Genetic relationships between tibial dyschondroplasia (TD) incidence and carcass and tibia characteristics in a pure line of a commercial broiler stock

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Introduction

Selection for high growth rate through many generations in the broiler populations has increased the rate of leg disorders (SORENSEN, 1989) which now cause 10–30% loss in meat type chicken. Tibial dyschondroplasia (TD) is a leg defect in broilers and referred mainly to fast growth. TD is highly heritable. SHERIDAN et al. (1978) reported heritability estimate of 0.33 in a line of broilers selected for a high incidence of TD at 7 weeks of age. BURTON et al. (1981) found a heritability for incidence of TD at 7 weeks of age of 0.26. YALÇIN et al. (1996) estimated heritability for TD as 0.25 on the binomial scale. Through four generations of divergent selection WONG-VALLE et al. (1993) reduced the incidence of TD 3.5% in the low incidence of TD line and raised the incidence to 61.9% in the high incidence of TD line. The realized heritability for the incidence of TD in the high incidence line was reported as 0.437 (WONG-VALLE et al., 1993).

These results suggested that TD could almost be eliminated from the population by selection. However, the value of implementing such a selection is clearly dependent on the genetic correlations between TD and main traits such as carcass characteristics which are of economical importance in poultry. ZHANG et al. (1995) estimated negative genetic correlations between the incidence of TD and both body weight and carcass component weights using three lines from the seventh generation of high and low incidence of TD lines developed by divergent selection, along with a randomised control line. They concluded that increasing carcass component weights should be feasible while decreasing incidence of TD (ZHANG et al., 1995).

Literature reports concerning the relationship between TD and bone parameters are inconsistent. RIDDELL (1975) noted that tibia growth was slightly faster in the high incidence of TD line than in the low incidence line. However, tibia weight, length, and width were found to be similar between broilers with and without TD (YALÇIN et al., 1996).

On the other hand, effects of TD incidence might be related to the degree of severity in the populations studied.

Materials and Methods

Animals and husbandry

One paternal (PL) and two maternal (ML1 and ML2) pure lines of a commercial broiler stock were used in the present study. Sires were mated to four dams within each line by artificial insemination. Records were made on 573 progeny of 94 sires, 254 progeny of 34 sires, and 155 progeny of 20 sires for PL, ML1, ML2, respectively (totally 982 progeny).

Chicks were wing-banded at hatching. Each line was raised separately in three floor pens in an environmentally controlled poultry house to 42 days of age. Birds consumed feed and water ad libitum. A starter (22.75% protein and 12.80 MJ/kg ME), grower (22% protein and 13.30 MJ/kg ME) and finisher diet (21% protein and 13.50 MJ/kg ME) were provided between 0 and 14, 15 and 28, and 29 and 42 days, respectively. Chicks received 23 hours of light and one hour of darkness.

Measurement of characteristics

Individual body weights were obtained on day 42 and sex was determined before processing. After overnight fasting birds were hung on shackles and electrically stunned, killed and moved through scalding. Feathers were plugged and the head, neck and shanks were removed. Carcasses were mechanically eviscerated and air chilled. Individual eviscerated carcass weights after chilling were measured. Carcasses were then dissected into wings, legs and breast without back portions and weighted. Carcass conformation was determined for each carcass as described by BILGILI (1997).
Each bird processed was examined for the presence and severity of TD by making longitudinal cut across the proximal end of the left tibia as described by EDWARDS and VELTMAN (1983). Severity index was 1. lesions less than 1 cm in length, 2. lesions greater than 1 cm in length affecting only part of metaphysis, and 3. lesions greater than 1 cm in length and affecting the whole of the metaphysis. All the scoring was done by one person. Right tibia was cleaned from muscle and connective tissues. Tibia length and width were measured in centimeters with caliper rule. Samples were dried at 105 °C for 24 hours and dry weight was obtained. Tibia ash weight was measured after samples have been ashed at 600 °C for 24 hours. The percentage ash was determined relative to dry weight of tibia.

