ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 11 (7): 438-444, 2012
ISSN 1682-8356

Live Performance Characteristics, Pathogen Load and Foot Pad Lesions in Range-Reared Heritage vs. Conventional Turkeys (*Meleagris gallopavo*)

B.A. McCrea[1], M.A. Leslie[2], L.M. Stevenson[3], K.S. Macklin[3], L.J. Bauermeister[3] and J.B. Hess[3]
[1]Department of Agriculture and Natural Resources, Delaware State University, Dover, DE, USA
[2]Masterfeeds, London, Ontario, Canada, [3]Department of Poultry Science,
Auburn University, Auburn, AL, 36849-5416, USA

Abstract: A study was performed to compare the performance of heritage (Bourbon Red) and conventional (Broad Breasted White) turkey varieties in an outdoor range management system in the Southeastern United States. Turkeys were brooded indoors to 4 weeks of age and then moved to outdoor pens until processed at 17 weeks of age. Period and cumulative BW gain, feed intake and feed conversion were compared at 7, 10, 13 and 17 weeks of age. The final live weight, carcass weight and carcass yield were compared for both varieties and sexes of turkeys. Foot pad lesions were scored at 4, 7, 10, 13 and 17 weeks of age. The presence of *Salmonella, Campylobacter, Clostridium perfringens,* total aerobes and total enteric counts were determined via cloacal swabs or carcass rinsate. Significant differences between varieties with regard to live performance and carcass data were noted. The BBW turkeys had a higher feed intake, weight gain, live weights, carcass weights and carcass yields than the BR turkeys. Significant differences between the sexes for live weight and carcass weight but not carcass yield were also noted. Foot pad lesions were often identified in the BBW strain, with the majority of the BBW turkeys (75.2%) having detectable lesions by week 17. In comparison, the BR turkey had no lesions at week 17. The pathogen load of the two varieties was not different with the exception of *Clostridium perfringens* and total anaerobic counts, both of which were higher in BBW. The data collected in this study will aid small producers with alternative production of heritage turkey varieties.

Key words: Turkeys, free range, *Salmonella*, *Campylobacter*, *Clostridium perfringens*, pododermatitis, heritage turkey

INTRODUCTION

In the United States, heritage turkeys are of interest to the consumer (Shriver, 2003 'Heritage' turkeys bring that old taste home. http:// www. usatoday. com/life/2003-11-05-turkey_x.htm Accessed Sept. 2009). The movement toward non-conventional poultry includes the marketing of specific heritage turkey varieties, such as the Bourbon Red (BR). Consumer (i.e., Slow Food, USA) and livestock conservation groups (i.e., American Livestock Breeds Conservancy; American Pastured Poultry Producers Association) support the use of alternative genetics on small farms for diversity and breed conservation. Heritage varieties are standard varieties used in past commercial turkey production. Heritage turkey varieties are the forerunners of the Broad Breasted White (BBW) variety, are slow-growing and mate naturally.

Poultry research in this area has been limited but many sustainable agriculture groups, such as Sustainable Agriculture Research and Education (SARE) and Animal Welfare Approved are funding studies to better extend information to producers. Some pastured turkey producers make claims about their methods of raising birds (i.e., improved health and vigor of their birds; yields and profitability) (Glass, 2003; Padgham, 2002; Rich, 1998). These claims have stimulated a few research forays into the feasibility of these statements in which different aspects of heritage turkeys were examined to determine if they have the potential for integration into and improvement of conventional turkey varieties. A survey of pasture turkey producers from eight locations in the United States included records on the weight gain, feed conversion, carcass yield, morbidity and mortality (Bender, 2006). Hartman *et al.* (2006) studied the relatedness of conventional and heritage turkey varieties with an aim to examine health status. Research into morphological, physiological and genetic differences among heritage varieties have been studied with an aim to use these characteristics for the improvement of the conventional turkey (Kamara *et al.*, 2007; Smith *et al.*, 2005).

