Genetic Parameters For Survival And Leg Strength In The Turkey

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Introduction

Fitness encompasses a range of defined traits in the turkey and other poultry, from general survival to specific health traits that can impact on welfare, quality of life and productivity. Mortality is one measure of fitness. Mortality on a commercial farm can result from a range of conditions, including disease, physiological stress, and aggressive behaviour. Leg strength and the ability to walk have long been known to be highly correlated to liveability in the field and as a consequence have been actively selected. Walking disorders can cause pain and affect the birds' ability to eat and drink (Nääs et al. (2009)), and cause economic losses for farmers in terms of culled or downgraded birds. In addition to animal welfare concerns, many fitness traits relate directly to turkey production and economic profitability (Wood (2009)).

Genetic selection is one potential method of improving commercial turkey fitness. Breeding programs have had great success in improving productivity through selecting for higher growth rate and meat yield, but the effects on fitness traits remain in question (Hafez and Hauck, (2005)). Selection for general survival has been applied widely in turkey and broiler chickens but with sporadic success (Flock et al. (2005)). One reason for this is the wide spectrum of survival heritability found in different studies. Layer studies have found general survival to be moderately heritable (e.g. Ellen et al. (2008)) but there are no estimates for turkey survival in the scientific literature.

Breeders may attempt to improve fitness by selecting birds based on conformation and locomotory traits. For example, birds suffering from injury, weakness or gait abnormalities may be culled from parental flocks. The success of such selection depends on the heritability of these traits and their genetic correlations with survival and production traits. Some poultry conformation defects have shown a substantial genetic basis and have been connected to survival differences (e.g. Ye et al. (1997); Kestin et al. (1999)). However, heritability of conformation and locomotory traits and genetic correlations with survival and other economic traits such as growth have been rarely estimated in the turkey. Here we present preliminary genetic parameter estimates of survival, conformation and locomotory traits and their relationships with body weight in a male turkey line from a commercial nucleus breeding program.

Material and methods

Populations. Data were obtained for one parental male line from a nucleus breeding stock. This line was selected for predominantly commercial traits that included growth rate, feed

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conversion, and meat yield traits. Growth, fitness and pedigree data were collected from poults hatched in 2000-2008. The pedigree contained 12 generations, with 1312 sires and 11851 dams. On average there were 24 contemporary groups (poults that hatched on the same day and were reared together) per year. The line was reared under conditions that resemble commercial practice that include commercial ventilation, litter treatment and housing densities.

Data collection. All birds were individually monitored and date of mortality recorded. Turkeys were assessed for conformation defects twice, first at 15 weeks post-hatch and then at 22 weeks post-hatch. Of the birds that were classified as having a defect, the most common conformation defects were pendulous crop, hip weakness, and leg and foot defects. At the second observation time, walking ability was also evaluated. Turkeys were individually walked and subjectively scored by expert personnel from 1 (poor motion, pitch and balance; severe inward leg angulation, weak hip or hock; bow/twisted leg) to 6 (fluid motion; excellent pitch and balance; low outward leg angulation; strong hip and hock; no leg defects). At both times, turkeys exhibiting unfit phenotypes were removed from the population.

Traits. Three fitness traits were defined. 1) Survival to 23 weeks (SURV; n=262217) was binary where 0 = died or removed from the population for health reasons, 1 = survived. Overall natural mortality rate was 10.8%. Due to limited rearing space, unfit birds that would not qualify as breeders were removed from the population, however most of these birds likely would have survived to slaughter age under normal rearing circumstances. 2) Walking score (WALK; 1 to 6 linear scale; n=167702) was approximately normally distributed. 3) Hip and leg strength (H/L; n=262217) was binary where 0 = hip and/or leg defect observed at any time in life, 1 = healthy. Body weight (BW; g; n=149712) recorded at 22 weeks was also considered because growth is an important component of the selection index in these lines. Trait means are summarized in Table 1.

