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# ENVIRONMENT, WELL-BEING, AND BEHAVIOR

## Effect of Sand and Wood-Shavings Bedding on the Behavior of Broiler Chickens

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**ABSTRACT** The purpose of this study was to determine the effect of 2 different bedding types, sand and wood shavings, on the behavior of broiler chickens. In experiment 1, 6 pens were divided down the center and bedded half with sand and half with wood shavings. Male broilers (10/pen) were observed by scan sampling at 5- or 12-min intervals throughout the 6-wk growth period during the morning (between 0800 to 0900 h), afternoon (1200 to 1500 h), and night (2300 to 0600 h). There was a significant behavior  $\times$  substrate  $\times$  week interaction during the day ( $P < 0.0001$ ) and at night ( $P < 0.0002$ ). Drinking, dustbathing, preening, and sitting increased in frequency on the sand side but decreased on the wood shavings side during the

day, as did resting at night. In general, broilers performed a greater proportion of their total behavioral time budget on the sand ( $P < 0.0001$ ) as they aged. Broilers used the divider between the 2 bedding types to perch; perching behavior peaked during wk 4. In experiment 2, male broilers were housed in 8 pens (50 birds/pen) bedded only in sand or wood shavings. Bedding type had no effect on behavioral time budgets ( $P = 0.8946$ ), although there were age-related changes in behavior on both bedding types. These results indicate that when given a choice, broilers increasingly performed many of their behaviors on sand, but if only one bedding type was provided they performed those behaviors with similar frequency on sand or wood shavings.

(*Key words:* broiler chicken, behavior, bedding, sand, wood shavings)

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### INTRODUCTION

Broiler chickens become increasingly inactive as they near market weight, spending as much as 80% of their time resting (Murphy and Preston, 1988; Newberry and Hall, 1990; Weeks et al., 2000). Inactivity is probably largely a consequence of selection and management for particular growth characteristics. The rapid growth of breast muscle in broilers moves the center of gravity forward and the legs outward, producing a gait pattern that is probably energetically inefficient and tiring (Corr et al., 2003). In addition, broilers may find walking painful (McGeown, et al., 1999; Danbury, et al., 2000) as they approach slaughter weight because they are increasingly prone to leg disorders (Mench, 2004). However, a lack of activity could in turn increase the incidence of gait and skeletal disorders (Haye and Simons, 1978; Thorp and Duff, 1988). The normal stress and strain that is caused by exercise is important for mechanically organizing the growth process of bone into the

proper patterns of twisting and angulation (reviewed in Lanyon, 1993; Rath et al., 2000).

A number of attempts have been made to increase the activity levels of broilers. Examples include increasing the distance between food and water sources (Haye and Simons, 1978) or placing barriers between the food and water (Bizeray et al., 2002a) to make broilers walk further to reach resources. However, using restricted food and water access as a means to promote locomotion in a commercial house could create a potential welfare problem, because broiler chickens with severe gait disorders may have difficulty reaching the food and water and, thus, starve or become dehydrated. Light management has also been used to increase activity, for example by increasing the light intensity (Newberry et al. 1985, 1988) or providing intermittent daily lighting (Simons and Haye, 1985). Both methods stimulated activity, but only intermittent lighting decreased leg problems. However, complete control over the lighting schedule under commercial conditions is not always possible. There are also other drawbacks to using certain lighting programs to reduce leg problems, such as a potential increase in breast blisters from longer periods resting on the keel bone (Deaton et al., 1978) and a greater incidence of hock and footpad burns (Sørensen et al., 1999).

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**Abbreviation Key:** CI = confidence interval.

Another way to increase activity levels might be to encourage broilers to display normal behaviors that require energetic movement that includes exercise of the legs, for example walking, foraging, and dustbathing behaviors (Arnould et al., 2004). Providing broilers with an enrichment device that stimulated them to perch, traverse inclines, forage, and dustbathe resulted in a slight improvement in gait score (Mench et al. 2001). A simpler and more cost-effective way to increase broiler activity in commercial houses might be to provide a bedding substrate that stimulates particular behaviors. Sand appears to be one such potential substrate. Broilers that are deprived of bedding and subsequently given a choice between sand, pine wood shavings, rice hulls, and a recycled paper bedding product choose to dustbathe and forage more in sand than in any of the other substrates (Shields et al., 2004). When sand-filled trays are placed in pens, broilers dustbathe and forage preferentially in the sand rather than in the wood shavings covering the pen floor (Arnould et al., 2004).

Sand is being considered as an alternative to pine wood shavings as bedding for broiler chickens in some areas of the United States (Grimes et al., 2002). Litter quality and bird performance parameters are similar for sand and wood bedding, and sand is advantageous in that it harbors fewer harmful microorganisms like *Escherichia coli* (Bilgili et al., 1999a,b). However, it is not known how the behavior of broilers would be affected by the use of sand bedding in commercial houses. The objectives of the 2 experiments presented here were to determine 1) whether broilers differentially perform particular behaviors on sand or wood-shavings bedding when given a choice between bedding types and 2) if behavioral time budgets differ between broilers reared on sand and those reared on wood shavings. The larger goal of these experiments was to determine whether sand bedding would promote the expression of more active behaviors and, perhaps, improve leg condition.

