e}	1.05 ± 0.763
29	30.47 ± 0.883^{a}	46.80 ± 1.267^{d}	1.75 ± 0.775
38	20.53 ± 0.100^{d}	64.23 ± 0.141^{a}	0.46 ± 0.112
39	18.24 ± 0.168^{e}	57.55 ± 0.204^{b}	0.85 ± 0.177
46	18.27 ± 0.344^{e}	87.03 ± 0.595^{d}	0.08 ± 0.002
47	12.12 ± 0.540^{g}	88.16 ± 0.478^{c}	0.46 ± 0.009
48	16.22 ± 0.341^{f}	84.99 ± 0.393^{e}	0.14 ± 0.004
49	15.67 ± 0.334^{f}	84.44 ± 0.365^{e}	0.71 ± 0.131
Cage Position	N.S.	N.S.	*
Window	22.41 ± 1.463	63.14 ± 3.969	0.44 ± 0.008^{b}
Corridor	22.74 ± 1.449	63.62 ± 3.968	0.99 ± 0.235^{a}
Cage Density	**	**	*
4	22.16 ± 1.228^{b}	64.58 ± 3.828^{a}	0.39 ± 0.006^{b}
5	22.98 ± 1.645^{a}	62.18 ± 4.089^{b}	1.03 ± 0.238^{a}
CP x CD	N.S.	N.S.	N.S.

a, b, c; Means in a column with different superscripts significantly differ. N.S.: Non Significant $^{*}p<0.05$, $^{**}p<0.01$.

More mortality was observed in five bird per cage because of the higher density. Extra one hen may cause deterioration in the cage environmental conditions and increase cannibalism risk. This observation could be confirmed with the findings of Testik (1984) and Guesdon and Faure (2003).

The effects of hen age, cage position and cage density on hen-day egg production, feed consumption and feed conversion were shown in Table 2. Hen age had a significant effect on hen-day egg production, feed consumption and feed conversion ($P<0.01$). It was observed that increasing hen age raised hen-day egg production and feed consumption. Hen-day egg production was significantly ($P<0.01$) higher in the window side than the corridor side. Feed consumption and feed conversion were not differed by cage positions. Cage density did not significantly influence the hen-day egg production, feed consumption and feed conversion. However, the feed consumption and hen-day egg production on the corridor side were less than on the window side, and feed consumption for five birds/cage was poorer than for four birds/cage. These results are well agree with the observations of Carey (1990), Nazligul *et al.* (1995), Bishop (1995) and Ipek *et al.* (2002). Nazligul *et al.* (1995) reported that cage side effects on hen-day egg production were not significant, but birds allocated on the window side generally produced more egg than the birds in the corridor side.

