Growth performance of fast-growing broilers reared under different types of production systems with outdoor access: Implications for organic and alternative production systems

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Primary Audience: Free Range Producers, Researchers, Organic Producers

SUMMARY

Outdoor access is an important part of organic and free-range poultry production, yet limited information exists on the effect of various housing and production systems on growth performance and colonization of food-borne pathogens. Therefore, the primary purpose of the current study was to evaluate the influence of different housing systems, particularly fixed versus small, portable houses, with and without outdoor access to pasture, on seasonal growth performance, leg quality, and presence of bacterial food-borne pathogens. In the current study, we used fast-growing broilers, as many small producers use commercial broilers due to their carcass conformation and high breast yield compared with slow-growing hybrids or standard heritage breeds. Although interest in alternative genetics exists because they may be more adapted to outdoor production, they require longer growing periods, with accompanying labor and cost. A pasture containing a mixture of forages was used to simulate the conditions common for small farms in the local region. The experiment had 4 treatment groups: (1) small, portable hoop houses with access to pasture, (2) small, portable hoop houses without access to pasture, (3) a fixed house with access to the outdoors, and (4) a fixed house without access to the outdoors. The present study was repeated at different times of the year to determine if a seasonal effect on the consumption of pasture and carcass quality was present. Overall, raising birds in hoop houses resulted in a reduced growth rate compared with birds raised in the fixed house. None of the production systems altered bone strength or feed conversion. Food-borne pathogens commonly associated with poultry were not found in any of the environments tested. Seasonal production was an issue in the small hoop house birds, as extreme heat in the summer resulted in early termination of that trial. Expanding on forage choice in pastures and customizing hoop houses to deal with weather fluctuations, especially in regions where extreme heat may affect production, are important considerations for these systems.

Key words: free range, broiler, range management, organic

2014 J. Appl. Poult. Res. 23:212–220
http://dx.doi.org/10.3382/japr.2013-00882

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DESCRIPTION OF PROBLEM

Interest in both the production and consumer demand for free-range and organic poultry has increased. Certified organic poultry has increased to over 30 million certified broilers, 7.6 million certified layer hens, and 785,000 certified organic turkeys in 2011 [1], and this market continues to grow. The USDA National Organic Program [2] rules require producers of organic poultry to provide outside access to birds. Alternative production systems vary from fixed houses with outdoor access (semi-intensive) to small, portable houses moved regularly to provide extensive space. When regular access to fresh forage is also a goal, it is often termed pastured poultry. Many small growers assume that access to pasture will result in improved FE and better growth [3, 4]. Additional production systems include access to the outdoors but may lack vegetation due to the dry season or dormant forages in winter. Whereas slow-growing meat chickens are often used in alternative production due to their rustic qualities and high foraging behavior, some free-range producers in the United States use modern fast-growing broilers. Whereas fast-growing broilers may not be adapted to outdoor production, they are faster growing and use feed more efficiently than slower growing strains or standard breeds, thus reducing the cost of feed as well as labor. Though some research involving slow-growing meat birds exists [5, 6], a lack of data has been noted as to how different types of free-range production systems affect the growth of commercial fast-growing broilers. An interest in how leg quality of broilers will be influenced with access to the outdoors or access to pasture has also been observed.

Due to the cost of maintaining pastures, many pasture poultry producers use pastures that are integrated with other livestock. These pastures are not planted to maximize forage consumption by broilers, but rather by ruminants. In the south-central parts of the United States these pastures consist of tall fescue (*Festuca arundinaceus*) and Bermuda grass (*Cynodon dactylon*), along with some legumes and forbs. Though poultry do consume forages, the amount of benefit they receive is dependent on the type of forage they consume, with legumes generally being more beneficial than grasses due to higher protein and lower fiber content [7]. Likewise, the breed of chicken used will also affect how well they forage, with fast-growing broilers possibly foraging less than slow-growing meat chickens, layers, and standard breeds [8].

The purpose of the present study was to compare the growth and FE of modern broilers reared under different housing and production systems with outdoor access. In addition, birds and their environment were sampled for *Salmonella* and *Campylobacter* to determine what affect management had on the prevalence of these food-borne pathogens.