## MATERIALS AND METHODS

### Experiment 1

Male Ross × Ross broiler chicks (n = 60) were purchased from a local hatchery. At d 1 of age, the chicks were separated into 6 different pens. Each pen measured 3.05 × 3.05 m and had an overhead brooder and 2 circular feeders. Each pen contained 2 cup waterers, which, along with the feeders, were arranged symmetrically on each side. Feed (Purina Mills Meat Builder without added medication; <http://www.purinamills.com>) and water were available ad libitum. Each pen was divided down the center with a 3.8 cm wide × 8.9 cm high pine board and filled to a depth of 2.5 cm with pine wood shavings on one side and masonry-grade (construction) sand on the other side. The location of the 2 substrates was alternated between the right and left sides of the pens. There were windows along the length of the building that allowed daylight to enter, but the study was conducted in the winter, so the days were short. There was also fluorescent lighting set to provide a 16L:8D cycle with the lights coming on at 0700 h and going

off at 2300 h. Although many different lighting programs are used by the broiler industry, an 8-h scotophase is recommended in some industry standards as a management practice to reduce leg problems (e.g., Certified Humane, 2004). The birds were managed in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999), and the experiments described below were approved by the University of California Davis Institutional Animal Use and Care Administrative Advisory Committee.

Behavioral observations were conducted 5 d per week starting when the chicks reached 7 d of age and continuing through 49 d of age. Each pen was observed 5 times a week during the afternoon (1200 to 1500 h). Each observation was 1 h long. Because there are circadian rhythms in behavior, pens were also observed once per week beginning at 0800 h to ensure a better approximation of behaviors that are more commonly performed in the morning. There were more afternoon observations than morning observations because parallel observations were being conducted to perform a detailed analysis of the structure of dustbathing behavior, which occurs primarily in the afternoon. The results of these parallel studies are reported elsewhere (Shields, 2004).

At the beginning of an observation session, an observer sat quietly about 2 m away from the front of a pen, allowed 5 min for the chicks to habituate to the observer's presence, then started a stopwatch and recorded data with pen and paper. Instantaneous scan samples (Martin and Bateson, 1986) of all the birds in a pen were conducted at the start of the observation and continued through the hour at 5-min intervals. During a scan sample, the location (i.e., side of the pen) and the number of individuals engaged in a behavior were recorded. Behaviors were divided into the following categories: stand, locomote, preen standing, scratch, feed, peck, sit, preen sitting, drink, dustbathe, perch (on the board that divided the 2 types of bedding), and other. Most behaviors recorded in the "other" category were aggressive pecks, threats, or chases. A Latin square was used to determine the order in which the pens were observed each week. Six different observers (S. J. Shields and 5 assistants) collected data.

Behaviors occurring at night were videotaped under red light when the birds were 34, 35, 38, 41 to 43, and 46 to 50 d of age. On each of these nights, video recording started at 2300 h and continued until 0600 h. Data were then taken from 1-h segments of the videos starting at 2300, 0200, and 0500 h. For each hour-long segment, an instantaneous scan sample was performed every 12 min, providing 6 samples per hour of video. The location and behavior of each bird were recorded during each scan. The only behaviors discernible on the videos were stand, locomote, feed, drink, perch, and rest. Because it was difficult to see whether the broilers had their eyes open, the category of resting included sleeping and sitting awake.

A score for each behavior was obtained for each observation by summing the number of birds engaged in that behavior over all of the 5-min (or 12-min, for night observations) scan samples in a particular observation. Separate

scores were calculated for the sand side and the wood shavings side of the pen. Perching could not occur on one side or the other because the perch actually separated the 2 bedding substrates; thus, this behavior was excluded from these calculations. Because some behaviors were rare, there were several scores with the value zero, which resulted in a substantial floor effect (Martin and Bateson, 1986). Therefore, we summed the behavioral scores for all of the observations so that there was one total score for each behavior in each pen for each week. This removed most of the zeros from the data set. Summing the observations over the week also prevented the problem of collinearity (lack of independence among independent variables) within the behavior  $\times$  substrate term or other higher-order terms. Because there were 6 pens and 6 wk, summing the values from each observation created a total of 36 behavioral scores on sand and 36 behavioral scores on wood shavings for each of the different behavior categories. To express each behavioral score as a proportion of the total behavior performed in a given week and pen, the behavioral score on each substrate was then divided by the total score for all the behaviors in that pen on both sides for that week. Dividing each behavioral score by the total possible behavioral score created a population time budget that could then be subjected to statistical analysis.

The category of "other" was excluded from the statistical analysis because there were relatively few scores above zero in this category. As a result the total budget for each pen in each week used in the analysis summed to less than 100%, thereby eliminating collinearity between the behaviors within the analysis.

Analyses were performed in the SAS software (SAS, 2000) using the PROC GLM procedure. All analyses were blocked by pen, which was treated as a fixed effect. Transformations were applied where needed to meet the assumptions of GLM (homogeneity of variance, normality of error, and linearity). The effectiveness of these transformations was confirmed using posthoc plots.