Similarly, research into alternatively-grown broilers has been completed by Fanatico *et al.* (2005) in which carcass yield in both fast and slow-growing broilers raised outdoors were found to be significantly different. Bone strength was improved but outdoor access did not

Corresponding Author: J.B. Hess, Department of Poultry Science, Auburn University, Auburn, AL, 36849-5416, USA

have an effect on weight gain, feed intake, feed efficiency, or yield for any strain of broiler. Conversely, Lance (1983) found that Georgia producers could grow heavier and more efficient turkeys on open range than in confinement houses, albeit this was a survey of large-scale turkey production. This may provide an opportunity for niche market flock owners to realize greater profits when raising heritage turkeys outdoors.

Given the variable results obtained from researchers with prior experience in conducting studies on poultry raised both indoors and outside, this study was designed to assess turkey production for a niche market in Alabama. The study determined the impact of small-scale range turkey production on the live performance characteristics of conventional and heritage turkeys. In addition, both foot pad lesions scores and pathogen load data were collected to better define the profile of this niche market for producers in the warm climates.

MATERIALS AND METHODS

Experimental design: A trial was performed at the Auburn University Poultry Research Farm during the late summer and early fall. All procedures were approved by the Auburn University Institutional Animal Care and Use Committee. Food and water were provided *ad libitum*. Feed was provided via a single, hanging, galvanized metal, tube-type feeder that was designed to hold 40lb. of feed. One feeder of this type was provided to each pen during brooding and also one feeder of this type was provided in each outdoor range pen. The watering system within the brooding pens consisted of nipple drinkers with one nipple for every 12 inches of pen length. The watering system in the outdoor range pens consisted of one turkey plasson waterers per pen. Two turkey varieties were compared: the conventional Broad-breasted White (BBW; Ridgeway Hatchery, LaRue, OH) and a Bourbon Red (BR; Decorah Hatchery, Decorah, IA) heritage variety. The age and strain of the breeder flocks was unknown. Beaks and toenails were not trimmed. No vaccinations were ordered at the time of purchase. Brooding of poults was completed in 1.22×3.05 m pens inside a conventional poultry house. One brooding pen was used for each variety of turkey with 66 straight-run poults per pen. Brooding pens provided food and water *ad libitum*, pine shaving bedding and natural lighting conditions. Poults were brooded until 4 weeks of age and then moved to outdoor range pens. Due to the heat of summer, supplemental heat was needed only during the first week of brooding.

For each variety, poults were randomly assigned to one of three outdoor range pens with final numbers being 22 birds/pen. Turkeys were maintained in 4.27×21.34 m pens (4.14 m^2/bird) under natural lighting conditions. Poults were maintained in these outdoor range pens until 17 weeks of age. Before bird placement, range pens were seeded with a mixture of Tall Fescue and Bermuda grass. Pens were covered with bird netting to prevent mortality due to predation. Next to the shelter in each pen, shade cloth was added to provide relief from the sun (Fig. 5). Temperature and humidity readings were recorded daily in the morning for the duration of the trial (Table 4).

Turkeys were weighed at four weeks of age and every three weeks thereafter. Specific diets for the duration of the study are described in Table 2 with the balance of each diet consisting of vitamins, trace minerals, calcium, phosphorous and salt. The starter diet did not contain a coccidiostat. The starter diet was pelletized and then crumbled, while all other diets were pelletized. Period and cumulative BW gain, feed intake and feed conversion were compared at 7, 10, 13 and 17 weeks of age. The sex of the birds in the BR treatment could not be determined until 17 weeks of age.

All turkeys were processed at 17 weeks of age. Carcass weights were determined after chilling. Carcasses were processed as whole carcasses without giblets (WOGs). All birds were processed on the same day.