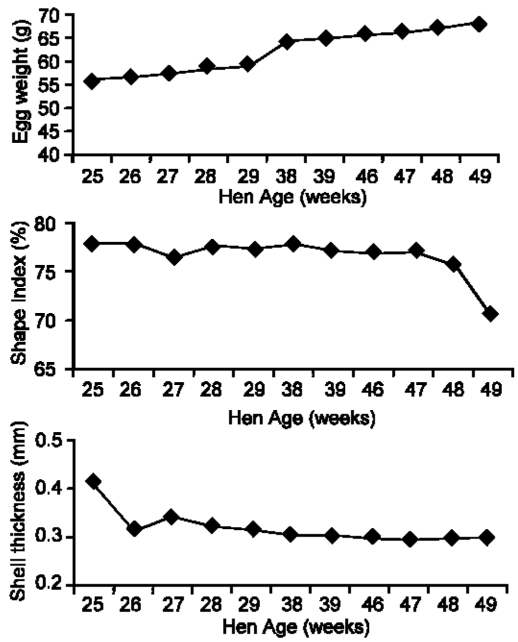

Fig. 1: Exterior egg quality characteristics in relation to hen age

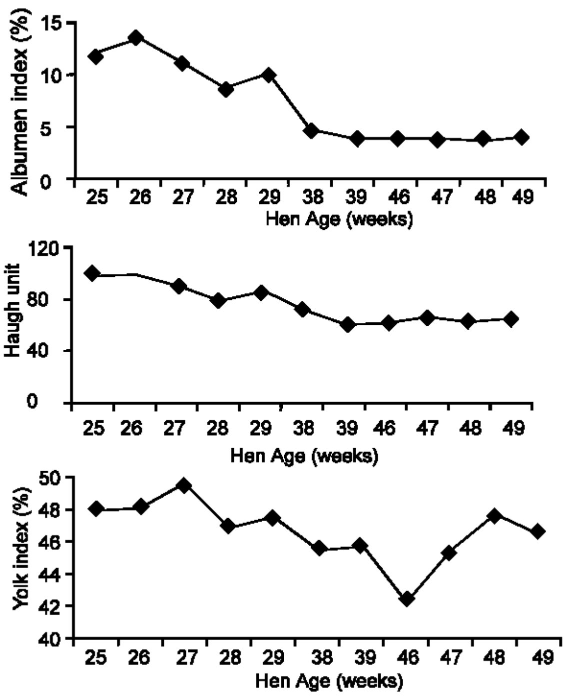

Fig. 2: Interior egg quality characteristics in relation to hen age

Ipek *et al.* (2002) stated that cage position did not have significant effect on feed consumption and feed conversion. Carey (1990) indicated that feed consumption of layers was not affected by cage population. Bishop (1995) observed that for hen-day egg production there was no significant effect of cage density in first and second laying years. It was determined that the hen age - cage position interaction for hen-day egg production was significant ($P<0.05$), whereas cage position did not have a significant effect on hen-day egg production. Despite the fact that there were no differences in feed consumption and feed conversion between the cage densities, the interactions among hen age and cage density were significant for the feed consumption and conversion.

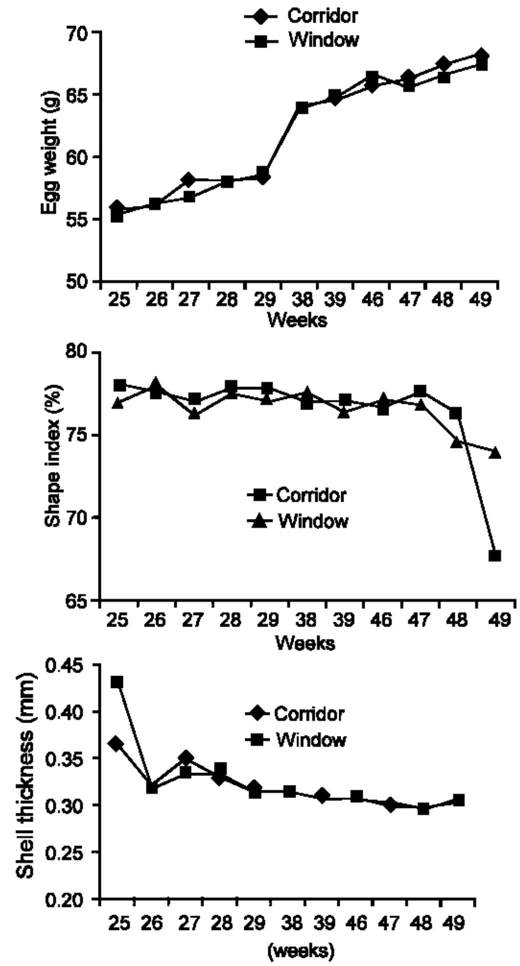

Fig. 3: Exterior egg quality characteristics in relation to cage position and hen age

This study showed that the characteristics of egg quality were significantly different hen ages ($P<0.01$). Exterior and interior egg quality characteristics were present Fig. 1 and Fig. 2, respectively. The characteristics of egg quality such as shape index, shell thickness, albumen index, yolk index and Haugh Unit deteriorated by the hen age . On the other hand, hen age improved the egg weight. The heaviest eggs in this experiment were collected in 49 wk of age whereas the lightest eggs were obtained in 25 wk of age. Monira *et al.* (2003) reported that one week caused 1.4 g difference in egg weight.

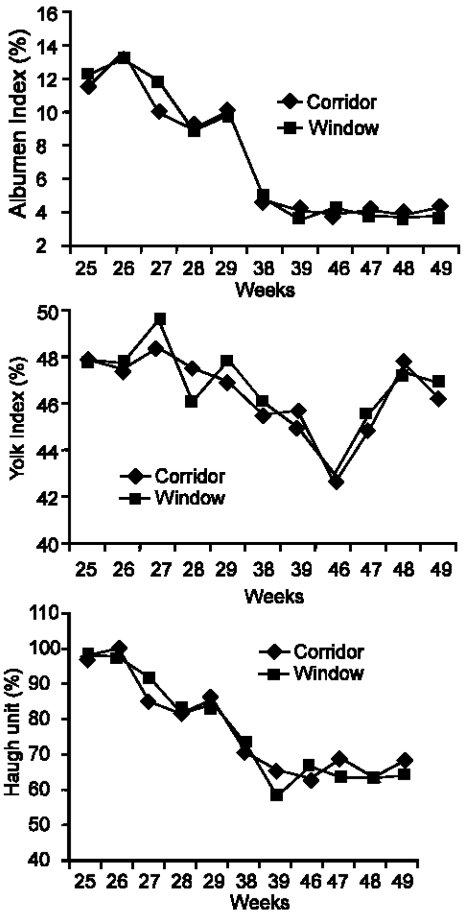

Fig. 4: Interior egg quality characteristics in relation to cage position and hen age