MATERIALS AND METHODS

Housing and Experimental Design

Small, portable hoop houses are a common method used to house poultry in free-range production systems. A small hoop house is an example; these typically consist of a mobile shelter that confines birds within the hoop house but are open on the bottom, allowing direct access to pasture. They provide protection from predators, allow birds to be sheltered from weather extremes, and usually receive some direct sunlight during at least part of the day. Houses are normally moved daily (or more often) to fresh pasture. The temperature in hoop houses typically fluctuates more than large fixed houses, as they often do not have the insulation necessary to hold heat at night or remain cool during the daytime. Additionally, as hoop houses are constantly being moved, they are not connected to power for mechanical ventilation or heating and must rely on natural air movement to ventilate on hot days or sunshine for warmth during cold weather. For these reasons, many growers choose to raise birds seasonally to avoid growing birds during the hottest and coldest times of year.

This study consisted of 4 treatment groups that were evaluated during the spring, summer, or fall to account for seasonal differences caused by weather and forage quality. The small hoop houses used in the current study included a small enclosed hut with flooring for protection against the elements and an attached run (2.6 m^2) that allowed direct access to pasture. Treatment 1 (portable hoop house with pasture) consisted of

Figure 1. Example of the hoop houses used in the present study.

broilers reared in hoop houses with access to 2.6 m^2 of pasture that were moved daily to provide fresh pasture for the birds (Figure 1). Treatment 2 (hoop house no pasture) consisted of broilers reared in hoop houses with a wooden floor inserted to prevent access to pasture. Treatment 3 (Fixed house with outdoor access) birds were housed in a fixed cinder block chicken house (Figure 2) with an indoor area of 9.3 m^2 and access to 93 m^2 of outdoor pasture. Treatment 4 (Fixed house no outdoor access) was housed in the same building, but without access to pasture. Each time the study was done, 260 Cobb 1-d-old male chicks were reared at the USDA Free Range and Organic Research Facility in Fayetteville, Arkansas. Prior to treatment placement, all birds were brooded in a naturally ventilated block house with a cement floor covered with 10 to 12 cm of shavings. All chicks were cool-room brooded in the fixed house using heat lamps as the only source of heat, with feed and water provided ad libitum. The fixed house contained glass windows to allow for natural air flow and lighting; the small hoop houses had small plexiglass windows. The birds in the fixed house treatment were housed in floor pens covered with litter; feed and water were provided indoors.

Immediately before allocation to treatment groups at 21 d of age, 20 birds were collected and evaluated for cecal *Salmonella* or *Campylobacter* counts. Following this collection, the other 240 chicks were randomly divided into 1 of the 4 treatment groups, with 60 birds being placed in each treatment. Six replications of treatments were carried out using small hoop houses (10 birds per house) and 4 replications of treatments using fixed house (15 birds per floor pen). At the time the birds in treatments 1 and 2 were moved to hoop houses, all birds, including those in treatments 3 and 4, were collected and transported to new pens in the same manner to try and eliminate transportation stress as a variable. All segments of this project complied with the provisions of the Institutional Animal Care and Use Committee, as specified by the Animal and Plant Health Inspection Service, USDA in 9 CFR Part 1 (1–91) [9].

Evaluation of Growth Performance

Feed and water were provided ad libitum and birds were weighed weekly. Feed was fully formulated for starter and growers diets and met or exceeded NRC requirements [10]. Feed consumption was recorded weekly from 21 until 49 d of age and feed conversion was determined weekly. Birds were maintained on natural light once they were separated into treatment groups. The 49-d growing period was selected to mimic the production methods of local small growers.

Pasture analysis was done at the Central Analytical Laboratory, University of Arkansas. During each trial, pastures were analyzed to determine the quality of DM, protein, ash, fat, and NDF according to the standard methods [11]. Neutral detergent fiber is a measure of the fibrous parts of the plants, such as cel-

Figure 2. Fixed house used in the current study.

lulose, lignin, and hemicellulose. These parts are not easily digested by chickens, as they lack the enzymes necessary to break them down. The pasture samples were collected from 5 different locations in the pasture one week after the birds were placed on pasture. Samples were collected by cutting the vegetation from a 30- × 30-cm area. The samples were then combined into a composite sample for analysis.