Bacterial isolation: Cloacal swabs and carcass rinsate were used to assess the presence of pathogens associated with turkeys. Both cloacal swabs and carcass rinsate samples were examined for *Salmonella* and *Campylobacter*. *Clostridium perfringens*, total aerobic counts and total enteric counts were taken from carcass rinsate samples alone. Cloacal swabs were taken the day before slaughter from five randomly selected birds in each pen. Each bird was swabbed twice using a sterile cotton-tipped applicator which was immediately placed into a tube containing 5 mL sterile phosphate-buffered saline for *Salmonella* culture or Bolton's Broth (Fisher Scientific, Pittsburgh, PA) for *Campylobacter* culture. Within the Auburn University Poultry Processing Facility, four randomly selected carcasses were rinsed, each with 400 ml of buffered peptone water (BPW), for each pen according to the procedure described in the Microbiology Laboratory Handbook (Microbiology Laboratory Handbook. 2003. Isolation and identification of *Salmonella* from meat, poultry and egg products. Food Safety and Inspection Service. Available at: http://www.fsis.usda.gov/Science/Microbiological_Lab_Guidebook/index.asp. Accessed July 6, 2007). All samples were placed in an ice chest during transport to the laboratory. All *Salmonella* samples were enriched in tertrathionate-Hajna Broth (Difco Laboratories, Detroit, MI) and incubated in aerobic conditions for 24 h at 37°C. Samples were then plated onto Xylose-Lysine-Tergitol 4 (XLT4) agar (Difco Laboratories, Detroit, MI) and incubated for 24 h at 37°C. Plates yielding characteristic colonies were counted and four colonies from each sample were subcultured to MacConkey agar and incubated for 24 h at 37°C.

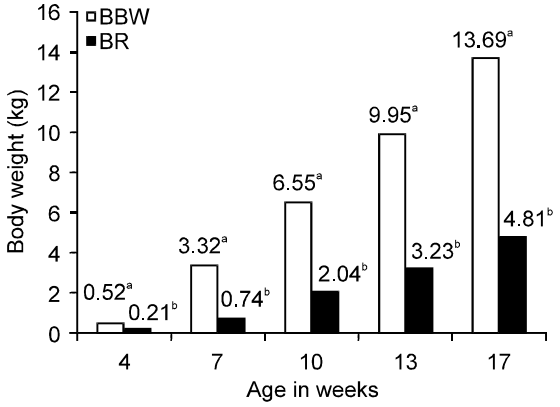

Fig. 1: Comparison of body weights (Kg) in Broad-breasted White (BBW) and Bourbon Red (BR) turkeys through 17 weeks of age. [a,b]Superscripts indicate significant differences ($p<0.05$) between turkey varieties

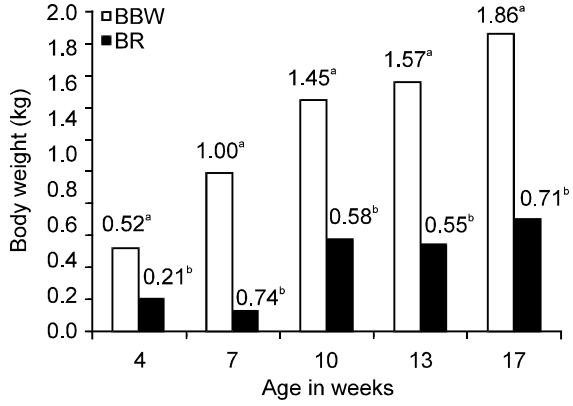

Fig. 2: Comparison of body weight period gains (Kg) in Broad-breasted White (BBW) and Bourbon Red (BR) turkeys through 17 weeks of age. [a,b]Superscripts indicate significant differences ($p<0.05$) between turkey varieties

