

Range and Confinement Rearing of Four Genetic Lines of Turkeys. 1. Effects on Growth, Mortality, and Walking Ability¹

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ABSTRACT Line by environment interactions complicate interpretation of results from long-term selection experiments. To investigate the potential effects of such interactions, a study was conducted in which birds from four genetic lines were reared in two environments. Birds from four turkey lines were brooded in confinement housing. At 8 wk of age, half of the birds from each full-sib family were moved to a large range pen and the remainder were placed in a large confinement

pen. Significant line by environment interactions were present only for walking ability scores of males. A general lack of significant line by environment interactions indicates that rearing environment of these lines may be altered without affecting interpretation of results from a selection experiment. In addition, the current randombred control lines continue to adequately serve as control populations for a long-term selection experiment.

(Key words: turkey, interaction, selection, growth, walking ability)

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INTRODUCTION

Genetic changes in growth and meat yield have resulted in correlated responses in feed intake, feed efficiency, incidence of leg abnormalities, and walking ability of both broilers and turkeys. Reduced walking ability may not only reduce the economic productivity of the animal enterprise, but may also result in reduced well-being of the animal. An animal's well-being is good when it is free from undue physical and psychological distress (Duncan, 1981). Undue physical and psychological distress may keep animals from performing to their genetic potential for economically important traits (Curtis, 1983). Understanding factors contributing to walking ability should allow improvement of both economic productivity and animal well-being.

Nestor (1984) observed a positive genetic correlation between 16-wk body weight and frequency of leg problems in turkeys. A line of turkeys selected for increased 16-wk body weight (F) exhibited more walking difficulties than did the control population (RBC2) from which it originated.

Two sublines were developed from Line F. Line FL was a subline produced by mass selection for increased shank width at 16 wk of age and Line FM was a subline produced by family selection for increased leg muscle

mass (Emmerson *et al.*, 1991). Emmerson *et al.* (1991) found that selection for increased shank width resulted in increased body weight relative to the RBC2 population, but at a slower rate than selection for body weight alone. Walking ability scores in confinement rearing were similar for Lines F, FL, and FM, in contrast to earlier research of Nestor *et al.* (1985), in which selection for increased shank width improved walking ability scores when turkeys were reared in a range environment. It may be hypothesized from the studies of Nestor *et al.* (1985, 1988) and Emmerson *et al.* (1991) that walking ability scores of Lines F and FL turkeys may not respond similarly in two different rearing environments.

The effect of rearing method on body weight has been investigated using various commercial strains of turkeys. Wyne *et al.* (1959) found that males of two turkey strains were heavier at 24 wk when range-reared than when confinement-reared. Females, however, had similar 24-wk BW in the two environments. There was no evidence of strain by environment interactions. Both Payne (1959) and Lance (1983) found that range-reared males and females were heavier when marketed than confinement-reared birds. The absolute difference between the two environments appeared to be greater for males than for females. Barnett *et al.* (1958), in contrast, found no differences in growth rate or mortality between range- and confinement-reared birds. The present experiment was designed to assay effects of range vs confinement rearing on body weight, leg bone growth, mortality, and walking ability scores of four genetic lines of turkeys and to determine the presence and importance of line by environment interactions.

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MATERIALS AND METHODS

Animals and Husbandry

Birds utilized in this experiment were from four lines. Lines RBC2 and RBC3 were randombred control populations of turkeys developed in 1966 and 1986, respectively (Noble *et al.*, 1995); Line F was a line selected 28 generations for increased 16-wk body weight (Nestor, 1984), which originated from Line RBC2; and Line FL was a subline of F selected 15 generations for increased shank width (Nestor *et al.*, 1985). The number of birds utilized from Lines RBC2, RBC3, F, and FL was 162, 126, 150, and 94, respectively. Upon hatching, poults of each line were wing-banded by full-sib family, beak trimmed with an arc trimmer (as described by Renner *et al.*, 1989), and placed with lines and sexes intermingled in two 5.5 × 8.25 m floor pens. Floor space allowance was 1,352 cm² per poult. Feed and water were provided for *ad libitum* consumption, and heat was supplied by heat lamps until the birds were 3 wk of age. All birds were fed a five-ration, declining-protein program based on the schedule for males (Naber and Touchburn, 1970). At 8 wk of age, half the birds from each family were moved to a range pen and the remainder were placed in a large confinement pen. Lights in the confinement house provided approximately 100 lx and were adjusted as needed to provide the same photoperiod as natural lighting. Space allowance from 8 to 20 wk of age was 5,521 cm² per bird in confinement rearing and 283,519 cm² per bird in range rearing.