The left tibiotarsus of each bird was also collected to test for bone strength. The tibiotarsi were cleaned of all muscle and connective tissue and stored in plastic bags at −20°C until 24 h before evaluation. Bone-breaking strength was measured using an Instron 4502 [12] with a 100-kg load cell and a crosshead speed of 20 mm/min collecting 10 data points per second; bones were supported on a 30-mm span. The bone-breaking strength (kg/mm of diameter) was determined by dividing the stress at yield by the diameter of the tibia [13, 14].

Microbial Evaluation

Twenty birds were euthanized, had ceca removed, and were evaluated for *Campylobacter* and *Salmonella* on d 21, with an additional 2 birds per pen (48 birds total) evaluated at 5 and 7 wk of age. Drag swabs (24 swabs per sampling) were pulled at these times to assess the environment for *Campylobacter* and *Salmonella.* Drag swabs were pulled, while applying light pressure, for 2 m in every pen and hoop house, and for 2 m in the fixed runs 1 m outside the fixed house of each pen with outside access. Samples were placed in sterile sample bags at the time of collection and disposable gloves worn during collection were changed after each sample to prevent cross-contamination.

In the laboratory, drag swabs were cut in half and one half was placed in *Campylobacter*-en-

Table 1. Results of the pasture analysis of during the different seasons the study was conducted[1]

Item (%)	Spring	Summer	Fall
DM	22.0	30.3	20.2
Protein	20.0	16.4	19.9
Ash	10.3	7.9	9.1
Fat	3.5	2.9	3.1
NDF	57.1	65.1	64.5

[1]Results shown are the means of samples that were collected at that time of year and represent a proximate analysis on 5 samples/treatment.

Table 2. Mean temperature during the trials

Item (°C)	Mean daily low	Mean daily temperature	Mean daily high	Lowest temperature	Highest temperature
Spring	9.4	15.5	22.1	−3.3	29.4
Summer	15.6	22.6	30.4	5.0	38.3
Fall	13.5	19.2	26.3	−0.5	37.2

richment broth [15] and incubated for 48 h at 42°C under microaerophilic conditions. After incubation, *Campylobacter* line agar [16] plates were streaked with 10 µL of broth sample and incubated for 48 h at 42°C then examined for characteristic colonies of *Campylobacter*. The other half of the drag swab was placed in tetrathionate broth and incubated for 18 to 24 h at 42°C. Following incubation, 10 µL of the sample was plated on brilliant green sulfa agar and XLT4 [17] agar plates and then incubated overnight at 37°C [18]. Plates were examined for characteristic *Salmonella* colonies. Confirmation of *Campylobacter* was performed using latex agglutination assay [19], and *Salmonella* using Difco BBL *Salmonella* O Antiserum Group Poly A-I and Vi [17].

Campylobacter evaluation from birds was performed using the procedure described by Aguiar et al. [20]. Two birds per pen were euthanized by approved Institutional Animal Care and Use Committee methods and had ceca removed. At the time of collection, ceca from each bird were placed into sterile sample bags and transported to the laboratory. Up to 1 g of cecal contents were squeezed into 15-mL tubes, serially diluted (1:10) with Butterfield's phosphate diluent [21], and then inoculated onto labeled *Campylobacter* line agar plates. Plates were incubated for 48 h at 42°C under microaerophilic conditions and then direct plates counts were recorded for *Campylobacter* colonies and converted to colony-forming units per gram.

Salmonella was evaluated by placing the cecum and its contents into sterile containers containing tetrathionate broth and incubating for 18 to 24 h at 42°C. A 10-µL sample was then plated on brilliant green sulfa agar and XLT4 agar plates, which were incubated overnight at 37°C. Plates were then examined for characteristic *Salmonella* colonies. Confirmation tests were as previously described.

Statistical Analysis

Data were subjected to ANOVA procedures using JMP [22], with significance determined between means with a P-value of less than 0.05.

RESULTS AND DISCUSSION

The results of the pasture analysis are shown in Table 1. Whereas the pasture quality was similar for the spring and fall, the summer pasture had a lower moisture and protein content. In addition, this difference in pasture quality could be explained by the higher temperatures (Table 2) and lower precipitation that occurred during the summer months, resulting in the pasture drying. Typically cool-season forages are higher quality than warm-season forages.