Campylobacter samples were direct plated onto modified-Campy Cefex agar (mCC) as well as enriched in Bolton's Broth. Direct plated samples were incubated under microaerophillic conditions (5% O_2, 10% CO_2, 85% N_2) for 48 h at 42°C. The *Campylobacter* samples enriched in Bolton's Broth were incubated microaerophillically for 24 h at 42°C and then plated onto mCC. These samples were then incubated in the same manner as described above. Plates yielding characteristic colonies were counted and four colonies from each sample were subcultured to sheep's blood agar (RBA) and incubated under microaerophillic conditions for 48 h at 42°C. Colonies where randomly selected, wet mounted on a slide and examined using phase contrast microscopy for characteristic colony morphology. Those colonies suspected of being

Table 1: Distribution of turkey foot pad lesion scores (%) by variety and age

	BBW[a]			BR[b]		
Age	None	Mild	Severe	None	Mild	Severe
4 weeks	23.7[d]	72.7[c]	0.0[e]	90.9[c]	9.1[d]	0.0[e]
7 weeks	68.0	35.4	0.0	100.0	0.0	0.0
10 weeks	96.6	3.0	0.0	90.9	9.1	0.0
13 weeks	72.2	24.0	0.0	98.4	1.6	0.0
17 weeks	24.8[d]	54.7[c]	20.5[e]	100.0[c]	0.0[d]	0.0[d]

[a]BBW = Broad-breasted White turkey

[b]BR = Bourbon Red turkey

[c,d,e]Superscripts within rows indicate significant differences ($p<0.05$) between paw lesion scores for each turkey variety

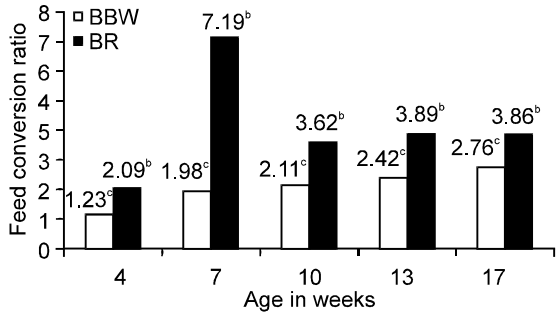

Fig. 3: Comparison of cumulative feed conversion ratio in both Broad-breasted White (BBW) and Bourbon Red (BR) turkeys[a].
[a]The cumulative feed conversion ratios are from 0 to 4 wks, 0 to 7 wks, 0 to 10 wks, 0 to 13 wks and 0 to 17 wks.
[b,c]Superscripts indicate significant differences ($p<0.05$) between turkey varieties

Campylobacter were verified of being so by testing for oxidate positive and urease negative.

Clostridium perfringens samples were direct plated onto Perfringens agar (OPSP) (Remel, Inc., Lenexa, KS). Plates were incubated anaerobically (5% CO_2, 5% H_2, 90% N_2) for 24 hrs at 42°C. Plates yielding characteristic colonies were counted and four colonies from each sample were subcultured to tryptic soy agar (TSA) (Fisher Scientific, Pittsburgh, PA) with 5% sheep's blood and incubated anaerobically for 24 hrs at 42°C. Isolates yielding double zone hemolysis on TSA blood were confirmed as *C. perfringens* using gram stain and cell morphology.

Carcass rinsate was plated onto MacConkey agar (MA) to determine the total enteric count. These same samples were plated onto sheep's blood agar (RBA) and Plate Count Agar (PCA). Rinsate was direct plated onto each of the aforementioned plates and incubated either aerobically (PCA and MA) or anaerobically (RBA) for 24 h at 37°C. Plates yielding characteristic colonies were counted.

