The effects of 2 genetic lines on spatial distribution and use and preference of perch and nest area in an aviary system

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ABSTRACT The objective of this trial was to evaluate spatial distribution, nest and perch usage, and preference of Lohmann Brown (**BH**) and Bovan White (**WH**) Leghorn hens raised in an aviary system. At 5 wk, 400 floor raised pullets, BH and WH strains, in equal numbers, were placed into 8 modified Big Dutchman Natura aviary units. Each aviary unit had 3 tiers with perches and an indoor litter area. At 25 wk, the number of birds was recorded by scan sampling every 4 h. The number of birds perching in each aviary unit was recorded every 4 h at 15, 25, and 35 wk. The number of eggs laid was recorded daily from 22 to 53 wk. A split-plot factorial design with Poisson distribution was used for analysis of spatial distribution and perch preference. Nest and perch usage was analyzed using a split-plot factorial design with binomial distribution. There was an interaction ($P < 0.0001$) indicating that during late afternoon and night, a higher number of WH were observed in the middle and top tier while a higher number of BH were observed in the litter area and bottom tier at 25 wk. The odds of observing WH perching were higher than the odds of observing BH perching during late morning, late afternoon, and night at 15 wk, from early afternoon to night at 25 wk, and during all afternoon at 35 wk. WH had higher nest usage than BH expressed by the higher odds of observing eggs from the nest area ($P = 0.071$). There was a strain and egg location interaction ($P < 0.0001$) for number of eggs laid indicating that WH were laying more eggs in the nest area and litter floor area compared to BH, whereas BH were laying more eggs in the metal aviary wire tiers in comparison with WH. In conclusion, WH showed greater degree of adaptation to aviary systems than BH expressed by greater usage of perches and nest areas and elevated tiers.

Key words: laying hens, aviary systems, perch use

INTRODUCTION

Genetic selection for hen adaptation to alternative housing systems is important to choose the most appropriate strain for specific environmental conditions in alternative housing systems. Adaptation to nests, nipple drinkers, and perches among others are important for the hen's welfare, production, and health. Hen adaptation to alternative housing systems has been evaluated by studying the use of vertical levels (Channing, 2001; Odén et al., 2002), egg laying location, egg production, and mortality (Van Horne, 1996; Colson et al., 2008).

Hens are highly motivated to use perches and will use them to reach resources, to roost at night, and to escape unwanted attention from other birds (Sandilands et al., 2009). Several studies have reported that perches may improve welfare by reducing incidence of feather pecking, cannibalism, and even aggression (Sandilands et al., 2009). Nests are multifunctional structures that have important purposes for the hens that can be non-mutually exclusive (Mainwairing et al., 2014). Furthermore, high use of nest boxes indicates that laying hens place considerable value on laying eggs in a secluded area (Cooper and Albentosa, 2003; Blokhuis et al., 2007).

Some experiments in floor pens or colony cages have showed that Brown and White Leghorn hens have different behavior and use of resources (Wall (2011), Faure and Jones, 1982; Silversides et al., 2012; Abrahamsson and Tausson, 1995). Sandilands et al. (2009) suggested that the ability of Brown hens to perch might be compromised by their higher body weight to wing area ratio compared to White Leghorn hens.

