Production, Bone Health, and Economic Comparison of Indoor versus Pasture-Raised Red Ranger Broilers

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Kayla Elmore, Graduate Research Assistant, Department of Animal Science, Iowa State University
Ajay Nair, Associate Professor, Department of Horticulture, Iowa State University
Elizabeth Bobeck, Associate Professor, Department of Animal Science, Iowa State University

Summary and Implications

Cover crop and livestock integrated systems are a sustainable practice that has been shown to improve soil health and system diversity. However, the effects of pasture-raised poultry systems on broiler performance and welfare have not been well-documented. The experimental objective was to compare the performance, physiological, and economic outcomes of Freedom Ranger broilers raised in outdoor pastured versus conventional indoor settings. 176 slow-growing Freedom Ranger broilers were started in brooders for 21d, and then half were transferred to either indoor floor pens or outdoor chicken tractors for a 6-week grow-out cycle. Performance and welfare measures were recorded weekly. At d64, 40 birds per treatment were euthanized for tibia collection, and bone mineral density was analyzed by Dual-energy X-ray Absorptiometry (DXA). Under our research conditions, performance and welfare measures were not significantly affected by housing treatments, but bone mineral content and density were significantly increased by 37.9% and 15.4%, respectively, in the outdoor flock ($P<0.05$). Future research will investigate the impacts of pasture-raised poultry systems on bird behavior and welfare.

Introduction

Livestock and cover crop integrated systems, such as pasture-raised poultry, aim to optimize nutrient usage within systems and minimize negative environmental impacts. Therefore, nutrients and energy from organic waste can be recycled by incorporating poultry into crop rotations, improving soil health, nutrient management, and soil quality while reducing pest management, fertilizer, and animal feed costs. However, relatively little is known about performance changes when integrating poultry into the crop rotation cycle, and even less is reported directly comparing pasture vs. indoor poultry. Therefore, the experimental objective was to determine the impact of housing system on Freedom Ranger growth performance, welfare, and bone quality.

Materials and Methods

All procedures were approved by the Iowa State University Institutional Animal Care and Use Committee. In spring 2021, 176 1d-old Freedom Ranger broilers were obtained from a commercial hatchery and transported to Iowa State University's Robert T. Hamilton Poultry Farm. To supply necessary supplementary heat during the brooding stage, the chicks were raised in brooders (12 birds/cage) for 3 weeks. On d21, birds were randomly assigned to 2 housing treatments, indoor (IN) and outdoor (OUT), for a 6-week grow-out cycle. 68 birds remained at Iowa State University's Robert T. Hamilton Poultry Farm and were housed on fresh litter in four 4 ft x 8 ft floor pens (17 birds/pen). 107 birds were transported to Iowa State University's Horticulture farm and housed on 30 ft x 30 ft spinach plots in four 5 ft x 10 ft partially covered tractors (27 birds/tractor). Tractors were moved to a new plot section daily to provide fresh ground and pasture foraging. The birds had *ad libitum* access to water and organic feed for the trial duration.

Pen body weight was recorded at placement and once weekly thereafter. Feed disappearance was recorded to determine feed intake, average daily gain, and feed conversion ratio. On d22, 20 birds per housing style were randomly selected for weekly welfare assessments, including footpad dermatitis, breast blister, and gait scoring. Scores were assigned according to National Chicken Council Animal Welfare Guidelines.

Footpad dermatitis scoring: Birds were removed from their home enclosures to assess each footpad. Water was used to rinse pads of debris when necessary. A passing score met the following criteria: normal skin and color or slight discoloration or darkening, hyperkeratosis, and lesions covering less than half of the footpad. A failing score included erosions, ulcers, or scab formation covering more than half of the footpad, including toes and hemorrhages or swelling.

Breast blister scoring: The breast blister presence was defined as being equal to or greater than 1.127mm. A score of 0 was described as having no blisters, score 1 was defined as small or colorless blisters and score 2 was defined as significant or dark-colored blisters.

Gait scoring: Birds were gently encouraged to walk a minimum of 5 feet. A score of 0 was defined as walking at

least 5 feet with no visible signs of lameness. A score of 1 was defined as walking at least 5 feet, but steps appeared awkward or uneven. A score of 2 was described as unable to walk 5 feet without sitting down or having obvious lameness.

Bone analyses: On d64, 40 birds per treatment were harvested at Iowa State University's Meat Lab for tibia collection. The cartilage cap was removed from the right tibia, and bone mineral density was analyzed by Dual-energy X-ray Absorptiometry (DXA).

Economic analysis: Feed costs were recorded throughout the study. On d64, the average feed cost per bird was calculated based on average feed intake and was corrected for mortality.