To examine the effect of bedding upon the overall time budget of the birds in a single analysis, the effects of behavior, week, and substrate on time budget proportion were examined. The GLM model for the analysis was proportion of the time budget taken up by each behavior = pen + behavior|substrate|week, with week as a continuous variable. In such an analysis the behavior term describes the shape of the time budget, a behavior  $\times$  substrate interaction describes how the budget differs on the 2 bedding types, and a behavior  $\times$  substrate  $\times$  week interaction describes how this difference changes with time (for further details see Chu et al. 2004). Therefore, the behavior  $\times$  substrate  $\times$  week interaction was examined to test for differential changes in the time budgets over time (i.e., week) on the 2 beddings. Week was treated as a continuous variable to explicitly test for progressive changes over time and to account for the fact that observations made close to one another in time will be more similar to each other than those separated in time. The data in this analysis were Box-Cox transformed with  $k = 1.25$  to produce the best error structure.

Bonferroni-corrected posthoc estimates were calculated for the rate of change in each behavior with time on each bedding type. Bonferroni-corrected posthoc contrasts were performed to compare these rates of change and, thus, determine whether any change in a behavior with time (i.e., week) differed between the 2 beddings. The change in overall use of each bedding type with time and the overall budgets on each bedding type were examined using posthoc contrasts equivalent to the week  $\times$  substrate and substrate  $\times$  behavior interactions, respectively. For each posthoc test, a combined  $P \leq 0.05$  for all comparisons was considered statistically significant.

Pecking, scratching, and feeding often occurred together, and so they were combined together into a new behavioral category, foraging. This behavioral category includes behaviors associated with high levels of locomotion and so can be considered a good general indicator of activity (Biz-ray et al., 2002b). The 3 behaviors were summed into a single score and converted to a proportion of the total behavioral time budget to obtain a separate analysis for foraging. We analyzed this foraging score using a GLM blocked by pen. The independent variables of interest were substrate and week (which again was treated as a covariate). Differential changes in foraging behavior on the 2 bedding types over time (i.e., week) were tested by the substrate  $\times$  week interaction. However, the error structure revealed nonlinearity, and a quadratic model was found to provide a better fit. Data were angular transformed for this analysis.

Because perching occurred between the 2 sides of the pen and could not be included in the analysis of the behavioral time budget, it was also analyzed separately in a GLM blocked by pen, in which week was the independent factor. Week was treated as a continuous variable; however, posthoc assessment of the error structure revealed evidence of nonlinearity. Therefore a GLM blocked by pen was used to perform a polynomial regression, which provided a much better fit to the data. To confirm these results the analysis was also run with week as a categorical variable. Data were angular transformed for this test. Tukey posthoc tests were used to determine significant differences between weeks in the analysis where week was treated as a categorical variable.

Because night video was only taken during the last 3 wk, day-of-age was used a term in the analysis instead of the week term to provide sufficient data resolution over time. The analysis was otherwise the same as that performed for the daytime time budgets. The behavior  $\times$  substrate  $\times$  day-of-age interaction was examined to test for differential changes in the time budgets over time (i.e., days of age) on the 2 beddings. Perching behavior was not included in this analysis because it could not be categorized as occurring on a particular side. Data were log transformed for this analysis. Posthoc analyses were performed as for the daytime time budgets.

## **Experiment 2**

Four hundred male Cobb broiler chicks were purchased from a local hatchery and distributed evenly among 8 pens.

The same types of pens were used in this study as in the first experiment. Overhead fluorescent lighting was the same as in experiment 1 (8D:16L) with the lights coming on at 0700 h. Because the study started in October, the days began to get shorter as the study progressed. Four pens were bedded approximately 17.8 cm deep in masonry-grade sand, and the other 4 pens were bedded in pine wood shavings to approximately the same depth. Husbandry was as previously described.

Beginning when the chicks reached 1 wk of age, each pen was observed for 1 h, 4 d per week. Observations continued until the chicks reached 7 wks of age. Two of the weekly observations on each pen were performed in the morning (between 0800 and 1200 h), and 2 observations were performed in the afternoon (between 1200 and 1600 h). During each 1-h observation, a trained observer sat in front of the pen and recorded behavioral data as described for experiment 1.

Scores for each behavior were summed and analyzed as in experiment 1. The behavioral categories used in experiment 2 were slightly different from the ones used in the first study. The category "feed" was split into the categories, "feed sitting" and "feed standing" for the time budget analysis, although both were included in the "foraging" category. The category of "other" was excluded from the statistical analysis to reduce the floor effect, but the behavioral categories of "chase" and "aggression" were left in the analysis because inspection of the data revealed that there were more scores above zero than in the previous experiment. Analyses of the overall behavioral time budget and foraging behavior were performed as previously described, except that pen was now nested within substrate rather than crossed with substrate. Hence, the GLM model for the time budget analysis became: Proportion of the time budget taken up by each behavior = pen (substrate) + behavior|substrate|week, with week as a continuous variable.

## RESULTS

### Experiment 1

The time budgets on the 2 bedding types changed differently over time (behavior  $\times$  substrate  $\times$  week interaction  $F_{9,675} = 4.39, P < 0.0001$ ; Figure 1). Posthoc contrasts comparing the rate of change in behavior between the 2 bedding types showed a significant difference in the rate of change of drinking, dustbathing, preening while sitting, and sitting behaviors on the 2 different beddings. Posthoc estimates of the rate of change in behavior on each bedding type revealed that there was a significant decrease in locomotion and standing behavior on both bedding types. In addition, the behaviors, drink, peck and scratch, did not change significantly on the sand, but decreased significantly on the wood shavings. There was a significant increase in sitting on the sand.