Footpad lesions: Foot pad lesions were classified into three groups, 0 (no lesions), 1 (minor lesions) and 2

Table 2: Turkey diet formulations for the duration of the study

Diet	Bird Age	ME (kcal/kg)	Crude protein (%)	% Corn	Soybean meal (%)	% Poultry by product meal
Starter 1	0-3 weeks	2990	27.5	44.2	39.2	10.0
Starter 2	3-6 weeks	2960	26	46.6	40.0	5.6
Grower 1	6-9 weeks	3030	23	54.3	34.3	5.0
Grower 2	9-12 weeks	3100	21.2	59.1	29.9	4.0
Finisher 1	12-15 weeks	3180	18.0	66.5	22.7	4.0
Finisher 2	15+ weeks	3180	16.0	72.7	17.4	4.0

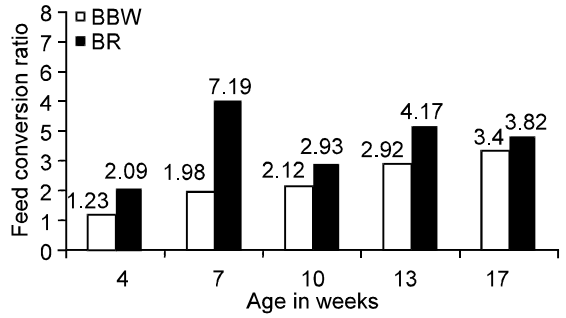

Fig. 4: Comparison of feed conversion ratio by period in Broad-breasted White (BBW) and Bourbon Red (BR) turkeys[a].
[a]The period feed conversion ratios are from 0 to 4, 4 to 7, 7 to 10, 10 to 13 and 13 to 17 wks

Table 3: Carcass weight and yield data from Broad Breasted White (BBW) and Bourbon Red (BR) turkeys, summarized by strain and sex

		Live Wt (kg):	Carcass Wt (kg):	Carcass Yield (%):
Strain				
	BBW	13.81a	10.90a	79.11a
	BR	4.80b	3.38b	71.52b
	SEM	0.158	0.126	0.367
Sex				
	Male	10.50a	8.06a	74.94
	Female	8.11b	6.23b	75.69
	SEM	0.162	0.134	0.392
Strain*Sex				
BBW	Male	15.27a	12.09a	79.42a
BBW	Female	12.35b	9.72b	78.81a
BR	Male	5.73c	4.03c	70.46c
BR	Female	3.86d	2.73d	72.57b
		SEM		0.190
		----------p-value----------		
Strain		***	***	***
Sex		***	***	NS
Strain*Sex		*	**	**

*p<0.05; **p<0.01; ***p<0.001

(severe lesions). The visual ranking system used to score footpad lesions indicated a score of 0 for no lesion present, a score of 1 for a mild lesion (lesion >7.5 mm) and a score of 2 for a severe lesion (lesion >7.5 mm). Both footpads on each bird were scored and the worst lesion score was used. The same individuals scored footpad lesions throughout the study.

Statistical analysis: Statistical analysis (ANOVA) was performed to determine differences between turkey varieties, sexes and interactions for foot pad lesion scores, bacterial prevalence, feed intake, weight gain, BW, live weights, carcass weights, carcass yields and feed conversion. The percent of turkeys with each lesion score (none, mild, or severe) was tallied for each pen. The percentages were arcsine transformed prior to analysis by ANOVA. Foot pad lesion scores were compared within varieties at the various ages. Bacterial counts were converted to $\log_{10}$ values and subjected to analysis of variance (SPSS for Windows, release 9.0, SPSS, Inc., Chicago, IL). All of the data were transformed prior to analysis but are presented in Table 5 in their untransformed state. A Tukey's test for significance was used to compare the means for the aforementioned treatments.

RESULTS AND DISCUSSION

Birds were raised through Summertime conditions in Alabama which included hot, dry conditions with daytime highs averaging 35C. Temperature and percent humidity readings did not contain any severe or abnormal fluctuations for the time of year during the study. BBW turkeys had higher feed intake (data not shown), weight gain (Fig. 2) and BW (Fig. 1) than the BR turkeys for each of the age periods ($p \leq 0.05$).