Only one week after birds were moved to hoop houses, BW were significantly less for wk

Table 3. Body weights for the birds grown in the spring (weight ± SEM)[1]

Treatment (g)	Bird age 4 wk	5 wk	6 wk	7 wk
Hoop house with pasture	1,154.4 ± 12.9^{b}	1,707.7 ± 19.0^{b}	2,429.6 ± 29.6^{b}	3,069.8 ± 42.8^{b}
Hoop house with no pasture	1,168.0 ± 12.1^{b}	1,722.0 ± 18.8^{b}	2,468.1 ± 25.9^{b}	3,128.4 ± 28.0^{b}
Fixed house with outdoor access	1,220.9 ± 16.6^{a}	1,853.4 ± 19.3^{a}	2,632.9 ± 22.0^{a}	3,428.1 ± 27.1^{a}
Fixed house with no outdoor access	1,231.3 ± 15.8^{a}	1,868.1 ± 19.1^{a}	2,594.6 ± 31.5^{a}	3,365.2 ± 38.6^{a}

^{a,b}Different letters in a column signify difference at $P < 0.05$.

[1]Birds were reared together for the first 3 wk and moved into treatment groups at that time (d 21).

Table 4. Body weights for birds grown in the summer (weight ± SEM)[1,2]

	Bird age		
Treatment (g)	4 wk	5 wk	6 wk
Hoop house with pasture	1,213.4 ± 10.9	1,764.5 ± 13.8[b]	2,259.5 ± 17.0[b]
Hoop house with no pasture	1,206.4 ± 12.4	1,746.5 ± 15.8[b]	2,208.2 ± 19.0[b]
Fixed house with outdoor access	1,224.7 ± 17.1	1,841.7 ± 25.4[a]	2,517.5 ± 27.5[a]
Fixed house with no outdoor access	1,228.4 ± 15.0	1,881.0 ± 21.0[a]	2,578.1 ± 27.2[a]

[a,b]Different letters in a column signify difference at $P < 0.05$.

[1]Birds were reared together for the first 3 wk and then moved into treatment groups.

[2]Trial was ended early due to welfare concerns for the birds due to high heat.

4, 5, 6, and 7 for both the spring- and fall-raised birds when compared with the birds raised in the fixed house (Table 3). For the summer-raised birds, although no difference in BW was detected in the first week after placement in the hoop houses (wk 4, Tables 4 and 5), BW were reduced by wk 5 and 6 when compared with the fixed house. During the summer trial, birds were removed from the hoop houses after wk 6 because of excessive ambient temperatures (above 37 C^{o} for 5 consecutive days), extreme drought conditions, and concerns about animal welfare. Fixed housing for free-range poultry can be engineered to create drafts. For example, the fixed house in the current study allowed air to enter via the popholes and rise over 12 ft to exit through the ridge line vent, creating a cooling draft at bird level. However, small, portable houses provide the opportunity to move housing to fresh pasture. In the temperate climate conditions of northwest Arkansas, the hoop houses in our study were not optimized for use in the summer. We have thus observed that many local farmers have adjusted their management using shade cloths and hoop houses with larger frames (Figure 3) and open design to allow for cross ventilation and dissipation of heat. The hoop houses used in the current study were not optimal for use in the summer, especially for the climate of northwest Arkansas. The design needs to be modified to allow for cross ventilation and effective dissipation of heat (Figure 3). No advantage in feed conversion was noted for birds with access to pasture or to outdoors during any season of this study (Table 6). Whereas the birds were observed consuming forages, the lack of difference in feed conversion between the different management systems indicates that they received little nutritional benefit from forage or that the amount that they consumed was insignificant when offered a fully formulated diet. This may be because pastures were not established specifically for poultry. Forage consumption by poultry is influenced by several factors, including the amount of time spent outdoors, amount of foraging behavior, type of plant, stage of growth, palatability, and nutritional content of the plants and nutritional needs of the birds [23]. The amount of forage that birds consume depends on the feeding method; for example, free-choice or cafeteria feeding is a method to increase the amount of nutrients that birds seek from forage. Based on research and on-farm observations, birds raised on pasture require less

Table 5. Body weights for the birds grown in the fall (weight ± SEM)[1]