Genetic analysis. Genetic parameters were estimated within each line with multiple-trait restricted maximum likelihood in ASReml 3.0 (Gilmour et al. (2009)). Parents of birds hatched in 2000 were assumed to be unrelated. A series of three-trait animal models were run, with BW always included. The model was $y_{ijkl} = \mu_i + sex_{ij} + group_{ik} + A_{il} + e_{ijkl}$, where y_{ijkl} is the observation of trait i for individual l, μ_i is the population mean of trait i, sex_{ij} is the fixed effect of sex j on trait i, $group_{ik}$ is the random effect of hatch group k on trait i, A_{il} is the random animal genetic effect of trait i for individual l, and e_{ijkl} is the random residual error of trait i for individual l. Heritability (h^2) and common environment (c^2) were ratios of genetic variance and hatch group variance, respectively, to total phenotypic variance. Because the binary trait observations do not follow a normal distribution assumed by this analysis, heritability of the binary traits on the observed scale was also transformed to an underlying liability scale as per Dempster and Lerner (1950).

Results and discussion

Survival to 23 weeks and hip/leg strength showed fairly low h^2 on the observed scale, but when transformed to an underlying liability scale h^2 estimates were higher (Table 1), predicting good response to selection. Comparable literature estimates of survival heritability are sparse for meat poultry. Survival heritability was higher than some estimates in layer hen studies (e.g. Ellen et al. (2008)). Hip/leg strength as defined in this study was a composite trait and thus unsurprisingly displayed lower heritability than has been calculated for some specific defects in broilers (tibial dyschondroplasia, Kuhlers and McDaniel (1996); valgus and varus angulations, Le Bihan-Duval et al. (1997)).

Table 1: Trait means, phenotypic standard deviations, heritability[a] on observed and liability scales, common environment[b] and genetic and phenotypic correlations[c] within a turkey male parent line

	mean	σ_P	h^2	c^2	SURV	WALK	H/L	BW
SURV	0.584	0.487	0.10 0.15^L	0.05	•	0.844	0.719	-0.457
WALK	2.481	1.022	0.21	0.09	0.675	•	0.918	-0.477
H/L	0.820	0.387	0.08 0.18^L	0.03	0.524	0.640	•	-0.503
BW	17050	1978	0.19	0.42	-0.115	-0.269	-0.138	•

[a]all h^2 s.e.≤0.011, L=liability scale; [b]all c^2 s.e.≤0.025; [c]all r_G (above diagonal) s.e.≤0.023 and all r_P (below diagonal) s.e.≤0.013.

General survival can display a range of heritability due to differential genotype expression with different environmental stressors, as well as other factors such as selection, non-additive genetic and environmental factors, antagonistic relationships among underlying health traits, and social interactions (Ellen et al. (2008); Vehviläinen et al. (2008)). Grouping natural mortalities and birds removed for fitness reasons together resulted in a much lower "survival" proportion than is typically reported, which may generate higher heritability. Estimates may also be biased because survival and hip/leg strength binary data do not conform to continuous normal distribution assumed by these analyses, and the data are censored such that once a bird is culled they have no further records. Future studies will examine survival and random regression analyses to determine if those methods are more appropriate.

Walking score had good h^2 and high positive genetic correlation (r_G) with survival, as well as moderate r_G with hip and leg strength (Table 1). Therefore, walking score should be a good indicator trait for selection to improve both overall survival and hip and leg strength. Although some strain comparisons (e.g. Ye et al. (1997)) have indicated genetic basis for walking ability in turkeys, Havenstein et al. (1988) estimated much lower heritability (0.06) for walking ability. The results of the current study likely derived from a greater amount of information in multi-generation data as well as high quality of observations from experienced scorers. Noble et al. (1996) found walking ability can be influenced by genotype by environment interaction. Possibly, the commercial rearing environment of the birds in this study allowed greater walking genotype expression leading to higher heritability.

Genetic correlations of fitness traits with body weight were negative (Table 1), indicating unchecked selection for growth will reduce survival, walking ability and hip/leg strength. Accordingly, Nestor et al. (2008) found that long-term selection for growth negatively impacted turkey walking ability. Genetic correlations between growth and skeletal defects have varied in studies and specific traits can relate to growth differently (Le Bihan-Duval et al. (1997)). Because r_G between the general fitness traits in this study and body weight were not overly strong, individuals with superior genotypes for both body weight and fitness traits should exist in the populations.

Conclusion

These analyses are part of a larger study that aims to find optimal selection methods to improve survival and fitness in modern commercial turkey strains. Genetic parameters in this study indicate that index selection should be effective at improving fitness, survival and growth simultaneously. Walking score should be a good indicator trait for selection to improve overall survival and hip and leg strength.

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