Overall, the feed conversion was superior in the BBW turkey when compared to the BR turkeys (Fig. 3). The feed conversion in BBW turkeys was statistically better than BR turkeys for all of the age periods except the thirteen to seventeen week period (Fig. 4). The observed poor feed conversion in BR birds from 4-7 weeks was likely due to stress from being moved to the pasture pens, while the larger BBW birds handled the stress of the move with little appreciable loss in production. Feed conversion rate for the BBW was significantly lower than the BR at 4, 7, 10 and 13 weeks of age. At 17 weeks of age, there was no difference in the feed conversion rate between the two varieties. In a similar study, albeit of conventional turkey strains raised indoors, it was found that the performance of the modern conventional turkey far outweighs older strains (Havenstein *et al*., 2007). Further research will be needed to examine heritage and conventional turkey performance indoors versus on pasture to answer questions on the benefits of pasture over conventional production. Mortality during the study was restricted to the loss of one BBW turkey during week 5.

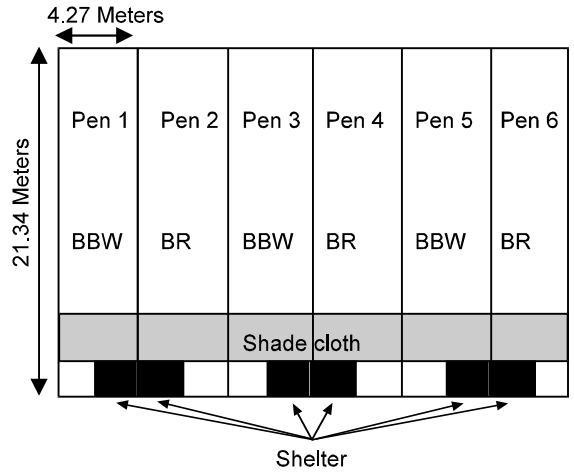

Fig. 5: Diagram of pen design

Final live weight, carcass weight and carcass yield were compared for both strains and sexes of turkeys. BBW turkeys had higher live weights (13.81 vs. 4.80 kg), carcass weights (10.90 vs. 3.38 kg) and carcass yields (79.11 vs. 71.52 %) than BR turkeys ($p \leq 0.05$). We chose to compare turkey strains at like ages rather than comparable weights in this trial. Heritage turkey strains are typically raised for a longer period than was used in this trial. If that was the case, the BR strain may have achieved higher body weights and had better carcass yields if left to mature. When raised on pasture and provided with supplements, a study of broilers noted an increase in final body weights and carcass yield over broilers without access to pasture (Ponte *et al*., 2008). It may be worthwhile for pastured heritage turkey producers to investigate the addition of supplements (cellulase or hemicellulase) to the diet to improve nutrient utilization. Alternatively, it is also recognized that such supplements to the diet may not be fully appreciated by the highly selective consumer of pastured heritage turkeys who is in search of a natural product.

Table 3 presents the processing data. From this table it can be observed that in both of the tested strains there were significant differences between the sexes for live weight and carcass weight but not carcass yield ($p \leq 0.05$). Additionally in Table 3, it can be observed that there were significant strain*sex interactions for live weight, carcass weight and carcass yield ($p \leq 0.05$). BBW males recorded the highest results for all three measurements. BR females had the lowest live weight and carcass weight, while the BR males had the lowest carcass yield. These results are not surprising given the genetic selection that has taken place in the conventional BBW variety. A similar strain*sex interaction was seen in work done with both 2003 and 1966 strains of BBW turkeys (Havenstein *et al*., 2007).

Table 4: Temperature and Humidity Averages for the Months in which the Study was Conducted

	Temperature (°F)		% Humidity	
Month	Min	Max	Min	Max
August	73.6	98.9	51.8	94.8
September	67.7	94.3	44.3	91.1
October	53.7	82.1	42.2	88.7
November	53.1	82.1	41.1	93.5
Overall averages	62.0	89.3	44.8	92.0