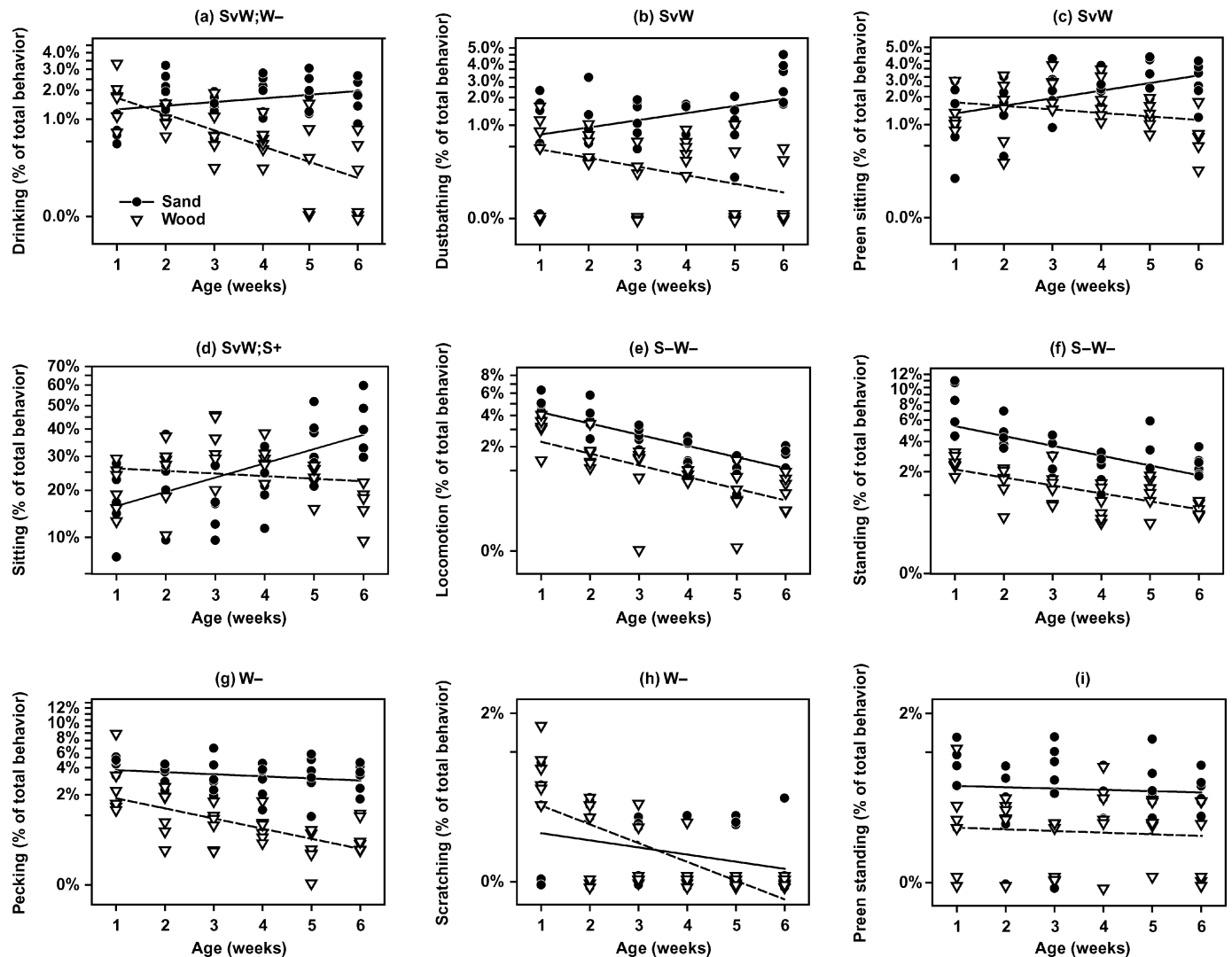
Posthoc contrasts revealed that, overall, the behaviors drink, dustbathe, locomote, peck, preen standing, and standing were significantly different on the 2 sides of the

pen ( $F_{9,675} = 6.61, P < 0.0001$ ). The proportion of the total behavioral time budget made up by each of these behaviors was significantly higher on the sand side of the pens (Figure 2). Post hoc contrasts also revealed that the birds performed a greater proportion of their total behavioral time budget on the sand as the experiment progressed ( $F_{1,675} = 57.31; P < 0.0001$ ).

Foraging behavior on the 2 bedding types changed differently over time ( $F_{1,61} = 7.89; P = 0.0067$ ; Figure 3). Posthoc analysis showed that foraging did not change significantly in the sand but decreased significantly in the wood shavings. The proportion of the total behavioral time budget that was spent foraging in sand did not change significantly over the course of the study. The proportion of the total behavioral budget that was spent foraging in the wood shavings decreased significantly.