The acceptance of multilevel aviary systems is increasing as it diversifies the hen's behavior repertory
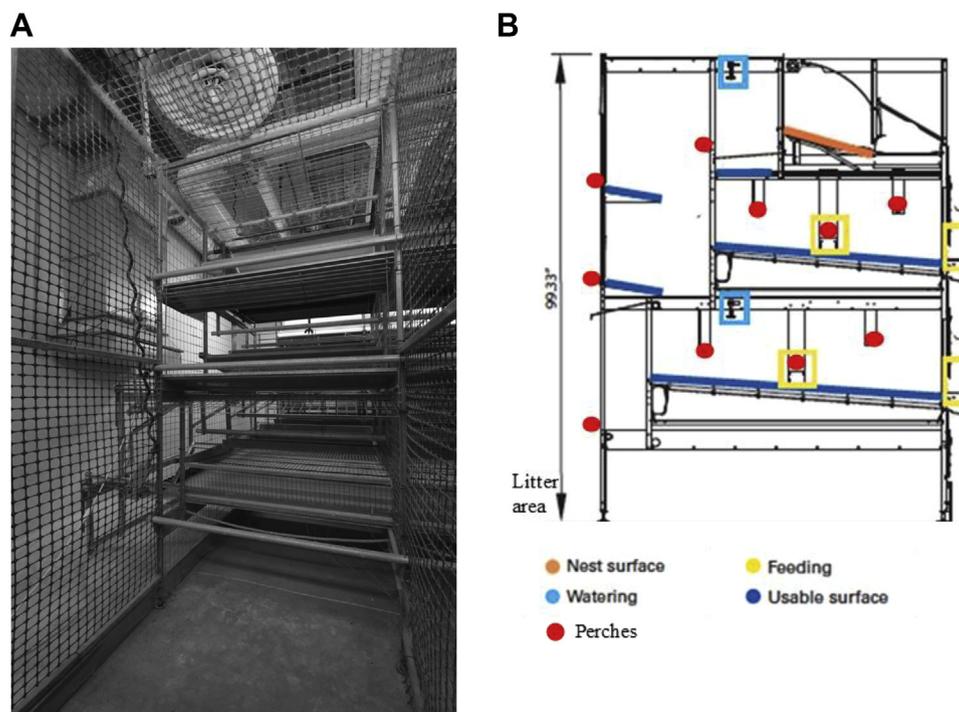
A

B

Figure 1. (A) Photo of unit. (B) Design of aviary system.

and allows producers to accommodate a larger number of hens. However, there is no study of strain effect on the hen adaption to the aviary system as indicated by the ability to utilize resources. Therefore, the objective of this trial was to evaluate spatial distribution, nest and perch usage, and preference during the layer phase of Brown and White Leghorn hens housed in a commercial aviary unit (Natura-60, Big Dutchman, 2020).

MATERIAL AND METHODS

At 5 wk of age, 400 floor raised pullets, Lohmann Brown and Bovan White Leghorn strains, in equal numbers, were placed into 8 aviary units (25 Brown and 25 White hens/aviary unit). Pullets were reared from 1 D of age at the University of Nebraska facilities and were purchased as day-old chicks from Hy-line International hatchery in Spencer (Iowa, USA). Pullets had not been beak trimmed. Design of aviary system (Natura 60, Big Dutchman Inc.) is shown in Figure 1. Each aviary unit had 3 metal sloped tiers and an indoor litter area (677 cm^2/bird) underneath and beyond the aviaries.

A manure belt system under the bottom tier was used for manure removal every 3 D.

Floor litter was changed or supplemented as required to maintain it in a dry condition.

Sloped stairways allowed birds to move freely among the different levels in the aviary. Hens had access to the litter area throughout the day. A sloped nest area (120 cm/bird) lined with brown artificial turf was located at the top tier in which eggs rolled out to an egg collection area in the inspection aisle. External feeder troughs (4.8 cm/bird) were provided in the middle

and lower tier. Internal feeder troughs were not used in this trial. Six and 2 nipple drinkers were provided in the top and bottom tier, respectively. Hens were provided with 2 perches in the top tier, 4 perches in the middle tier, and 4 perches in the bottom tier (22 cm/bird). This is the standard configuration of the Natura 60 commercial aviary marketed worldwide. Feed and water were provided ad libitum. Feeding and egg collection was done manually once daily at 9:00 am. Lights went on at 7:00 am and off at 10:00 pm to provide 15 h of light.

At 25 wk of age, the number of birds on bottom, middle, top tier and litter area and perches from each aviary unit was recorded by scan sampling every 4 h starting at 8:00 am, then noon, 4:00 pm, 8:00 am, and midnight to evaluate spatial distribution and perch preference. The total number of birds perching in each aviary unit was recorded every 4 h from 8:00 am to 12:00 pm at 15, 25, and 35 wk of age to evaluate perch

Table 1. Effects of source of variation, spatial distribution, and perch preference in aviary systems (P values).