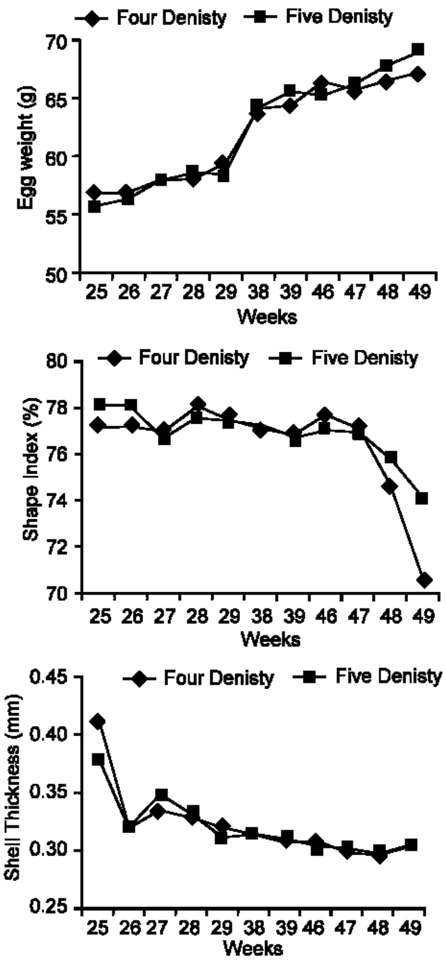

Fig. 5: Exterior egg quality characteristics in relation to cage density and hen age

The characteristics of egg quality, except the egg weight, were better in the first week than the last week of the study. These results were similar to the findings of Curtis *et al.* (1985), Saylam *et al.* (1992), Silversides *et al.* (1993), Akbas *et al.* (1996), and Uyanik *et al.* (2001). Most of the interior and exterior egg quality characteristics for window side were greater than that of corridor side (Fig. 3, 4). For example birds on window side laid heavier eggs comparing to the corridor side. Nazligul *et al.* (1995) reported that the genotype has a significant effect on egg weight and quality not the cage location. Ipek *et al.* (2002) reported that egg quality parameters decreased from window side to corridor side but this reduction was not significant.

The results obtained for characteristics of interior and exterior egg quality were similar for different cage densities (Fig. 5, 6). Egg samples were collected from the hens in the lower cage density had higher shell thickness, albumen index, yolk index and Haugh Unit than other cage density. Egg weight and shape index, however, was greater for the higher cage density. These findings are well agree with the literature. Bhat and Aggarwall (1989) reported that cage density did not influence the yolk index, Haugh Unit and shell thickness. The effects of cage density were not significant for yolk index, shape index and Haugh Unit although there were differences between egg quality parameters which was reported by Okan *et al.* (1989). Uluocak *et al.* (1990), indicated that the responses found for shape index, shell thickness, albumen index and Haugh Unit were not different among cage densities. However, yolk index was significantly affected by the cage density. Saylam *et al.* (1992) found that albumen index and Haugh Unit fairly decreased by increased cage density, whereas the shape index and yolk index remained relatively constant with the increasing cage density. Süto *et al.* (1997) stated that the cage density did not have a significant effect on egg quality characteristics although large differences between Haugh Unit and shell thickness for three and four birds per cage occurred. Lee and Moss (1995) who compared different cage densities in various treatments, determined that Haugh Unit was affected by

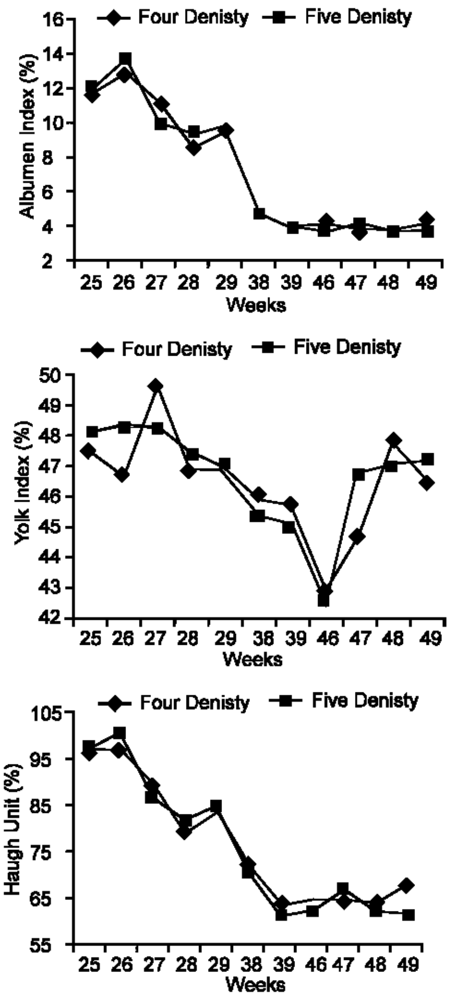

Fig. 6: Interior egg quality characteristics in relation to cage density and hen age

