Short- and long-term movement patterns in complex confined environments in broiler chickens: The effects of distribution of cover panels and food resources

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ABSTRACT In captivity, the positioning of structural enrichment and food resources influences behavior and space use. The aim of this experiment was to examine the influence of cover panels and the positioning of food resources on the movement and space use of domestic fowl (Gallus gallus domesticus). Eight groups of 45 male chickens were used for this study. Each group was temporarily divided into 2 groups of 20 birds; each group was used to investigate the influence of cover panels and the effects of food resources. In the cover panel treatments, 20 birds were placed in the 10-m² testing enclosures that contained one 2-m cover panel in the center, four 0.5-m panels in a zigzag fashion, or had no panels (controls). In the food resource treatments, the position of the feed trays varied, with 1 feed tray in the center; 2 feed trays, one at each edge; or 4 feed trays, one at each corner of the enclosure. Locations of focal birds were collected through instantaneous scan sampling that was recorded as X,Y coordinates. From these X,Y coordinates, we calculated net and total distance moved, mean and maximum step lengths, and angular dispersion of the path of movement. To calculate long-term space use, 3 replications for each of 3 cover panel and food resource treatments were placed in nine 10-m² enclosures for 1 wk. Locations of focal birds in each group were collected by ad libitum scan sampling and data were used to calculate core areas by kernel estimates. Mixed model ANOVA was used to determine the effects of the distribution of cover panels and positioning of food resources on movement parameters during the study period, whereas 1-way ANOVA was used for core areas. Surprisingly, our analyses showed that long-term and short-term movement was not affected by changing the location of cover panels or food resources. Only net distance seemed to be affected to a certain degree by the presence of the cover and the distinctive availability of food resources.

Key words: broiler chicken, domestic fowl, movement and space use, cover panel, food resource

INTRODUCTION

An animal’s ability to survive and produce offspring depends on its capability to locate food resources and avoid predators. Animals have evolved diverse anti-predator mechanisms to prevent predators from detecting, attacking, capturing, or consuming them (Alcock, 1998) by taking refuge underneath or behind cover such as trees and shrubs (van der Veen, 2002; Blumstein et al., 2004; Fisher et al., 2004). Cover availability plays a key role in influencing site selection and spatial distribution patterns (Jensen et al., 2003; Wratten et al., 2003; Novoa et al., 2006; Buler et al., 2007). For example, nest densities of the gray partridge (Perdix perdix) and ring-necked pheasant (Phasianus colchicus) were greatest in areas with the most cover (Novoa et al., 2006). Lesser prairie chickens (Tympanuchus pallidicinctus) used sites that had a higher cover and greater density of shrubs (Patten et al., 2005) and this was found to be positively correlated with the survivorship of adult birds. Studies by Dawkins et al. (2003) on habitat preference in free-range broiler chickens (Gallus gallus domesticus) indicated that the number of birds ranging was positively correlated to the proportion of tree cover in the range area.

Improving the biological functioning of captive animals by modifying their environment, such as by providing them with cover panels or changing the location...
and the presentation of food, is known as environmental enrichment (Newberry, 1995). Cover can be defined as a protected area where animals can rest undisturbed. Cover does not necessarily have to be in the form of vegetation. Production environments can consist of cover panels, barrier perches, or other structures that offer a similar sense of protection to animals (Cornetto and Estévez, 2001; Bizeray et al., 2002; Cornetto et al., 2002; Leone and Estévez, 2008a,b). Cornetto and Estévez, (2001) were able to obtain a more homogeneous bird distribution within the experimental enclosures when cover panels were provided in the center with 80% of the use of the center being around the panels. Cover panels used in broiler breeder farms produced a marked increase in the home range sizes of the males and resulted in a significant improvement in reproductive performance and economic returns to producers (Leone and Estévez, 2008b).

Availability of food resources also influences behavior, with animals generally displaying a strong preference for habitats with the highest concentration of food resources over others (Herbinger et al., 2001; Musiega et al., 2006; Buler et al., 2007). For example, Estévez et al. (2002) found that laying hens that choose to feed at the central area of the experimental enclosure tended not to abandon that area until food started to get severely depleted. Leone and Estévez (2007) also demonstrated that broilers were able to detect differences between high-, medium-, and low-quality food patches that were provided under experimental conditions and were distributed accordingly.