	Bird age			
Treatment (g)	4 wk	5 wk	6 wk	7 wk
Hoop house with pasture	1,245.0 ± 10.1[b]	1,819.7 ± 14.9[b]	2,488.7 ± 24.4[b]	3,181.2 ± 29.8[b]
Hoop house with no pasture	1,219.3 ± 9.9[b]	1,810.4 ± 18.5[b]	2,479.5 ± 22.0[b]	3,143.4 ± 27.7[b]
Fixed house with outdoor access	1,335.3 ± 12.4[a]	2,011.1 ± 17.8[a]	2,783.3 ± 28.3[a]	3,457.8 ± 36.3[a]
Fixed house with no outdoor access	1,327.9 ± 11.5[a]	1,989.3 ± 18.25[a]	2,770.3 ± 25.3[a]	3,488.4 ± 32.0[a]

[a,b]Different letters in a column signify difference at $P < 0.05$.

[1]Birds were reared together of the first 3 wk and then moved into treatment groups at that time.

Table 6. Feed conversion at 6 wk of age (kilograms of feed required for a kilogram of weight gain)[1]

Treatment	Spring	Summer	Fall
Hoop house with pasture	1.85 ± 0.05	1.81 ± 0.02	1.81 ± 0.02
Hoop house with no pasture	1.86 ± 0.04	1.78 ± 0.08	1.83 ± 0.02
Fixed house with outdoor access	1.90 ± 0.04	1.81 ± 0.02	1.77 ± 0.01
Fixed house with no outdoor access	1.90 ± 0.05	1.79 ± 0.02	1.80 ± 0.01

[1]Numbers in a column were not significantly different at $P < 0.05$.

protein than birds raised in commercial settings [2]. Raising poultry on suitable forages, such as legumes, may result in improved FE. High-quality forage can provide significant protein, vitamins, and phytochemicals.

The results of the tibiotarsus breaking strength are shown in Table 7. No difference was observed in the amount of force required to break the tibiotarsi between the treatments at wk 7 for either the spring- or fall-raised birds. The summer-raised birds were not evaluated, as they were removed from the study after wk 6 due to excessive environmental heat. Researchers of alternative rearing systems for layers have indicated that physical activity would enhance bone strength [24]; however, others [25, 26] found that increased activity did not change the shear strength of the tibia. No *Salmonella* or *Campylobacter* counts were found in any of the cecal or environmental samples in this experiment. Because no positive samples were found, we suggest that biosecurity measures were effective for preventing contamination of all treatment groups.

CONCLUSIONS AND APPLICATIONS

1. Access to pasture or to the outdoors did not alter growth rate or feed conversion.

Figure 3. A modified design of the hoop house used by a local farmer.

Table 7. Bone strength comparison for birds in varying housing systems (stress at yield kilograms per millimeters of diameter)[1,2]

Treatment	Spring	Fall
Hoop house with pasture	6.3 ± 0.2	6.7 ± 0.1
Hoop house with no pasture	6.3 ± 0.2	6.5 ± 0.2
Fixed house with outdoor access	6.7 ± 0.2	6.4 ± 0.1
Fixed house without outdoor access	6.2 ± 0.2	6.8 ± 0.2

[1]Numbers in a column were not significantly different at $P < 0.05$.

[2]Summer data not available as it was terminated early for welfare concerns.

2. Access to pasture or to the outdoors had no effect on the tibial bone strength or *Salmonella* or *Campylobacter* counts.
3. Raising birds in small, portable hoop houses decreased their rate of growth in the current study. However, management strategies, such as the use of shade cloths, may mitigate the effect of high temperatures.
4. Also, the amount of forage that birds consume depends on the feeding method; for example, free-choice or cafeteria feeding is an alternative feeding method that uses nutrients, particularly protein and vitamins, in pasture forage without diluting a fully formulated diet [27].

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Acknowledgments

This work was funded in part by the USDA, National Institute of Food and Agriculture, Organic Agriculture Research and Extension Initiative Grant 2011-01955 (Washington, DC). Additionally, the authors thank Robert Holmes and Trish Lowery (University of Arkansas) and Scott Zornes, and Wally McDonner (USDA, Agricultural Research Service) for their assistance in conducting this research.