Statistical analysis

Chi-square test was used for the percentage of grade A carcass among lines and between sexes. Data were analyzed using HARVEY’s (1990) Mixed Model Least Squares and Maximum Likelihood program with a model including line and sex as fixed effects, sire within line as random effects and line by sex interaction. Sire model rather than sire + dam model was used in this analysis because family structure made it possible to estimate dam variance component in a reliable way. As some unreliable and not estimated genetic parameters were found by sire model, the data were also analysed by animal model. Thus, variance, covariance components and genetic parameters were also estimated using the derivative free multiple trait Restricted Maximum Likelihood (REML) procedure considering multtrait animal model (TD incidence or severity with one of the other traits) by using DFREML program of MEYER (1997).

The model was the same for each trait and in the following structure:

\[ y = X\beta + Za + e \]

where \( y \) is the vector of observations, \( \beta \) is the vector of fixed line and sex effect and \( a \) is a vector of individual additive genetic values, \( e \) is the vector of residuals, and \( X \) and \( Z \) are incidence matrices relating observations to the effects in the model. Expectations for random effects were:

\[ E(a) = 0 \]
\[ V(a) = G \sigma^2_a \]
\[ V(e) = R \sigma^2_e \]

Results and Discussion

Line had a significant effect on body weight at 6 weeks of age and weights of carcass, total breast and wing being higher in PL than ML1 and ML2 (Table 1). Leg weight was significantly higher in ML2 than ML1, whereas leg weights of PL were highest. Effects of sire:line were not significant on body weight at 6 weeks of age and carcass characteristics. Percentage of grade A carcasses averaged 83.2, 80.0 and 82.9 % for PL, ML1 and ML2, respectively, being insignificant among lines (\( P = 0.341 \)). Males had a significantly greater (\( P = 0.007 \)) percentage of A grade carcasses (88.2 %) than females (81.2 %).

The highest incidence and severity of TD were obtained in line ML1 (Table 2). There was no significant difference for TD incidence and severity between PL and ML2 lines. Although sex effect was not significant for TD incidence and severity, males had a higher incidence of TD. Similar results were obtained by YALÇIN et al. (1996) and KUHLER and McDaniel (1996). Sire effect was significant for the severity of TD while the sire had no effect on TD incidence.

The lengths of tibia were similar for the birds from different lines. Tibia length was affected by sire. Birds from ML1 and ML2 had wider and heavier tibiae than those birds from PL. Sire effect was not significant for tibia width, dry weight, and ash. Tibia length, width and dry weight were higher in males than females. The percentage of tibia ash did not differ among lines and between sexes.

Heritability estimates for TD incidence and severity index were 0.43 and 0.52, based on sire model, and 0.21 and 0.36 based on animal model, respectively (Table 3). Heritability estimates for TD incidence were in general agreement with the estimates reported in literature (WONG-VALLE et al., 1993; KUHLERS and McDaniel, 1996; YALÇIN et al., 1996). Heritability of tibia dry weight and ash could not be estimated based on sire model because of negative variance component estimates. The estimates of heritability for tibia dry weight and ash were low based on animal model. Heritability of tibia length was higher based on animal model than obtained by sire model. Heritability of width from two estimation procedures was close to each other (Table 3).

Table 1. Least squares means by line, sex and interaction between line and sex for body weight at 42 days and carcass characteristics

<table>
<thead>
<tr>
<th>Line</th>
<th>Body Weight (g)</th>
<th>Carcass Weight (g)</th>
<th>Total breast weight (g)</th>
<th>Leg weight (g)</th>
<th>Wing weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>1882 ± 21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1349 ± 19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>504 ± 7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>596 ± 9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>166 ± 2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ML1</td>
<td>1649 ± 18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1143 ± 16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>413 ± 6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>506 ± 7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>145 ± 2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>ML2</td>
<td>1678 ± 23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1188 ± 20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>420 ± 8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>540 ± 9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>151 ± 2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1843 ± 20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1289 ± 16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>470 ± 6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>575 ± 8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>161 ± 2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Female</td>
<td>1630 ± 16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1164 ± 13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>422 ± 5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>520 ± 6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>147 ± 2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a, b, c</sup> Means in a column with no common superscript differ significantly (\( P < 0.05 \))
Total carcass weight. Correlations between TD incidence and total breast, leg and wing weights ranged from -0.245 to -0.123, while it was out of parameter space for wing weight from animal model. A negative correlation between incidence and severity index of TD with carcass conformation also indicated that a decrease in TD incidence and severity would increase carcass conformation. 