Perching was first noticed when chicks were less than 1 wk old. Visual inspection of the data suggested that perching decreased from wk 1 to 2, then increased at wk 4, and then decreased again to wk 6. The data were, therefore, fit to a cubic polynomial. There was a significant week  $\times$  week  $\times$  week interaction ( $F_{1,63} = 8.30, P = 0.005$ ), indicating that perching decreased, increased, and then decreased again as a progressive function of age. When the analysis was rerun with week as a categorical variable, these results were confirmed ( $F_{5,61} = 6.73, P < 0.001$ ). Perching declined from wk 1, when it made up 3.0% [95% confidence interval (CI): 2.1 to 3.9%] of the population time budget, to wk 2, when it was 1.8% (95% CI: 1.1 to 2.5%) of the population time budget. In wk 3 perching was 1.9% (95% CI: 1.3 to 2.7%) of the population time budget. Its frequency then increased in wk 4, when it reached 2.9% (95% CI: 2.1 to 3.9%) of the time budget, and then finally decreased to 1.5% (95% CI: 0.9 to 2.2%) and 0.7% (95% CI: 0.3 to 1.2%) of the total behavioral time budget in wk 5 and 6, respectively. Tukey pairwise comparisons revealed that there was more perching during wk 1 than in wk 6 and significantly more perching in wk 3 and 4 than in wk 6.

For nighttime behavior, there was a significant behavior  $\times$  day-of-age  $\times$  substrate interaction ( $F_{4,755} = 5.50, P = 0.0002$ ), indicating that the time budgets on the 2 bedding types changed with age. Bonferroni-corrected posthoc estimates showed that resting increased significantly from 13.9% (95% CI: 9.4 to 20.5%) of the total behavioral time budget at 34 d of age to 61.2% (95% CI: 42.2 to 88.7%) of the total behavioral time budget at 50 d of age) on the sand and decreased nonsignificantly from 27.5% (95% CI: 18.7 to 40.4%) to 12.0% (95% CI: 8.2 to 17.6%) on the wood shavings as the birds aged. Posthoc contrasts showed that this difference in rates of change of resting behavior on the 2 bedding types was significant. None of the other behaviors showed significant differences between the 2 bedding types in their rate of change with age. Posthoc contrasts at the mean age of the birds in the analysis (42 d) showed that the behavioral time budget differed on the 2 bedding types ( $F_{4,755} = 5.36, P = 0.0003$ ) and that drinking, feeding, resting, and standing were all performed more on the sand side of the pen (Figure 4).



**Figure 1.** Significant change in behavior as a proportion of the total behavioral time budget over the course of experiment 1. All figures are residual plots with each data point plotted as its residual from the least squares lines (LSL). The data points represent the behavioral time budget score corrected for pen. The significant posthoc tests for each behavior are indicated beneath the panel letter as follows:  $S \neq W$  = the change in behavior over time differed between sand and wood shavings,  $S+$  = the behavior increased significantly in the sand over time,  $S-$  = the behavior decreased significantly in the sand over time, and  $W-$  = the behavior decreased significantly in the wood shavings over time. Each panel of the graph indicates a different component of the total time budget: (a) drinking, (b) dustbathing, (c) preening while sitting, (d) sitting, (e) locomotion, (f) standing, (g) pecking, (h) scratching, (i) preening while standing.

## Experiment 2

Rather than providing both bedding types in each pen, in experiment 2 each pen contained only 1 of the 2 bedding substrates. The behavioral time budgets did not change differently with time on the 2 types of bedding (the week  $\times$  treatment  $\times$  behavior interaction was not significant:  $F_{12,566} = 0.53$ ,  $P = 0.8946$ ). However, planned posthoc contrasts revealed that overall the behavioral time budgets did change significantly with week on both substrates ( $F_{12,566} = 20.78$ ,  $P < 0.0001$ ; Table 1). Thus, posthoc Bonferroni-corrected comparisons showed that aggression, chasing, feed standing, locomotion, pecking, and standing all decreased significantly with time in both treatments, whereas preen sitting and sitting increased significantly on both treatments with time.

The separate analysis of foraging confirmed the lack of an effect of bedding. There was no difference in foraging behavior between the 2 bedding types ( $F_{1,38} = 2.62$ ,  $P = 0.1141$ ). However, there was an overall effect of time (i.e., week;  $F_{1,38} = 26.90$ ,  $P < 0.0001$ ), such that the time spent foraging on both bedding types declined from 26.2% (95% CI: 24.4 to 28.1%) in wk 1 to 18.7% (95% CI: 17.1 to 20.4%) in wk 6.

## DISCUSSION

In experiment 1, bedding type did influence behavior but not only in the way expected. Active behaviors (dustbathe, locomote, and peck) were performed more often on the sand, but so too were inactive behaviors (resting and sitting). Furthermore, there was no significant difference be-