Source of variation	Spatial distribution	Perch preference
Strain	0.052	0.007
Location[1]	<0.0001	0.213
Time of day	0.007	<0.0001
Strain × location	<0.0001	<0.0001
Time of day × location	<0.0001	0.677
Strain × time of day	0.133	0.018
Strain × time of day × location	<0.0001	0.036

[1]For spatial distribution, number of hens in each of the 3 tiers and litter area were taken into account for analysis. For perch preference, hens roosting in perches located in each of the 3 tier tiers were taken into account for analysis.
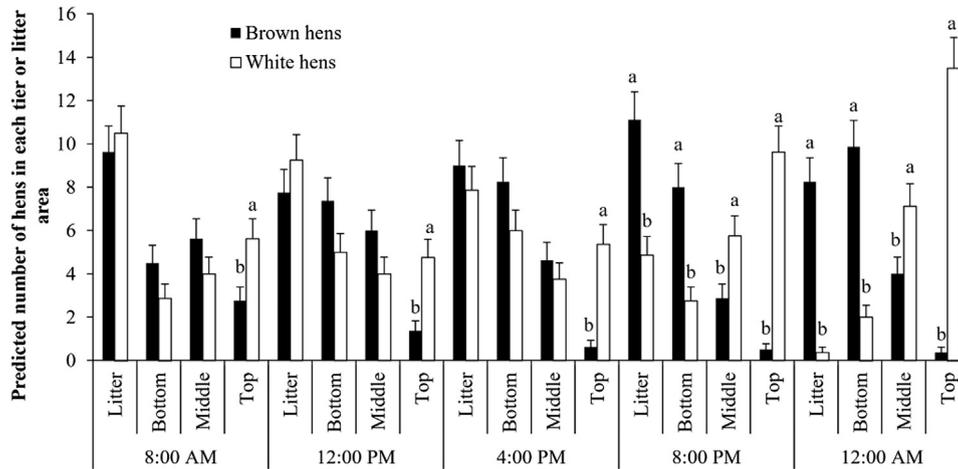
Figure 2. Effect of strain on spatial distribution in three-tier aviary system with access to indoor litter area at 25 wk of age. [a,b]Means within a time of day and a location lacking a common superscript differ ($P \leq 0.05$). Average number of hens from each strain in each aviary unit was 23. Bars represent SEM.

usage. Aviary units were scanned in a random order. The number of eggs laid in the nest area, metal tiers, and litter floor eggs from each aviary unit was also recorded daily from 22 to 53 wk of age to evaluate nest usage and egg location in the aviary system. All procedures were approved by the University of Nebraska–Lincoln Institute of Animal Care and Use Committee.

A split-plot factorial design with Poisson distribution was used for analysis of spatial distribution and perch preference. Strains were considered as subplots and location as main factor, and time of day as repeated measures. Poisson distribution was implemented to evaluate the rate of occurrence of an event estimated by relating the logarithmic transformation of predicted value to a linear function (Petrie and Watson, 2013). Thus, rate of an event is the exponential of a predicted value. The relative rate is the exponential of an estimated coefficient in the Poisson model and represents the ratio of 2 rates

(Petrie and Watson, 2013). Nest and perch usage was analyzed using a split-plot factorial design with binomial distribution resulting in the generation of odds ratio (Szumilas, 2010). Strain was considered subplot, and time of day and age were considered repeated measures. There were a total of 8 replicates for each treatment combination. Means were separated with a P-value 0.10.