Although, as indicated above, a fair number of studies have analyzed spatial distribution of broilers under provision of cover panels and variable distributions of food resources, none of these have looked at the short- and long-term movement patterns that result in such spatial distribution. Therefore, the aim of this study was to determine the influence of the presence and distribution of cover panels and food resources on short- and long-term movement patterns in broiler chickens.

**MATERIALS AND METHODS**

**Study Birds and Site**

Three hundred sixty-four 1-d-old male broiler chicks (Ross 708) were obtained from a commercial hatchery. We choose to conduct the study with birds of one sex, males, to reduce behavioral variability that is known to occur in mixed-sex groups. The birds were randomly divided into 8 groups of 45 and each group was housed in a 5-m$^2$ (2.5 × 2 m) pen. Pen characteristics and provision of resources were identical to the ones described in our previous study on the movement of male broilers (Malapur et al., 2009). All birds were tagged for individual recognition with the Swiftack identification system for poultry (Heartland Animal Health Inc., Fair Play, MO) on both sides of their neck. The tags were laminated paper tags, 2.5 cm in diameter, identifying individuals in each experimental group size. In this study, 20 birds in each group were used to determine the effects of cover panels, whereas another 20 were used for the food resources experiment. Five birds remained in the home enclosures in the event of mortalities. The same 20 birds from each experimental pen were always tested under all cover panel conditions. Similarly, the second group of 20 individually marked birds was tested under all food resource situations.

These studies were conducted at the University of Maryland Applied Poultry Research Laboratory from March to May 2007. The methods followed in this experiment were approved by the University of Maryland Institutional Animal Care and Use Committee (protocol number R-05-24).

**Movement Patterns**

**Experimental Design.** The birds were maintained in their home enclosures but were temporarily transferred to the testing enclosures for the experimental trials. Six testing enclosures of 10 m$^2$ (4 × 2.5 m) were used, 3 enclosures for each study (cover panels and food resources). To habituate the birds to handling and transportation (located across the room from the home enclosures), and to minimize any stress that could alter the results of this study, birds from each home pen were transferred to the testing pens every weekday during the first 2 wk of age. During training, birds stayed in the testing enclosures for a 30-min period and then returned to their home pens. All experimental groups were trained in all 3 treatments.

In the cover panels treatment, the cover panels were constructed by using white polyvinyl chloride piping 0.04 m in diameter for the frames. The frames were supported by two 1-m pipes made of the same material. The panels were constructed in such a way that they would stand vertically and perpendicular to the floor. A piece of black translucent plastic mesh with openings 0.01 × 0.03 cm was attached to the panel frame with cable ties similar to the model described by Cornetto and Estévez (2001). The 3 testing enclosures differed in the size and position of cover panels with 1) a 2-m cover panel as a middle partition placed at the center of the enclosure (CP1, Figure 1a), 2) four 0.5-m cover panels arranged in a zigzag pattern with the outer panels being equidistant (0.5 m) from the edge of the enclosure (CP2, Figure 1b), and 3) control or enclosure with no cover panels (CP3), similar to a standard enclosure. In this experiment, each trial lasted for 1 h during which birds had access to water but not to feed.

However, feed played an important role in the food resources experiment, with feed being provided as a part of the experimental design. The 3 distributions of food resources containing identical amounts of feed that were used in this experiment included 1) 1 large container that held 3.6 L of feed placed in the center of the
enclosure (FR1, Figure 2a), 2) 2 containers with 1.8 L of feed each located equidistant (0.5 m) from the edge of the enclosure (FR2, Figure 2b), and 3) 4 containers with 0.90 L of feed, with 1 container located in each of the 4 corners of the enclosure (FR3, Figure 2c).

Method of Observation. The actual experiments (cover panels and food resources) began at 3 wk of age of the birds and ended at 5 wk of age. Each sampling period lasted for 1 h between 1500 and 1930 h during which 3 groups of 20 birds were randomly selected from 3 home enclosures and placed in 3 experimental testing enclosures of 10 m². We choose the time of the observations to avoid any disturbances that could have possibly originated from the morning daily care routine and to accommodate a feasible schedule for the observer. In both experiments, each group composed of the same 20 birds (for cover panels and food resources, respectively) from each of the 8 home enclosures was tested once per treatment (CP1, CP2, and CP3 and FR1, FR2,
and FR3). The observations were collected following a randomized schedule that was constructed before the beginning of the data collection. These testings were conducted on different days during the course of the experiment. We chose to work at very low densities to ensure that movement patterns of the birds were not limited or affected by the effects of density.