Traits Measured and Statistical Analyses

Poults were weighed to the nearest 0.1 lb. (with data converted to kilograms prior to analysis) at 8, 16, and 20 wk of age. Shank width (measured in millimeters from side to side), depth (measured in millimeters from front to back), and length (in centimeters) were recorded for all birds at 16-wk of age. Each bird was scored for walking ability by the method of Nestor *et al.* (1985) at 16 wk of age. Scores from 1 to 5 indicated no, slight, moderate, severe, and extreme difficulty walking, respectively.

Previous studies with turkeys indicate that traits measured at the same age may be expressed differently in males and females, such that parameter estimates for the same traits are different for the sexes (Havenstein *et al.*, 1988a,b; Toelle *et al.*, 1990). Body weight at 16 and 20 wk, shank width, shank length, shank depth, and walking ability scores at 16 wk were analyzed by analysis of variance for each sex, with line, rearing environment, and the interaction between them as sources of variation. When the line by environment interaction was significant, data were analyzed within line to determine whether environments differed as well as within environment to determine whether lines differed. Duncan's multiple range test (SAS Institute, 1988) was used when separating multiple means.

TABLE 1. Mean 16- and 20-wk body weight of four lines of turkeys by sex, line, and environment

Age	Sex	Environment	Line ¹				$\bar{x} \pm SE$
			F	FL	RBC2	RBC3	
16 wk	Male	Range	13.87	11.90	8.15	12.18	11.18 ± 0.20 ^a
		Confinement	12.80	11.29	7.69	11.37	10.63 ± 0.18 ^b
	Female	Range	13.27 ± 0.16 ^a	11.63 ± 0.12 ^b	7.93 ± 0.08 ^c	11.79 ± 0.13 ^b	8.54 ± 0.18 ^a
		Confinement	10.54	8.49	5.79	8.73	8.04 ± 0.17 ^b
20 wk	Male	Range	10.13	8.37	5.65	8.42	14.55 ± 0.26 ^a
		Confinement	10.35 ± 0.08 ^a	8.42 ± 0.08 ^b	5.71 ± 0.05 ^c	8.57 ± 0.11 ^b	13.57 ± 0.24 ^b
	Female	Range	17.81	15.39	10.72	16.00	10.48 ± 0.22 ^a
		Confinement	16.39	14.32	9.81	14.54	9.66 ± 0.21 ^b
		Range	17.01 ± 0.21 ^a	14.91 ± 0.16 ^b	10.28 ± 0.12 ^c	15.30 ± 0.19 ^b	
		Confinement	12.77	10.34	7.18	10.79	
		Range	12.15	9.92	6.80	10.18	
		Confinement	12.49 ± 0.11 ^a	10.11 ± 0.10 ^c	6.98 ± 0.07 ^d	10.46 ± 0.16 ^b	

^{a-d}Means in a row or column with no common superscripts differ significantly ($P \leq 0.05$).

¹F = A line selected 28 generations for increased body weight at 16-wk of age; FL = A subline of F selected 15 generations for increased shank diameter at 16-wk of age; RBC2 = A randombred control population developed in 1966, which served as the base population for F; and RBC3 = A randombred control population developed in 1986.

TABLE 2. Mean 16-wk shank length of four lines of turkeys by sex, line, and environment

Sex	Environment	Line ¹				$\bar{x} \pm SE$
		F	FL	RBC2	RBC3	
		(cm)				
Male	Range	21.5	21.6	19.9	20.9	20.9 ± 0.09
	Confinement	21.7	21.5	20.0	20.7	20.8 ± 0.08
	$\bar{x} \pm SE$	21.7 ± 0.10 ^a	21.6 ± 0.08 ^a	19.9 ± 0.06 ^c	20.8 ± 0.08 ^b	
Female	Range	17.8	17.4	16.0	16.9	17.0 ± 0.09
	Confinement	17.6	17.4	16.1	16.7	16.9 ± 0.08
	$\bar{x} \pm SE$	17.7 ± 0.07 ^a	17.4 ± 0.10 ^b	16.1 ± 0.11 ^d	16.8 ± 0.11 ^c	

^{a-d}Means in a row or column with no common superscripts differ significantly ($P \leq 0.05$).