Tibia length was negatively, but width was positively correlated with TD incidence. TD severity was negatively correlated with tibia length and equal to -0.304 based on sire model while it was 0.091 based on animal model. 

These results suggest that incidence of TD shows negative genetic correlations with carcass weight and conformation. Therefore, including TD in a breeding scheme would not lead to indirect negative responses on carcass weight. Furthermore, an increase in carcass conformation may be expected due to a moderate negative genetic correlation between TD incidence/severity and carcass conformation. Decreasing tibia severity index may lead to an increase in tibia length in sire families.

**Summary**

Genetic correlations of TD incidence with carcass and bone characteristics were estimated by studying the progeny of one paternal and two maternal pure lines of a commercial broiler stock. Heritability estimates of TD in-

<table>
<thead>
<tr>
<th>Sire model</th>
<th>Animal model</th>
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<tbody>
<tr>
<td><strong>TD Incidence</strong></td>
<td><strong>TD Severity</strong></td>
</tr>
<tr>
<td><strong>TD Incidence</strong></td>
<td><strong>TD Severity</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carcass characteristics</th>
<th>Sire model</th>
<th>Animal model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass weight</td>
<td>-0.245 ± 0.503</td>
<td>-0.407 ± 0.692</td>
</tr>
<tr>
<td>Total breast weight</td>
<td>-0.123 ± 0.512</td>
<td>-0.211 ± 0.501</td>
</tr>
<tr>
<td>Legs weight</td>
<td>-0.044 ± 0.622</td>
<td>-0.241 ± 0.306</td>
</tr>
<tr>
<td>Wings weight</td>
<td>-0.180 ± 0.555</td>
<td>-1.000 ± 1.191</td>
</tr>
<tr>
<td>Carcass conformation</td>
<td>-0.319 ± 0.390</td>
<td>-0.331 ± 0.609</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tibia parameters</th>
<th>Sire model</th>
<th>Animal model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibia length</td>
<td>-0.136 ± 0.367</td>
<td>-0.154 ± 0.328</td>
</tr>
<tr>
<td>Tibia width</td>
<td>0.218 ± 0.518</td>
<td>0.166 ± 0.539</td>
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NE not estimated
Yalçın and Akbaş, Genetic relationships between tibial dyschondroplasia and tibia characteristics in broilers

cidence were 0.43 and 0.21 from sire and animal model. Negative genetic correlations were estimated between incidence of TD and carcass characteristics. The genetic correlation between TD severity index and carcass conformation tended to be negative and moderate. This observation indicated that carcass conformation would be decreased when birds had a higher severity index of TD.

**Keywords**

Broiler, genetic correlations, heritability, TD severity, TD incidence, carcass characteristics, tibia characteristics

**Zusammenfassung**

Genetische Korrelationen zwischen der Häufigkeit an Tibialer Dyschondroplasie und Merkmalen des Schlachtkörpers sowie der Tibia bei einer Zuchtlne einer kommerziellen Broilerherkunft


**Stichworte**

Broiler, genetische Korrelation, Heritabilität, TD-Häufigkeit, TD-Schweregrad, Schlachtkörpermerkmale, Tibiamerkmale

**References**


HARVEY, W. R., 1990: User's guide for LSMLMW and MIXMDL PC-2 version. The Ohio State University, Columbus, Ohio.


MAYER, K., 1997: DFREML version 3.0 user notes.


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