cage density in only one treatment in their experiment. Altan *et al.* (2002) reported that Haugh Units for white layers were significantly impacted by cage density, while Haugh Units for brown layers were unchanged. The results found for egg quality characteristics such as shape index, shell thickness, albumen index and yolk index were similar between cage densities which was reported by Ipek *et al.* (2002).

The influence of the interaction among hen age and cage density on albumen index was clearly expressed in this study. The interaction between hen age and cage density for albumen index was significantly influenced ($P<0.05$) while the interaction between hen age and cage density for egg quality characteristics were not significant. Cage position - density interaction had a significant effect on only shape index ($P<0.05$).

In conclusion, the results obtained from present experiment showed that the increasing hen age had measurable effects on production parameters (PP) and egg quality characteristics (EQC). Even though there was not any observed differences in cage positions for PP and EQC, the findings of PP and EQC obtained for window side were better than corridor side. It is because, indoor temperature and humidities, light intensity and air flow were more appropriate in window side. Laying hens, having optimum indoor temperature and humidity, adequate light intensity, and better ventilation managed effective egg production with higher quality. This study demonstrated that increasing cage density by four to five hens per cage or reducing unit cage floor area per hens did not significantly affect egg production and egg quality. However, the results attained for cage density pointed out that performance of hens housed in four hens per cage were more satisfactory than the other one. There was no interaction among hen age, cage position and cage density for other variables, while hen age - cage position interaction for hen-day egg production, hen age x cage density interaction for feed consumption, feed conversion and albumen index and cage position x cage density interaction for shape index were significant.

Table 2: Effects of hen age, cage position and cage density on percentage hen-day egg production, feed consumption, feed conversion (Mean±SE)

Parameters	Hen-day egg production (%)	Feed consu-mption (g)	Feed conve-rsion (Kg/Kg)
Hen Age (wk)	**	**	**
25	84.11 ± 0.552^{bc}	$105,97\pm0.992^{f}$	$1,90\pm0.059^{a}$
26	$85,33\pm0.552^{ab}$	$105,69\pm1.021^{f}$	$1,88\pm0.022^{b}$
27	$86,07\pm0.552^{a}$	$106,88\pm0.992^{e}$	$1,87\pm0.019^{b}$
28	$83,49\pm0.552^{cd}$	$105,33\pm1.035^{f}$	$1,81\pm0.019^{cde}$
29	$84,97\pm0.552^{ab}$	$104,44\pm1.058^{g}$	$1,79\pm0.022^{e}$
38	$86,35\pm0.552^{a}$	$116,36\pm0.121^{d}$	$1,83\pm0.064^{cd}$
39	$85,30\pm0.552^{ab}$	$119,12\pm0.203^{c}$	$1,84\pm0.017^{bc}$
46	$82,46\pm0.552^{d}$	$119,07\pm0.412^{c}$	$1,83\pm0.028^{cd}$
47	$82,61\pm0.552^{d}$	$126,45\pm0.651^{a}$	$1,93\pm0.017^{a}$
48	$82,12\pm0.552^{de}$	$121,53\pm0.409^{b}$	$1,81\pm0.086^{cde}$
49	$80,79\pm0.552^{e}$	$122,19\pm0.401^{b}$	$1,81\pm0.012^{de}$
Cage Position	**	N.S.	N.S.
Window	$84,76\pm0.393^{a}$	114,11±1.756	1,84±0.015
Corridor	$83,17\pm0.393^{b}$	113,71±1.739	1,84±0.010
Cage Density	N.S.	N.S.	N.S.
4	84,08±0.429	114,40±1.473	1,85±0.014
5	83,85±0.429	113,42±1.979	1,83±0.012
HA x CP	*	N.S.	N.S.
HA x CD	N.S.	**	**
CP x CD	N.S.	N.S.	N.S.

a, b, c; Means in a column with different superscripts significantly differ. N.S.: Non Significant $^{*}p<0.05$, $^{**}p<0.01$.

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