Observations were conducted following similar methods to the ones described in Mallapur et al. (2009). Twenty birds from 3 pens were gently captured in their home enclosures and together transferred in crates to the corresponding experimental pen. All 3 groups were moved at the same time and birds in each group were released in the center of their corresponding testing pens. A 30-min habituation period was allowed before the start of the observations. The assignment of each group to the experimental pen was predetermined at random before the start of the observations. Each experimental group was tested a total of 3 times, once in each experimental pen (CP1, CP2, and CP3). These testings were conducted on different days during the course of the experiment. The same procedure was used for the food resources experiment, with groups of birds being tested in FR1, FR2, and FR3.

There were 4 focal birds in each experimental group and each was observed continuously for 5 min during the sampling period of 1 h (5 min × 4 focal birds × 3 groups, a total of 12 focal birds observed per hour of observation). The exact location of the focal bird was recorded with instantaneous scans every second for the duration of the 5-min period (approx. 300 data points for each focal bird per sampling period). The order of observation of the 4 focal birds in each group and experimental pen was randomized. Locations of focal birds were directly recorded in a scaled map as X,Y coordinates (in cm) with a Tablet PC (Satellite R Series, Toshiba, Beijing, China) and Chickitaizer software (Sanchez and Estévez, 2006). The software generated an output table containing the X,Y coordinates of all observed locations for each focal bird within each group and experimental treatment.

**Calculation of Behavior Variables and Statistical Analyses.** As in our previous study (Mallapur et al., 2009), we used the locations generated by the Chickitaizer software to calculate the variables described in Table 1. These include mean and maximum step length, number of steps, duration of pauses, percentage of time paused, net and total distance traveled, and tortuosity of the movement pattern for each focal bird.

We use step length to mean the distance traveled between the scans and it is not to be confused with a real step taken by the bird to move that distance between scans. Hence, step length in this context is the Euclidean distance (in m) between location \( i \) \((x_i, y_i)\) and the subsequent location \( i+1 \) \((x_{i+1}, y_{i+1})\):

\[
\sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}.
\]

We found that our method of recording locations with the Tablet PC gave us an observation error of approximately 0.045 m in distance between consecutive locations at the same coordinates. To correct for this, all distances between consecutive locations smaller than 0.045 m were considered to be nonmovement and so were recorded as a pause. If distance between 2 scans was larger than 0.045, it was recorded as a step.

The steps recorded for each focal bird in the 5-min observation period were defined as the Euclidian distance between 2 sequential locations during 1 observation period. All other parameters were calculated as described in Table 1.

To estimate tortuosity of the movement (or angular dispersion), we first calculated the resultant vector length and the mean direction of movement (Fisher, 1993). The mean direction, \( \theta \), is defined as 

\[
\theta = \tan^{-1} \left( \frac{S}{C} \right)
\]

where \( S \) is the sum of the sine of the angle of each location and \( C \) is the sum of the cosine of the angle of each location.

### Table 1. Definitions of the animal movement and space use variables used in the study

<table>
<thead>
<tr>
<th>Technical term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Step length</td>
<td>Euclidean distance between location ( i ) ((x_i, y_i)) and the subsequent location ( i+1 ) ((x_{i+1}, y_{i+1})), defined as ( l(i,i+1) = \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2} )</td>
</tr>
<tr>
<td>2. Number of steps</td>
<td>Total number of steps taken calculated as total number of actual moves made by the focal bird</td>
</tr>
<tr>
<td>3. Mean step length</td>
<td>The average length of all steps (larger than 0.045 m in length)</td>
</tr>
<tr>
<td>4. Maximum step length</td>
<td>The longest Euclidean distance between subsequent locations</td>
</tr>
<tr>
<td>5. Net distance</td>
<td>The Euclidean distance between the first and last observed location</td>
</tr>
<tr>
<td>6. Total distance</td>
<td>Sum of distances for all successive steps</td>
</tr>
<tr>
<td>7. Pause</td>
<td>Focal bird remains at the same location between consecutive observations (i.e., when the bird was recorded as not moving or moving a distance less than 0.045 m)</td>
</tr>
<tr>
<td>8. Duration of pause</td>
<td>The number of consecutive observations without a step</td>
</tr>
<tr>
<td>9. Mean duration of pauses</td>
<td>The average of all the pause lengths</td>
</tr>
<tr>
<td>10. Percentage of time paused</td>
<td>The total number of pauses divided by the total number of observations</td>
</tr>
<tr>
<td>12. Tortuosity</td>
<td>Measured as the sample estimate of the angular dispersion of the turning angles between consecutive locations</td>
</tr>
</tbody>
</table>

1 All values were calculated per bird for the 5-min observation period.
where \( C = \Sigma \cos \theta_i \), \( S = \Sigma \sin \theta_i \), and \( \theta \) is the turning angle between 2 consecutive locations. The mean resultant length is defined to be \( R = n^{-1} \sqrt{C^2 + S^2} \) and lies in the range \((0, 1)\).