¹F = A line selected 28 generations for increased body weight at 16-wk of age; FL = A subline of F selected 15 generations for increased shank diameter at 16-wk of age; RBC2 = A randombred control population developed in 1966, which served as the base population for F; and RBC3 = A randombred control population developed in 1986.

Mortality data were analyzed by nonparametric methods. To determine whether lines differed in mortality, a Kruskal-Wallis H -test (Hollander and Wolfe, 1973) was utilized. To determine whether rearing environments differed in mortality, a two-sample Wilcoxon signed-rank test (Hollander and Wolfe, 1973) was utilized. Significance for each test was accepted at $P \leq 0.025$, for an overall $P \leq 0.05$.

RESULTS AND DISCUSSION

Mortality

Mortality did not differ among lines nor between environments, confirming work by Barnett *et al.* (1958). Mortality of range-reared birds was 8.2, 7.35, 3.75, and 4.55% for Lines F, FL, RBC2, and RBC3, respectively. Similar values for confinement-reared birds were 10.1, 8.25, 2.25, and 4.35% for Lines F, FL, RBC2, and RBC3.

Body Weight

Regardless of line and sex, range-reared birds were significantly heavier at 16 and 20 wk of age than were confinement-reared birds (Table 1), confirming previous work by Payne (1959), Wyne *et al.* (1959), and Lance (1983). Differences among lines in 16- and 20-wk BW observed in the present study are consistent with previous reports on

these lines (Nestor, 1984; Nestor *et al.*, 1988; Emmerson *et al.*, 1991; Noble *et al.*, 1995).

Shank Length

Unlike body weight, shank length was not influenced by rearing environment (Table 2). Lines significantly differed in shank length, with the order of the lines different for males and females. Male F and FL birds had the longest shanks, followed by RBC3 males, with RBC2 males having the shortest shanks. Females from all four lines differed in shank length and lines were ranked F, FL, RBC3, and RBC2, respectively.

Shank Width

Range-reared birds had significantly wider shanks than did confinement-reared birds, regardless of sex and line (Table 3). Regardless of sex, all four lines differed in shank width and lines were ranked FL, F, RBC3, and RBC2, respectively. These differences among lines are consistent with previous reports (Nestor, 1984; Nestor *et al.*, 1988; Emmerson *et al.*, 1991; Noble *et al.*, 1995).

Shank Depth

Shank depth (diameter measured from front to rear) was originally measured in these four lines in 1992. It was

TABLE 3. Mean 16-wk shank width of four lines of turkeys by sex, line, and environment

Sex	Environment	Line ¹				$\bar{x} \pm SE$
		F	FL	RBC2	RBC3	
		(mm)				
Male	Range	17.0	21.5	13.9	16.3	16.9 ± 0.25 ^a
	Confinement	16.8	20.8	13.7	15.8	16.4 ± 0.22 ^b
	$\bar{x} \pm SE$	16.9 ± 0.13 ^b	21.2 ± 0.19 ^a	13.8 ± 0.09 ^d	16.0 ± 0.09 ^c	
Female	Range	15.8	18.8	12.3	14.8	14.9 ± 0.21 ^a
	Confinement	15.2	18.0	11.8	14.5	14.4 ± 0.20 ^b
	$\bar{x} \pm SE$	15.6 ± 0.13 ^b	18.4 ± 0.23 ^a	12.0 ± 0.07 ^d	14.6 ± 0.14 ^c	

^{a-d}Means in a row or column with no common superscripts differ significantly ($P \leq 0.05$).

¹F = A line selected 28 generations for increased body weight at 16-wk of age; FL = A subline of F selected 15 generations for increased shank diameter at 16-wk of age; RBC2 = A randombred control population developed in 1966, which served as the base population for F; and RBC3 = A randombred control population developed in 1986.

TABLE 4. Mean 16-wk shank depth of four lines of turkeys by sex, line, and environment

Sex	Environment	Line ¹				$\bar{x} \pm SE$
		F	FL	RBC2	RBC3	
		(mm)				
Male	Range	26.2	27.5	22.6	24.6	25.0 \pm 0.19 ^a
	Confinement	25.5	26.7	21.0	23.8	24.0 \pm 0.20 ^b
	$\bar{x} \pm SE$	25.8 \pm 0.19 ^b	27.2 \pm 0.14 ^a	21.8 \pm 0.14 ^d	24.2 \pm 0.14 ^c	
Female	Range	22.5	23.4	18.8	21.0	21.2 \pm 0.18 ^a
	Confinement	21.8	23.1	18.4	20.5	20.6 \pm 0.17 ^b
	$\bar{x} \pm SE$	22.2 \pm 0.13 ^b	23.2 \pm 0.14 ^a	18.6 \pm 0.08 ^d	20.7 \pm 0.14 ^c	

^{a-d}Means in a row or column with no common superscripts differ significantly ($P \leq 0.05$).