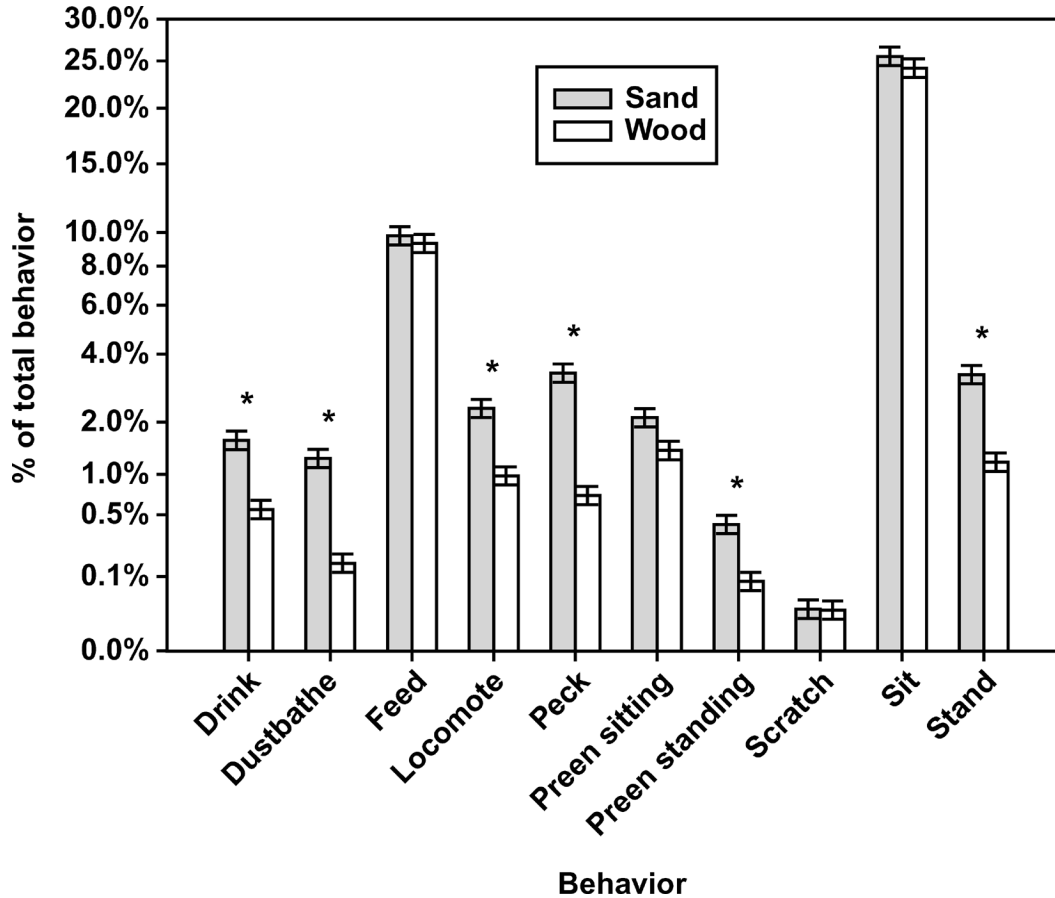


Figure 2. Overall distribution of behaviors on each side of the pen as shown by the proportion of total behavioral time budget for each behavior. Error bars depict SEM. \*Significant difference at  $P \leq 0.05$ .

tween the behaviors of broilers given only sand or wood shavings in experiment 2. Thus there was no support for the idea that exercise could be increased and leg problems decreased by housing broilers on sand bedding. Although the present experiment did not show that active behaviors were increased by the provision of sand bedding, it did show that the broilers preferred sand to wood shavings when they were given a choice.

It was interesting that the birds sat and rested more on the sand rather than on the wood shavings, because wood shavings subjectively seem to be a softer substrate. There might be a perceptual difference in the way sand appears to broilers or in the way it feels on their feet and in their plumage. Cleanliness, temperature at lower depth in the bedding, odor, or some other characteristic of the bedding may be more important than the softness of the bedding for resting. Bilgili et al. (1999a) found that sand bedding in commercial houses is cleaner than wood shavings in that it harbors fewer microorganisms, such as *Escherichia coli*. Although they found no difference between sand and wood shavings in moisture content, temperature, or ammonia production, the quality of sand and wood shavings may be different deeper in the sand, where broiler chickens create small depressions in which to rest. Bedding depth might also be a factor in the preference observed in experiment 1. The bedding depth in this experiment was rather

shallow, particularly as compared with the shavings depth typically found in a commercial house. It is possible that shallow sand provides more comfort or has better insulative properties than shallow wood shavings, although this would need to be assessed experimentally.

Pecking and scratching decreased on the wood shavings side of the pen but increased on the sand side, which could occur for several reasons. One possibility is that scratching and pecking are usually performed prior to a dustbath, and there was significantly more dustbathing on the sand side of the pens as the birds aged. Another possibility is that the decrease in these behaviors reflects the changing condition of the litter. Sand may stay more friable than wood shavings and, therefore, might be an easier or more rewarding surface in which to scratch and peck. Foraging also declined significantly on the wood shavings and increased on sand. The texture or mix of colors of the sand might have elicited feeding more than the wood shavings, perhaps because it was more similar to the type of surface on which fowl would forage naturally. It is also possible that sand particles resembled the small stones that chickens ingest if they have access to them. The motivation to find and ingest small pebbles for grit may still be strong despite the lack of need for poultry to have grit to digest commercially prepared poultry feed.