Mean values of each of the collected variables were averaged over the 4 focal birds from each group for each experimental treatment. A mixed model ANOVA (Quinn and Keough, 2002) was used to test the effects of the distribution of cover panels and food resources. The residuals from the models were tested for normality and variance homogeneity. In cover panels, total distance, net distance, total number of pauses, percentage of pauses, number of steps, and tortuosity, and total distance in food resources were skewed with unequal variance and hence were log-transformed. The remaining values in food resources were normally distributed and did not need to be transformed. To control for experiment-wise error rates, the Tukey-Kramer honestly significant difference method (Kramer, 1956) was used for all mean comparisons. All analyses were conducted using SAS v. 9.1 (SAS Institute, Cary, NC).

**Core Area Estimation**

**Experimental Design.** For the purpose of this paper, core area is defined as the area where a bird is most likely to be found under normal activity patterns (White and Garrott, 1990). To estimate core areas, bird locations must be recorded for a relatively long period because diverse areas of the enclosure may be used by birds for different activities, or at diverse times. This part of the study was conducted during the sixth week of age, with the same birds after completing the study of individual movement patterns. For this, the 8 groups of 20 birds were temporarily divided into groups of 10 for both experiments and we randomly selected 9 groups for 3 replicates of the 3 treatments (CP1, CP2, and CP3 for the cover panels experiment and FR1, FR2, and FR3 for the food resources experiment). Experimental groups of birds were taken from the same home pen, avoiding potential problems with hierarchy formation and mixing unfamiliar birds. Each group was randomly placed in one of the nine 10-m² (4 x 2.5 m) experimental pens constructed for the core area study. The testing pens were identical to the 10-m² enclosures used in the previous part of this study except that in cover panels a tubular feeder was placed at the rear end of the enclosure. The different groups were continuously housed in these conditions for a 10-d period. Birds that were not used for the core area study remained in their original home enclosures.

**Observation Methods.** Bird locations were recorded for all 3 replications of each treatment for both experiments between 1300 and 1930 h for 10 d. Each observation period lasted for 1 h. During this hour, the locations of the 4 focal birds within each of the 9 groups were recorded sequentially in random order. Each round of observations took 12 min approximately and a total of 5 observations were collected per hour. From all of these observations, we collected a total of 125 locations per focal bird during the study period. Observations were conducted following identical methods used in the movement pattern study by recording the bird location in X,Y coordinates using the Tablet PC and the Chickitaizer software (Sanchez and Estévez, 2006).

**Statistical Analyses.** Data were analyzed using methods from our previous study (Mallapur et al., 2009). To calculate core areas (Samuel et al., 1985) we used multivariate kernel density estimation (Worton, 1989, 1995), which has been used to investigate animal movement in captive animals (Estevez and Christman, 2006). Kernel estimates were calculated using the free-ware Octave (http://www.gnu.org/software/octave/). Near the boundary of the enclosure, the kernel density estimation was modified by reflection (Miller and Christman, unpublished data). Based on previous research on captive animal movement and for comparative purposes, the 30th, 50th, and 90th percentile probabilities were chosen for analyses (Estevez et al., 1997; Estévez and Christman, 2006; Leone et al., 2007). Individual (estimated for each focal bird) and group core area estimates (for the 4 focal birds in each group) were calculated and used for statistical analyses. These values were averaged per group before statistical analyses.

The effects of the treatments on both individual and group core areas were tested using a randomized complete block design with home enclosure for each experiment (cover panels and food resources). The residuals for the 30th percentile probabilities in cover panels and the 30th and 90th percentile probabilities in food resources were not normally distributed and data were log-transformed. To control for experiment-wise error rates, the Tukey-Kramer honestly significant difference method (Kramer, 1956) was used for all mean comparisons. All analyses were conducted using SAS v. 9.1 (SAS Institute).