RESULTS AND DISCUSSION

There was an interaction effect of genetic strain, time of day, and location ($P < 0.0001$) (Table 1) on spatial distribution in aviary systems at 25 wk of age. During the morning (8:00 am) and early afternoon (noon), a higher number of White hens compared to Brown hens were observed at the top tier ($P < 0.05$) and hens from both strain seemed evenly spread out for the rest of areas ($P > 0.10$) (Figure 2). During late afternoon (4:00 pm) and night (8:00 pm), a higher number of White hens were observed in the middle and top tier while a higher number of Brown hens were observed in the litter area

Table 2. Effect of strain and age on perch usage in aviary systems.

Age (wk)	Strain	Mean	CI
		Odds[1]	
	Brown	0.41[b]	0.33–0.50
	White	0.74[a]	0.61–0.89
15		0.82[a]	0.70–0.96
25		0.41[b]	0.34–0.50
35		0.50[b]	0.41–0.59
Treatment comparisons		Odds ratio[2]	
	Brown vs. White	0.56	0.43–0.74
15 vs. 25		1.99	1.64–2.42
15 vs. 35		1.65	1.36–2.01
25 vs. 35		0.83	0.67–1.02
Source of variation		P-values	
Strain		0.0004	
Age		0.0001	
Age×strain		0.590	

[a-b]Means within a column lacking a common superscript differ ($P \leq 0.05$).
[1]Odds of observing hens using perches over not observing them for each treatment group.
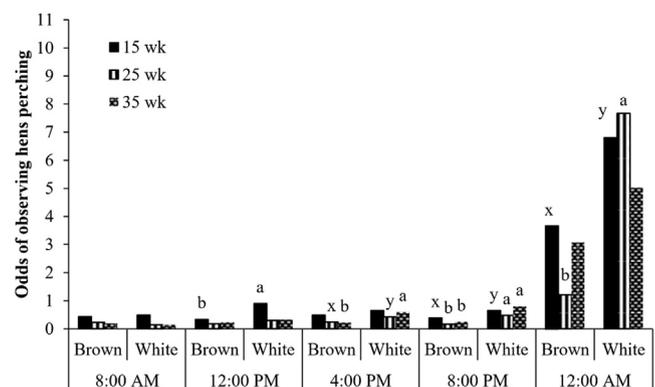[2]Ratio of the odds of observing hens using perches for 2 treatment groups.

Figure 3. Interaction effect of strain, age, and time of day on odds of observing hens perching ($P < 0.013$). [a,b]Means within an age and time of day lacking a common superscript differ (P 0.05). [x,y]Means within an age and time of day lacking a common superscript differ (P 0.10). Bars represent SEM.
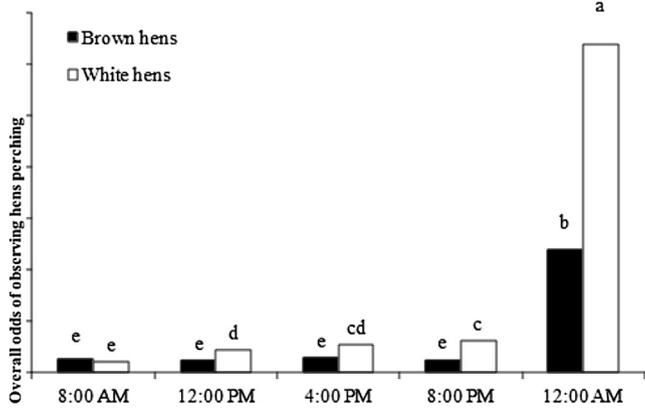
Figure 4. Effect of strain and time of day on overall odds of observing hens perching. [a-e]Means lacking a common superscript differ ($P \leq 0.05$). Bars represent SEM.

and bottom tier. At 8:00 am, hens from both strains were observed with the highest number in the litter area compared to any other aviary area; this continued to be true only for White hens until 12:00 pm.

Similar to our results, Abrahamsson and Tausson, 1995 reported a higher number of Brown hens in the litter area than White hens in a three-tier aviary system. A possible contributory factor of the strain differences could be the different profile BW of these 2 genetic lines. White hens (with lower BW than Brown hens) will have lower wing loading facilitating movement vertically throughout the aviary system. Furthermore, because bottom tier and the litter area provided almost all resources such as feed, water, perch, and scratching area, the expected necessity of Brown hens to move to upper tiers for nesting might have not been high enough.