Performance and DXA data were analyzed using PROC MIXED (SAS version 9.4). Footpad dermatitis, breast blister, and gait scores were observed by treatment, and gait scores were analyzed using PROC FREQ. Differences between means were detected using PDIFF, and a p-value of 0.05 or lower was considered significant.

Results and Discussion

No significant differences were detected between treatments across feed intake, weight gain, average daily gain, or carcass weight ($P > 0.10$). However, OUT birds had a significantly increased FCR by 30 points during the finisher phase ($P = 0.0138$; Table 1). Further, this result drastically increased the total feed cost per kg of gain by $0.38 per OUT bird compared to IN during the finisher phase (Table 3). When comparing the overall cost per bird based on feed intake, the OUT birds cost $0.09 more per bird on average (Table 3). We hypothesized that OUT birds might have reduced performance (i.e. altered feed intake or gain) compared to IN birds due to the ability to forage on less digestible plant matter during the growth cycle in addition to time spent foraging. Additionally, the OUT birds had a less temperature-controlled environment compared to IN (Figure 2). When comparing temperatures and FCR over time, there is not a clear indicator of negative impact of weather fluctuations on FCR in our setting, but more investigation is needed. Because spinach was depleted quickly upon moving the tractor, and did not replenish itself with repeated exposures, the lack of housing treatment effect in other performance parameters may have resulted from this quick reduction in plant matter (Photo 1).

Bone mineral content and density were significantly improved in the OUT treatment, with the OUT birds having 37.9% more bone mineral content and 15.4% more bone mineral density than IN ($P= 0.0147$ and 0.0037, Table 2). Bone area remained unaffected by treatment ($P= 0.0988$). The addition of daily tractor movement and natural environment stimuli may be interpreted as a cause for a positive effect on bone mineral content and density due to new environment and increased motivation to forage.

Footpad dermatitis and breast blisters were not observed in either treatment. In addition, all IN birds received a gait score of 0 over the six consecutive weeks. However, only 95.8% of OUT birds received a gait score of 0 and 5 scorings of 1. Two scores of 1 were present during week 5 and one score of 1 on weeks 6, 7, and 8 (Figure 1). Leg lameness prevalence increased by approximately 4.2% in the OUT birds when compared to the IN birds, however, lameness presence overall was low.

In conclusion, birds housed in the OUT housing system were less feed efficient during the finisher period, costing $0.09 more in feed per bird, but had little to no effect on all other performance measures throughout all growing periods. While the OUT housing system did not negatively impact footpad dermatitis or breast blister occurrence, it did have a positive impact on bone mineral content and density. In future work, bird behavior will be examined to investigate further the impacts of pasture-raised poultry systems on bird welfare.

Photo 1. Spinach plots with chicken tractors during the day of bird placement.

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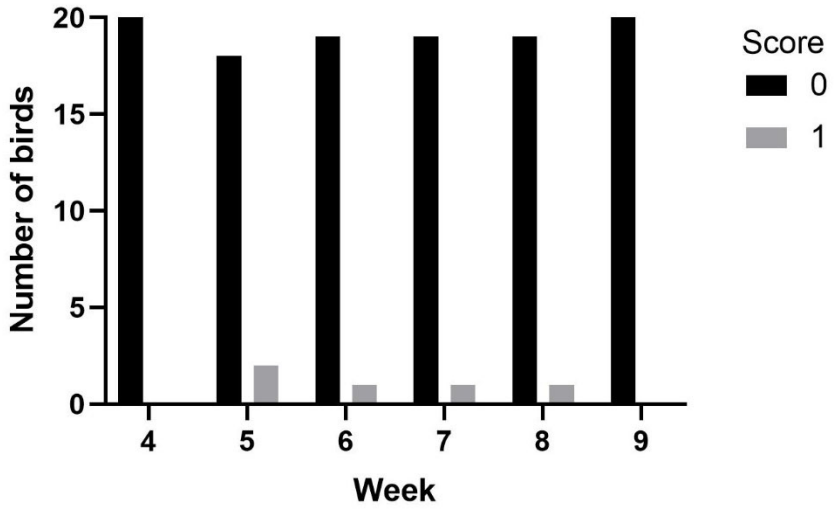

Figure 1. Distribution of gait scoring of the outdoor flock by week. A total of 20 slow-growing broilers received weekly scores using a 0-2 scale over six consecutive weeks. IN birds are not represented as no scores above 0 were observed over the six consecutive weeks.