Variability between pens left no significant differences between foot pad lesion incidences for the two varieties at 7, 10 and 13 weeks. At 4 and 17 weeks of age, BR turkeys had a significantly lower number of birds with mild foot pad lesions than BBW turkeys (Table 1). Pododermatitis in turkeys is a problem for conventional producers. These results support the findings of Clark *et al*. (2002) where comparisons of foot pad lesion scores for conventional turkey strains (BUTA, Nicholas and Hybrid) in the United States and the United Kingdom found that there were no significant differences between the two countries with regard to turkey varieties. Our early results are consistent with the findings that litter type (wood shavings) may contribute to higher foot pad lesion scores since turkeys were raised indoors until week 4. Once moved to pasture, the improvement in foot pad condition may indicate that the production system in which birds are raised contributes to lower foot pad scores in some turkey varieties. At week 17, the larger and heavier birds may place more strain on their feet, thereby increasing the incidence of foot pad lesions. Additionally, litter was not provided under the shelters in the outdoor range pens which may have been a contributing factor to the increased incidence of foot pad lesions.

With regard to the prevalence of bacterial pathogens, there were no significant differences between the two varieties in the recovery of *Salmonella* or *Campylobacter*. *Salmonella* was not recovered from cloacal swabs or carcass rinses. *Campylobacter* was not recovered from direct plated samples. *Campylobacter* was recovered from enriched carcass rinsate in both BBW (n = 5) and BR (n = 5) turkeys. In this study, the recovery of *Campylobacter* and *Salmonella* was lower than the average prevalence reported (31.2% and 36.9%, respectively) in a recent study of carcass rinses from conventional turkeys in Canada (Arsenault *et al*., 2007). The low prevalence of bacteria in our study may be attributed to the pasture management system, small number of birds, or low pen density in which the turkeys were maintained. *C. perfringens* was recovered from 58.3% of BBW carcasses but BR carcasses did not yield the organism.

Total bacterial counts identified BBW turkeys as significantly different from BR turkeys with the blood agar plates but not with the PCA plates. Blood agar plates

Table 5: Bacterial prevalence and populations as recovered from cloacal swabs and carcass rinses[a]

	Campylobacter		*Campylobacter*							
	Salmonella		Cloacal swab			Carcass rinse			Total anaerobes			
Variety	Cloacal swab (n = 30)	Carcass rinse (n = 24)	Direct plate (n = 30)	Enriched (n = 30)	Direct plate (n = 24)	Enriched (n = 24)	*C. perfringens* (n = 24)[a]	PCA (n = 24)	RBA (n = 24)	Total enterics (n = 24)
Bourbon red	0	0	0	0	0	5	0.0%	5.42×10^{5} cfu/ml	1.20×10^{5} cfu/ml[b]	4.54×10^{2} cfu/ml
Broad-breasted white	0	0	0	0	0	5	58.3%	1.93×10^{6} cfu/ml	3.07×10^{4} cfu/ml[c]	8.79×10^{2} cfu/ml

[a]All of the data were transformed prior to analysis but are presented here in their untransformed state
[b,c]Superscripts within columns indicate significant differences ($p<0.05$) between turkey varieties

which measure total anaerobes, produced a significant higher counts on BR turkeys (1.20×10^{5} cfu/ml) than on BBW turkeys (3.07×10^{4} cfu/ml). The total aerobic bacterial counts showed that BBW and BR turkeys had an average count of 1.93×10^{6}cfu/ml and 5.42×10^{5} cfu/ml, respectively. The average recovery of total enteric bacteria from BBW and BR turkeys was 8.79×10^{2} cfu/ml and 4.54×10^{3} cfu/ml, respectively (Table 5). The observed higher incidence of *C. perfringens* in BBW turkeys was an interesting result. Future research may elucidate the factors that led to such a finding.

Conclusions: BBW turkeys performed better in the areas of weight gain, body weight, carcass weights and feed conversion than the BR turkeys. There are large differences between turkey varieties with regard to live performance and carcass data. The majority of BR turkeys never acquired foot pad lesions and no birds of this variety acquired severe lesions, compared to the BBW which, by the end of the trial, had 75.2% of the bird positive for footpad lesions. The results of this trial indicate that there are no differences between turkey varieties with regard to *Salmonella*, *Campylobacter* and total enteric counts. BR turkeys had significantly fewer *C. perfringens* positive carcasses and total anaerobic counts than BBW turkeys.