**RESULTS**

**Short-Term Movement Patterns**

The treatments in cover panels and food resources did not have an effect on any of the parameters studied in this experiment, which is surprising (see Table 1 for parameters and definitions). Table 2 shows the results of the statistical analysis for all of the parameters under cover panel and food resource treatments and because the treatments are not statistically significantly different, only the overall means for the core panel and food resource experiments of the parameters were analyzed in this study. Total distance traveled in the cover panel treatment was the only parameter that was close enough to statistical significance (\( F_{2,24} = 2.84; P = 0.08 \)) to merit a comment. We observed longer total distance traveled in CP1 followed by CP2 and CP3 (CP1: 1.74 ± 0.57, CP2: 1.10 ± 0.44, CP3: 0.87 ± 0.38). Also,
although it did not reach significance levels \((P = 0.1)\), in CP1, the number of steps taken by the birds \((9.41 \pm 2.87)\) was higher than steps taken in CP2 \((6.53 \pm 2.48)\) and CP3 \((4.44 \pm 1.58)\).

### Core Area Estimation

The different treatments of distribution of cover panels and food resources did not have any significant effect in the 30th, 50th, and 90th percentiles of individual or group core areas, respectively. Table 3 shows the results of the analysis as well as means and SE for each percentile.

### DISCUSSION

In this paper, we report the findings from 2 experimental treatments conducted to address the influence of distribution of cover panels and feed resources on movement and space use in broiler chickens. The objective was to examine the provision of artificial cover and its effect on movement and the utilization of enclosure space by the birds. We initially hypothesized that the provision of cover panels that varied in size, location, and number would positively influence movement and space use. Clearly, this was not the case in this study. Although a lot of effort was invested in terms of experimental design, data collection, and statistical analysis, which are rather complex when it comes to movement analysis, none of the parameters studied seemed to be affected by the treatment using a type I error rate of 0.05. This is with the exception of total distance traveled for the cover panel treatments, which was sufficiently close to significance to merit mention in this discussion.

In this study, total distance traveled appeared to be longer for birds maintained in CP1 followed by CP2, and birds in CP3 showed the lowest total distance traveled \((CP1: 1.74 \pm 0.57, CP2: 1.10 \pm 0.44, CP3: 0.87 \pm 0.38)\). This result suggests that cover disposition has a positive effect on travel distance and how this cover is located appears to be important for the movements of broilers.

Nevertheless, the overall lack of effects are in clear opposition to the positive results of cover detected by Newberry and Shackleton \((1997)\), as well as in previous studies conducted in our laboratory \((Cornetto and Estévez, 2001; Cornetto et al., 2002)\). Cornetto and Estévez \((2001)\) observed a significant increase in the use of the center region of the enclosure for the 2 cover treatments and a reduction in the level of disturbances and aggression when cover was provided \((Cornetto et al., 2002)\). Availability of cover panels also provides a hideout and retreat from potential aggressors under

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**Table 2. The effect of cover panels and positioning of food resources on the study parameters**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cover panels</th>
<th>Food resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean step length (m)</td>
<td>0.10</td>
<td>0.69</td>
</tr>
<tr>
<td>Maximum step length (m)</td>
<td>1.72</td>
<td>0.52</td>
</tr>
<tr>
<td>Number of steps</td>
<td>2.58</td>
<td>0.12</td>
</tr>
<tr>
<td>Net distance (m)</td>
<td>0.62</td>
<td>0.51</td>
</tr>
<tr>
<td>Total distance (m)</td>
<td>2.84</td>
<td>1.74</td>
</tr>
<tr>
<td>Number of pauses</td>
<td>0.33</td>
<td>0.1</td>
</tr>
<tr>
<td>Mean duration of pauses (s)</td>
<td>0.18</td>
<td>0.69</td>
</tr>
<tr>
<td>Percentage of pauses</td>
<td>0.8</td>
<td>0.13</td>
</tr>
<tr>
<td>Tortuosity</td>
<td>0.17</td>
<td>1.19</td>
</tr>
</tbody>
</table>

1\(^\text{F, P, and mean values (SE) are presented for all of the parameters.}\)