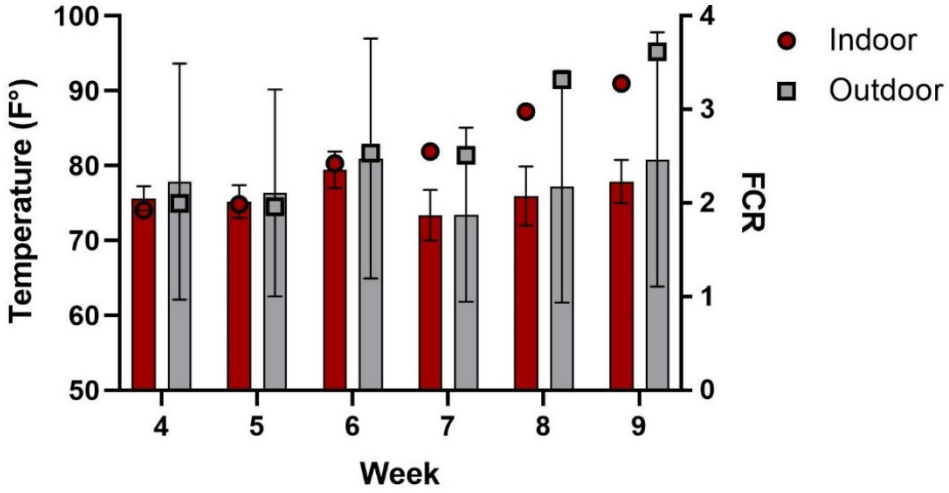

Figure 2. The average feed-to-gain ratio (FCR) with standard error per bird (dots) with the average ambient temperature per week (bars) for both IN and OUT treatments.

Table 1. Average feed intake, weight gain, ADG[1], and FCR[2] by each growing phase and overall, averaged per bird. *Within rows, letters denote means are significantly different (P<0.05).*

Performance Measure	IN[3]	OUT[4]	SEM	P-value
Feed Intake (kg)				
Brooder	0.79	0.79	0.007	
Grower	3.21	3.24	0.110	0.7894
Finisher	2.31	2.36	0.141	0.7615
Overall	6.31	6.39	0.250	0.7730
Weight Gain (kg)				
Brooder	0.47	0.47	0.003	
Grower	1.42	1.44	0.122	0.8374
Finisher	0.74	0.69	0.058	0.4875
Overall	2.63	2.60	0.180	0.9184
ADG (kg)				
Brooder	0.038	0.038	0.0002	
Grower	0.051	0.052	0.0043	0.8374
Finisher	0.053	0.049	0.0042	0.4875
Overall	0.042	0.041	0.0029	0.9184
FCR (kg)				
Brooder	1.67	1.67	0.015	
Grower	2.26	2.25	0.054	0.5969
Finisher	3.12[a]	3.42[b]	0.036	0.0138
Overall	2.40	2.46	0.033	0.3009

Growing phases include brooder wk 1-3, grower wk 4-7, and finisher wk 8-9.
[1]ADG= Average Daily Gain
[2]FCR= Feed Conversion Ratio
[3]IN= Indoor flock
[4]OUT= Outdoor flock

Table 2. Average carcass weight, area, BMC[1], and BMD[2] readings of dual-energy x-ray absorptiometry (DXA) postmortem. *Within rows, letters denote means are significantly different (P<0.05).*

DXA Measure	IN[3]	OUT[4]	SEM	P-value
Carcass Weight (kg)	2.158	2.069	0.0612	0.1508
Area	1.797	2.398	0.3590	0.0988
BMC (kg)	0.118[a]	0.190[b]	0.0289	0.0149
BMD (g/cm^3)	0.066[a]	0.078[b]	0.0040	0.0037

[1]BMC= Bone Mineral Content
[2]BMD= Bone Mineral Density
[3]IN= Indoor flock
[4]OUT= Outdoor flock

Table 3. Average feed intake and body weight by each growing phase and overall, averaged per bird. Total feed cost and total feed cost per kg of gain by growing phase, averaged per bird and corrected by mortality. Feed costs were $1.25 per kg. Brooder included the first 3 weeks of life, grower included weeks 4-7, finisher included weeks 8-9. Feed cost per kg animal was calculated by cost per kg feed x feed conversion ratio; on a per bird basis for each phase.

Performance Measure	IN[1]	OUT[2]
Feed Intake (kg)		
Brooder	0.79	0.79
Grower	3.21	3.24
Finisher	2.31	2.36
Overall	6.31	6.39
Feed Cost (US dollar)		
Brooder	$0.99	$0.99
Grower	$4.02	$4.05
Finisher	$2.89	$2.95
Overall	$7.90	$7.99
FCR		
Brooder	1.67	1.67
Grower	2.26	2.25
Finisher	3.12	3.42
Overall	2.40	2.46
Feed Cost / kg Gain		
Brooder	$2.09	$2.09
Grower	$3.12	$2.82
Finisher	$3.90	$4.28
Overall	$3.00	$3.08

[1]IN= Indoor flock
[2]OUT= Outdoor flock