¹F = A line selected 28 generations for increased body weight at 16-wk of age; FL = A subline of F selected 15 generations for increased shank diameter at 16-wk of age; RBC2 = A randombred control population developed in 1966, which served as the base population for F; and RBC3 = A randombred control population developed in 1986.

hypothesized that selection for increased shank width was also increasing shank depth. Line differences in shank depth of males and females parallel line differences in shank width (Table 4), confirming the aforementioned hypothesis. As with shank width, range-reared birds had deeper shanks than did confinement-reared males and females, regardless of line.

Walking Ability Scores

Line and environment interacted to affect walking ability scores of males. Range-reared males from Lines FL and RBC2 had improved walking ability scores (lower means), but rearing environment did not affect walking ability scores of Line F or RBC3 males (Table 5). Relative ranking of the lines was different for the two rearing environments. Under confinement rearing, Line RBC2 males had lower walking ability scores than the other three lines. When range reared, Lines FL and RBC2 had similar walking ability scores, Line RBC3 males had greater scores, with Line F males having the greatest scores.

Differences among lines in behaviors and body weights may influence walking ability scores in these environments. Based on casual observations, Line FL and RBC2 birds appear to be more active than birds from Lines RBC3 and F, and placing these "active" lines in an environment that reduces their activity may be detrimental to them.

The presence of the line by environment interaction influencing walking ability scores confirms the aforementioned hypothesis that these lines of turkeys may not respond similarly to a change in rearing environment for walking ability scores. Were line by environment interactions to occur, they would be most likely in traits with little genetic influence (i.e., low to moderate heritability). The heritability estimates of walking ability scores of males obtained by Havenstein *et al.* (1988a) from the sire variance component (0.06) were much less than similar estimates for male body weight (0.60), male shank width (0.47), and male shank length (0.54).

Walking ability scores of females were similar under range and confinement rearing, regardless of line (Table 5). Line F females had greater walking ability scores than Line RBC3 females, Line FL was intermediate to F and RBC3, and Line RBC2 females had lower walking ability scores than Line RBC3 females.

TABLE 5. Mean walking ability scores¹ at 16-wk of four lines of turkeys by sex, line, and environment

Sex	Environment	Line ²				$\bar{x} \pm SE$
		F	FL	RBC2	RBC3	
Male ³	Range	3.5 ^{a,x}	2.0 ^{c,y}	1.7 ^{c,y}	3.0 ^{b,x}	2.5 \pm 0.09
	Confinement	3.3 ^{a,x}	3.0 ^{a,x}	2.2 ^{b,x}	3.2 ^{a,x}	2.9 \pm 0.09
	$\bar{x} \pm SE$	3.4 \pm 0.11	2.5 \pm 0.12	1.9 \pm 0.10	3.1 \pm 0.09	
Female	Range	2.3	1.9	1.1	1.8	1.8 \pm 0.08
	Confinement	2.3	2.2	1.2	2.1	1.9 \pm 0.08
	$\bar{x} \pm SE$	2.3 \pm 0.09 ^a	2.1 \pm 0.13 ^{ab}	1.1 \pm 0.05 ^c	2.0 \pm 0.11 ^b	

^{a-c}Means within rows with no common superscripts differ significantly ($P \leq 0.05$).

^{x,y}Means within columns with no common superscripts differ significantly ($P \leq 0.05$).

¹On a scale from 1 to 5 indicating no, slight, moderate, severe, or extreme difficulty walking, respectively.

²F = A line selected 28 generations for increased body weight at 16-wk of age; FL = A subline of F selected 15 generations for increased shank diameter at 16-wk of age; RBC2 = A randombred control population developed in 1966, which served as the base population for F; and RBC3 = A randombred control population developed in 1986.

³Line and environment interacted.

In conclusion, line by environment interactions were generally lacking in this experiment. Presence of such interactions may complicate interpreting results from selection experiments when the selected line and its control respond differently to an environmental change (Gowe and Fairfull, 1990). The general lack of line by environment interactions in this experiment and an apparent lack of genetic drift (Noble *et al.*, 1995) indicate that Line RBC2 continues to serve as an adequate control for selected lines F and FL, with the exception of walking ability scores of males.

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