REFERENCES

Arsenault, J., A. Letellier, S. Quessy, J.P. Morin and M. Boulianne, 2007. Prevalence and risk factors for Salmonella and Campylobacter spp. carcass contamination in turkeys slaughtered in Quebec, Canada. J. Food Prot., 70: 1350-1359.

Bender, M., 2006. The Importance of Genetics: Biological fitness and productivity in range-based systems comparing standard turkey varieties and industrial stocks. SARE Grant Final Report. SARE Project no.: LS02-134. http:// www. sare. org/ reporting/ report_viewer.asp?pn=LS02-134&ry= 2006&rf=1Last accessed on July 6, 2007.

Clark, S., G. Hansen, P. McLean, P. Bond, Jr., W. Wakeman, R. Meadows and S. Buda, 2002. Pododermatitis in turkeys. Avian Dis., 46: 1038-1044.

Fanatico, A.C., P.B. Pillai, L.C. Cavitt, C.M. Owens and J.L. Emmert, 2005. Evaluation of slower-growing broiler genotypes grown with and without outdoor access: growth performance and carcass yield. Poult. Sci., 84: 1321-1327.

Glass, K., 2003. Raising Heritage Turkeys. Pages 107-108 in J. Padgham (Ed.)., Raising Poultry on Pasture. Ten Years of Success. The American Pastured Poultry Producers Association Compilation.

Hartman, S., S.A. Taleb, T. Geng, K. Gyenai, X. Guan and E. Smith, 2006. Comparison of plasma uric acid levels in five varieties of the domestic turkey, *Meleagris gallopavo*. Poult. Sci., 85: 1791-1794.

Havenstein, G.B., P.R. Ferket, J.L. Grimes, M.A. Qureshi and K.E. Nestor, 2007. Comparison of the performance of 1966- versus 2003-type turkeys when fed representative 1966 and 2003 turkey diets: growth rate, livability and feed conversion. Poult. Sci., 86: 232-240.

Kamara, D., K.B. Gyenai, T. Geng, H. Hammade and E.J. Smith, 2007. Microsatellite marker-based genetic analysis of relatedness between commercial and heritage turkeys (*Meleagris gallopavo*). Poult. Sci., 86: 46-49.

Lance, G.C., 1983. Economic evaluation of total confinement and open range turkey production systems in Georgia. Poult. Sci., 62: 1142-1154.

Padgham, J. 2002. Raising Historical Turkeys. Pages 105-106 in J. Padgham (Ed.)., Raising Poultry on Pasture. Ten Years of Success. The American Pastured Poultry Producers Association Compilation.

Ponte, P.I.P., C.M.C. Rosado, J.P. Crespo, D.G. Crespo, J.L. Mourao, M.A. Chaviero-Soares, J.L.A. Bras, I. Mendes, L.T. Gama, J.A.M. Prates, L.M.A. Ferriera and C.M.G.A. Fontes, 2008. Pasture intake improves the performance and meat sensory attributes of free-range broilers. Poult. Sci., 87: 71-79.

Rich, R., 1998. Research Adventure. Pages 103-104 in J. Padgham (Ed.)., Raising Poultry on Pasture. Ten Years of Success. The American Pastured Poultry Producers Association Compilation.

Shriver, J., 2003. 'Heritage' turkeys bring that old taste home. http://www.usatoday.com/life/2003-11-05-turkey_x.htm Accessed Sept. 2009.

Smith, E.J., T. Geng, E. Long, F.W. Person, D.P. Sponenberg, C. Larsen and R. Gogal, 2005. Molecular analysis of the relatedness of five domesticated turkey strains. Biochem. Genet., 43: 35-47.