There was an interaction ($P = 0.013$) among strain, age, and time of day on perch usage (Table 2, Figure 3). The odds of observing White hens perching were higher than the odds of observing Brown hens perching at noon, 4:00 pm, 8:00 pm and midnight at

15 wk of age, from 4:00 pm to midnight at 25 wk of age, and at the 4:00 pm, 8:00 pm, and midnight periods at 35 wk of age (Figure 3). Also, there was an interaction ($P = 0.0002$, Table 2) between strain and time of day indicating similar strain effects on overall perch usage regardless of age (Figures 3 and 4) indicating that the odds of observing White hens perching was higher than the odds of observing Brown hens perching during the entire day with the exception of 8:00 am.

There was an interaction ($P = 0.036$) effect among strain, time of day, and perch location on predicted number of hens perching (Table 1, Figure 5). At 8:00 am, a higher number of Brown hens were perching in the bottom and middle tier compared to White hens. At 12:00 pm and 8:00 pm, a higher number of Brown hens were perching in the lower tier than White hens, whereas a higher number of White hens were perching in the top tier than Brown hens. At 4:00 pm, a higher number of White hens were perching in the top tier than Brown hens. At 12:00 am, a higher number of Brown hens were perching in the lower tier while a higher number of White hens were perching in the middle and top tier.

In agreement with our results, Silversides et al. (2012) found more White hens (76.3%) used perches than Brown hens (6.8%) in floor pens right before the lights went off. Faure and Jones (1982) also reported that Brown Leghorn hens almost completely failed to use high perches and had lower perch usage than White Leghorn in litter floor pens. In the present study, the preference of perches in lower tiers of Brown hens could be a result of less capacity to move vertically throughout the aviary system. On the other hand, White hens seemed to prefer perches in higher tiers especially during the night after lights were off. In a study comparing various perch heights, during the daytime, lower perches were used more for standing and walking, while higher perches were used more for sitting and sleeping (Struelens et al., 2008).
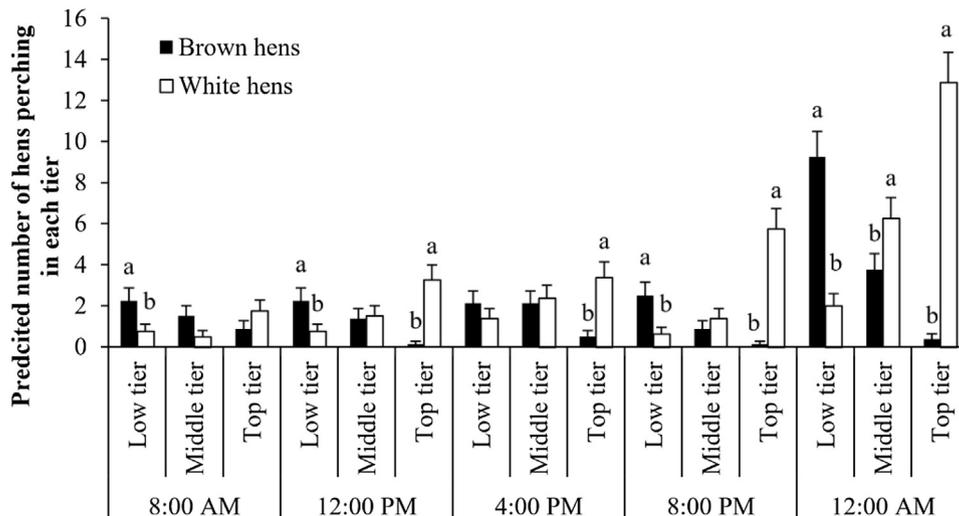

Figure 5. Effect of strain, and time of date on perch preference in three-tier aviary system at 25 wk of age. [a,b]Means within a time of day and a tier lacking a common superscript differ ($P \leq 0.05$). Bars represent SEM. Predicted number is the exponential of rates of hens perching in each location.