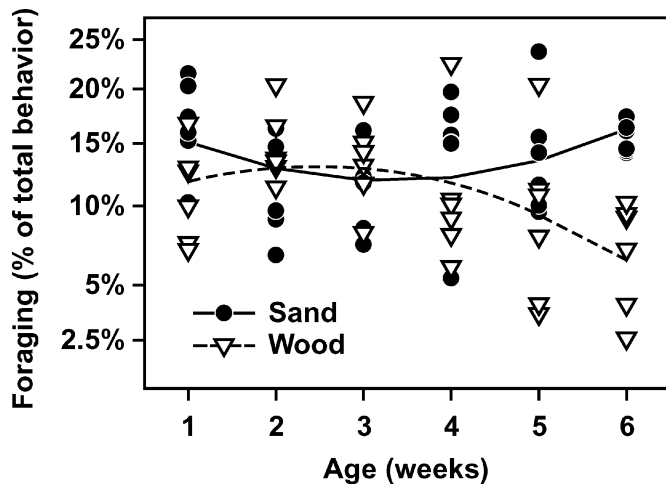


Figure 3. Change in foraging behavior on each side of the pen by week. Foraging behavior did not change significantly in the sand but did decrease significantly in the wood shavings.

One unexpected result from the first experiment was that drinking behavior tended to increase significantly on the sand side of the pen and that at night birds also drank more on the sand side. This could simply be because the birds drank at the drinker nearest to them, and because they spent a greater proportion of their time on the sand tended to be closer to the sand side drinker. However, there was no difference in the amount of feeding behavior that occurred on each side during the day. Because eating and drinking usually occur together, it would be expected that drinking would also occur approximately equally on

both sides of the pen, but this was not the case. Another possibility is that properties of the bedding affected the quality of the water. Bedding sometimes got into the automatic cup waterers, and the wood shavings became suspended in the water to a greater extent than the heavier sand. The result was that the water tended to stay cleaner on the sand side of the pen, which might be one reason that the birds walked to the sand side to drink. Also, when water spilled out onto the bedding the wood shavings in the area around the drinker became wetter than the sand. One advantage of using sand as bedding, then, would be that the water supply and the area around the water supply stays cleaner, at least when cup watering systems are used, as in the present study.

Our results agree with previous work showing that broiler chickens become increasingly inactive (Murphy and Preston, 1988; Newberry and Hall, 1990; Weeks et al., 2000). In the experiments presented here, behaviors such as sitting and preen sitting increased with time, whereas behaviors that required more energy expenditure such as locomotion, stand feeding, standing, aggression and chase decreased on both bedding types. In contrast, lighter-type breeds such as Leghorns are much more active than broilers, displaying behaviors such as aggression, running, and frolicking when they are 6 wk old (Mench, 1988). As mentioned previously, this increasing inactivity is probably largely a consequence of rapid growth rate and its associated effects on body conformation and leg problems. Slow-growing broilers are much more active at 6 weeks of age than are fast-growing broilers (Bokkers and Koene, 2003). The motivation to move around in familiar surroundings may also be lacking when the housing environment for broilers does not provide

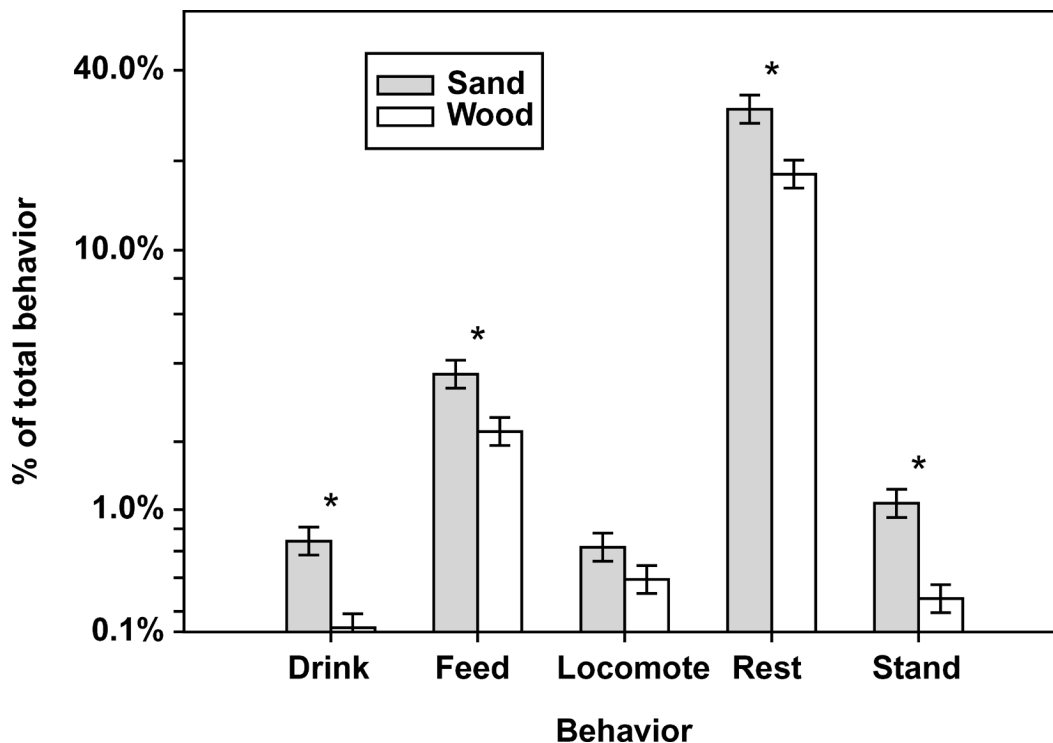


Figure 4. Overall distribution of behaviors on each side of the pen at night. \*Significant differences at P ≤ 0.05.