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**Table 3. Influence of cover panels and position of food resources on the 30th, 50th, and 90th percentile individual and group core areas**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentile</th>
<th>(F_{2,36})</th>
<th>(P)-value</th>
<th>Mean % (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover panel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual core areas</td>
<td>30</td>
<td>1.09</td>
<td>0.4344</td>
<td>0.21 (0.002)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.63</td>
<td>0.5981</td>
<td>0.51 (0.003)</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>1.13</td>
<td>0.4271</td>
<td>1.85 (0.01)</td>
</tr>
<tr>
<td>Group core areas</td>
<td>30</td>
<td>1.43</td>
<td>0.3603</td>
<td>0.36 (0.04)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2.21</td>
<td>0.2633</td>
<td>0.90 (0.08)</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.22</td>
<td>0.8159</td>
<td>3.61 (0.19)</td>
</tr>
<tr>
<td>Food resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual core areas</td>
<td>30</td>
<td>0.62</td>
<td>0.5892</td>
<td>0.18 (0.01)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.51</td>
<td>0.6437</td>
<td>0.45 (0.01)</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.1</td>
<td>0.9066</td>
<td>1.75 (0.02)</td>
</tr>
<tr>
<td>Group core areas</td>
<td>30</td>
<td>0.49</td>
<td>0.6211</td>
<td>0.29 (0.03)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.01</td>
<td>0.9914</td>
<td>0.71 (0.02)</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.03</td>
<td>0.9688</td>
<td>2.87 (0.09)</td>
</tr>
</tbody>
</table>

1\(^\text{F, P, and mean values (SE) are presented for all of the parameters.}\)
commercial housing systems and has been proven to improve reproductive performance in broiler breeders (by increasing in 4.5 chicks produced per hen and production cycle), therefore increasing economic return for the farmer (Leone and Estévez, 2008b). Similar patterns of preference for covered areas were observed in free-ranging broilers (Dawkins et al., 2003). Their study showed that the number of birds found ranging outside their enclosures was positively correlated with the amount of tree cover area.

On the other hand, to access optimal foraging sites, animals need to move and this choice balances the potential benefits such as high-quality food resources and the risks of leaving cover and increasing exposure to predation (Larsen and Boutin, 1994; Fahrig, 2007). The aim of the food location treatments was to examine the influence of distribution of food resources on the short-term and long-term movement in domestic fowl. It has been suggested that to maximize their intake, animals will often modify their movement patterns when favorable habitat types in food resources are discovered. Leone and Estévez (2008a) showed, for example, that the use of space and interindividual distances between birds increased as the feed trays became more widely distributed. Our purpose in this study was to create a gradient of food distribution from a clumped source of food resources (FR1) to feeding more uniformly distributed across the enclosures making it more accessible to the birds (FR3) so as to motivate the birds to move farther to access food resources. Conversely, the results of this study showed no effect of the feed distribution in any of the parameters analyzed (Table 1), under any of feed distributions within the experimental enclosure. Further, the sizes of core areas at the different percentiles were very stable and not affected by any of the cover panel or food resource treatments.

Because the effects of cover and food distribution have been clearly demonstrated in previous experiments, our most plausible explanation for the lack of effects in this study could be related to the experimental design itself. Although in previous studies data were collected in the home enclosure of the birds without moving them to a different location, in this study birds remained only for short periods of time in the experimental enclosure for all treatments. This may result in broilers being too wary and fearful of their new temporary environment, which therefore masks any potential effects that our treatments could have had under other circumstances. In addition, broilers were fed ad libitum in their home pens and therefore their motivation to move around might have been very limited. We must also mention that in these experiments we used a very low density of birds, which may affect to a certain extent the results of this experiment. Nevertheless, in our estimation, we thought it was more reasonable to use low densities so that the birds would have more chances to show their full potential in differences of behavioral choices in terms of use of panels or the location of food resources. Although testing animals for short periods of time in different enclosures is not uncommon in animal behavior research, perhaps this method may have some limitations when it comes to the study of movement patterns in broilers. Alternatively, if the birds were fearful of the new environment, then use of cover panels should have been higher, but this was clearly not the case. We can therefore speculate that because the birds were exposed to the arena during the training period, this thorough training was sufficient to make them feel comfortable and safe, eliminating the effect of novelty of the testing environment and consequently reducing the need to use cover panels for protection. However, this second hypothesis does not seem to be a feasible explanation due to the lack of effects related to the food resource experiments.

In conclusion, the results of this experiment conducted with broiler chickens under very specific experimental situations show very little effect of the disposition of cover panels (with the exception of total distance traveled) or the distribution of food resources on short- and long-term movement patterns. It is reasonable to recommend that studies such as this be conducted under home conditions at least in broilers.

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