Table 3. Effect of strain on nest usage in three-tier aviary system.

Strain	Mean	CI
	Odds[1]	
Brown	2.13	1.79–2.54
White	2.65	2.24–3.15
Treatment comparison	Odds ration[2]	
Brown vs. White	0.80	0.63–1.03
Source of variation	P-values	
Strain	0.071	
Age	0.982	
Strain × age	0.999	

[1]Odds of observing eggs in nest area over not observing them for each treatment group.
[2]Ratio of the odds of observing eggs in nest area for 2 treatment groups.

White hens tended to have a higher nest usage than Brown hens expressed by the higher odds of observing eggs from the nest area ($P = 0.071$) (Table 3). Both strains laid the greatest proportion of eggs on the nest tier compared to the wire open tier areas and litter areas. There was no interaction effect of age and strain (P 0.999) indicating that strain effect on nest usage was fairly consistent during different time periods of the trial. There was a strain and egg location interaction ($P < 0.0001$) for number of eggs laid indicating that White hens were laying more eggs in the nest area and litter floor area compared to Brown hens, whereas White hens were laying fewer eggs in the metal aviary tiers in

comparison with Brown hens (Table 4). This is very similar to the findings of Wall (2011) who reported more dirty eggs laid by Hyline White hens compared to Hyline Browns in colony style cages. Singh et al., (2009) and Abrahamsson and Tausson, 1995 reported observing higher numbers of White hens in the nest area than Brown hens in a three-tier aviary system. In the present study, greater preference of nest area of White hens than Brown hens might be a result of a greater ability to reach the top tier and greater motivation to lay at the higher levels. The fact that most mislaid eggs were laid on metal tiers for Brown hens but on litter floor for White hens suggested that these strains have different broody behaviors. In either area, mislaid eggs are more likely to be dirty and cracked resulting in economic losses.

In summary, white hens showed greater degree of adaptation to aviary systems than Brown hens expressed by greater usage of perches and nest areas and elevated tiers. White hens seemed to be more suitable for aviary systems than Brown hens in terms of utilization of resources. However, the higher activity and movement throughout the aviary of White hens could also potentially incur in greater incidence of bone fractures. Further studies of nest design to increase attractiveness for Brown hens in aviary systems are necessary to prevent mislaid eggs.

Table 4. Effect of strain and nest location on number of laid eggs and relative rates.

Strain	Egg location	Mean	Confidence interval
		Predicted number of laid eggs[1] (aviary unit/wk)	
Brown	Nest	79.22[b]	74.21– 84.50
	Wire	16.28[d]	14.07– 18.84
	Floor	19.22[d]	16.83– 21.96
White	Nest	97.93[a]	92.24–103.54
	Wire	1.32[e]	0.77– 2.28
	Floor	34.95[c]	31.69– 38.54
Treatment comparisons		Relative rate[2]	
Brown	Floor vs. nest	0.24	0.21– 0.28
	Floor vs. wire	1.18	0.98– 1.42
	Nest vs. wire	4.87	4.19– 5.66
White	Floor vs. nest	0.36	0.32– 0.40
	Floor vs. wire	26.46	15.45– 45.31
	Nest vs. wire	73.97	43.19–126.72
Brown vs. white	Floor	0.55	0.47– 0.64
Brown vs. White	Nest	0.81	0.75– 0.88
Brown vs. White	Wire	12.32	7.17– 21.19
Source of variation		P-values	
Strain		0.0003	
Egg location		<0.0001	
Strain×egg location		<0.0001	
Age		0.334	
Strain×age		0.999	
Egg location×age		0.308	
Strain×egg location×age		0.822	

[a-e]Means within a column lacking a common superscript differ ($P \leq 0.05$).
[1]Exponential of rates of laid eggs at each delimited location.
[2]Ratio between the rates of 2 treatment groups.

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