**Table 1.** Change in the behavioral time budget over the 6-wk period of experiment 2

Behavior	Change in behavioral time budget		Significant change? <sup>2</sup>
	Week 1 mean (95% CI) <sup>1</sup>	Week 6 mean (95% CI) <sup>1</sup>	
Aggressive	1.1% (0.7% – 1.5%)	0.2% (0.1% – 0.5%)	Yes
Chase	0.6% (0.3% – 0.9%)	0.0% (0.0% – 0.0%)	Yes
Drink	3.0% (2.3% – 3.8%)	3.0% (2.3% – 3.7%)	No
Dustbathe	1.0% (0.6% – 1.5%)	1.0% (0.6% – 1.5%)	No
Feed Sitting	1.1% (0.7% – 1.6%)	1.2% (0.8% – 1.7%)	No
Feed Standing	17.1% (15.5% – 18.7%)	12.2% (10.8% – 13.7%)	Yes
Locomote	5.0% (4.1% – 6.0%)	1.8% (1.3% – 2.4%)	Yes
Peck	6.5% (5.5% – 7.6%)	4.0% (3.2% – 4.9%)	Yes
Preen sitting	3.3% (2.6% – 4.2%)	7.4% (6.3% – 8.6%)	Yes
Preen standing	2.2% (1.6% – 2.9%)	1.0% (0.6% – 1.5%)	No
Scratch	0.6% (0.3% – 1.0%)	0.1% (0.0% – 0.3%)	No
Sit	47.0% (44.9% – 49.2%)	64.2% (62.1% – 66.2%)	Yes
Stand	10.1% (8.8% – 11.4%)	2.9% (2.2% – 3.7%)	Yes

<sup>1</sup>Mean percentage of time the behavior occupied in the time budget; the 95% confidence interval (CI) is shown in parenthesis

<sup>2</sup>Significance level of  $P < 0.05$ .

much complexity or novelty (Newberry, 1999). There are undoubtedly other factors that contribute to the decrease in activity as broilers age, and these may become apparent with additional experimental work.

In the first experiment, in which pens were divided, broilers used the divider to perch. As in other experiments that have reported that broilers do not use perches extensively (Hughes and Elson, 1977; Pettit-Riley and Estevez, 2001; Estevez et al., 2002), perching behavior was only a relatively small percentage of the time budget (0.7 to 3.0%). Also in agreement with other studies (LeVan et al., 2000; Pettit-Riley and Estevez, 2001), perching peaked in wks 3 and 4 and then decreased, probably as a consequence of growth-related changes in body conformation or leg soundness that make perching increasingly difficult.

In experiment 1, the finding that dustbathing was performed more on the sand than on the wood shavings is in agreement with previous work in our laboratory showing that broilers prefer sand to wood shavings, paper bedding, or rice hulls for dustbathing (Shields et al., 2004). Laying hens also prefer to dustbathe in sand rather than in wood shavings or straw (Petherick and Duncan, 1989; van Liere, 1991; Sanotra et al., 1995). The results of experiment 2 were more surprising, because based on experiment 1 it was expected that broilers housed on sand bedding would show more dustbathing behavior than those housed on shavings. Instead, the pattern of dustbathing behavior, as well as other behaviors, was similar on both bedding types. This finding suggests that the chickens' behavioral time budget was relatively inflexible and that they adjusted to the less preferred substrate.

The results of the second experiment may suggest that the preference for sand is a weak preference. But it is also possible that the motivation to perform the behaviors that we measured is so high that broilers will perform them even if the conditions are not ideal. Or it may be that other factors that differed between the 2 experiments, for example the strain of broilers used or the depth of the

bedding, caused a different pattern of substrate usage in the 2 studies. Obviously, more testing is warranted.

Several conclusions can be drawn from these studies. First, under the conditions in our experiment, broiler chickens rested more on sand, suggesting that there was some difference between sand and wood shavings that made the sand a preferred resting substrate. These observations also confirmed that broilers become increasingly inactive as they age. Finally, these studies demonstrated that, when given a choice, the broilers dustbathed, foraged, and drank more on sand than wood-shavings bedding but that their behavioral time budget was similar on wood-shavings bedding when no choice was provided. Because there was no difference in activity levels when broilers were raised on only shavings or sand, it is unlikely that the provision of sand bedding would improve leg condition due to exercise-related effects. Similarly, Arnould et al. (2004) found that, although broilers are attracted to trays of sand placed in their pens and use the sand preferentially for dustbathing and foraging, providing sand trays has little effect on overall locomotor activity and does not decrease leg problems.

The present experiments demonstrated a complex relationship between broiler behavior and bedding type. From these results it could not be determined definitively whether the broilers chose the sand to perform their activities or whether instead they performed more of their activities on the sand side simply because they preferred to spend their time on the sand. Further testing is, therefore, needed to determine the various motivating factors underlying broilers' choices of particular bedding types. Also, the experimental conditions in these studies differed in several important respects from commercial rearing conditions, and so it would be important to examine the effects on behavior of such variables as bedding depth and condition, stocking density, and lighting cycle.

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