Application of ordinal logistic regression model for evaluation of skin quality grading data in Sheep

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This study was conducted to compare and evaluate skin quality grading of two indigenous (Blackhead Ogaden [B1] and Hararghe Highland [B2]) with two crossbreds (% Dorper x Blackhead Ogaden [B3] and % Dorper x Hararghe Highland [B4]) lambs. Following a 90 days feeding trial period, 6 lambs from each breed, a total of 24 lambs were randomly selected and slaughtered for the evaluation of skin quality grading. Visual inspection of the skin was undertaken by trained panel and skin quality grade was made according to 1 to 5 scales with 1 being excellent and 5 being poor. Ordinal logistic regression methodology was used for analyzing response outcomes. The results showed that, the preference ordering for skin quality grading to have the rank B2 > B4 > B3 > B1. Skin quality of the crossbred lambs “B3” was found to be better than indigenous breed “B1”; while the skin quality grading of the indigenous breed “B2” was found to be better than both “B4” and “B1.”

Key words: Lamb breeds, ordinal response, skin.

INTRODUCTION

Ethiopia is home to 25 000 000 sheep and 21 000 000 goats (CSA, 2010) which are valuable for their meat, milk and skin. There is high demand for live animals as well as meat from small ruminants of Ethiopia by consumers in the Middle East, North and West African countries. The proximity of Ethiopia to consumers in the Middle Eastern countries and their taste preference for meat from indigenous animals is advantages for the Ethiopian meat export market (Belachew and Jemal, 2003).

Skin from sheep and goats is another important resource that serves as a raw material for tanning industries for the production of leather and leather products (FAO, 1995; Alem, 2002). Skin and its processed products represent a major source of foreign exchange earnings in the country. Animal skins should meet minimal quality standard levels required by the leather industry in order to be commercialized and bring profit to the producers. Besides management practices and processing techniques, skin quality is also affected by the genotype (Alberto, 2002; Costa et al., 2005; Tsegay et al., 2012a). Skin quality is usually assessed by international standards of physicochemical tests, which are intended to guarantee leather quality and uniformity (Tsegay et al., 2012a).

Although, sheep and goats in Ethiopia form an important component of the livestock population, their productivity remains low due to many factors such as poor nutrition, poor genetic potential, animal disease and lack of proper management (Warmingt, 1990; Adugna, 2000). Thus, productivity of sheep and goats can in part be enhanced through genetic improvement by employing planned selection and breeding programs within the indigenous breeds as well as through crossbreeding of the indigenous ones with known and better performing exotic breeds. Despite the availability of different sheep and goat breeds in the country, efforts made so far to improve their productivity through genetics is limited. There had been some work in this regard such as a crossbreeding of Somali goats with Anglo Nubian breed done by FARM Africa in collaboration with governmental

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institutions such as Haramaya University, Debub University and the Ministry of Agriculture, with the objective of improving the milk production of local goats. Although, improvement in milk production through crossbreeding has been achieved, the impact appeared to be not long lasting.

Crossbreeding of indigenous sheep with exotic Dorper has been conducted since 2008 under the auspices of the "Ethiopian Sheep and Goat Productivity Improvement Program". The objective of such crossbreeding program was to improve the productivity of indigenous sheep and goat in terms of meat, milk and possibly skin quality. Previous research results showed that, crossing of Ethiopian indigenous sheep (Blackhead Ogaden [B1] and Hararghe Highland [B2]) with Dorper improved the growth performance and carcass traits (Tsegay et al., 2012a; 2013). However, there was slightly variation on skin and leather quality of indigenous and crossbred lambs (½Dorper½Blackhead Ogaden [B3] and ¾Dorper¾Haraghe Highland [B4]) (Tsegay et al., 2012a).

Therefore, introduction of exotic breeds in order to improve meat and milk production through cross breeding with the indigenous might also require further investigation whether it has an impact on skin quality or not.

Hence, this study is aimed at comparing and evaluating the impact of cross breeding on skin quality grading of four breed-groups, namely two crossbred (B3 and B4) and two indigenous breeds (B1 and B2) lambs.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Haramaya University Sheep Farm. The University is located at the Eastern escarpment of the Rift valley at about 520 km East of Addis Ababa, at a latitude of 9° 26’, longitude of 42° 03’ and altitude of 1980 m.a.s.l. It has 780 mm of rain fall during the cropping season and the mean annual maximum and minimum temperatures are 23.4 and 8.25°C, respectively (Mishra et al., 2003).

Experimental animals and treatments

In this experiment a total of 24 ram lambs were used for skin analysis study. These lambs consisted of 4 breed-groups based on their blood-level, namely two indigenous breeds B1 and B2 and two crossbreds B3 and B4. Each of the 4 breed-groups had 6 experimental lambs in it. Lambs were de-wormed with acaricides (vetazinon 60% EC) against external parasites, and sprayed with spectrum anti-helmentic (albendazole) against internal parasites, and vaccinated for pasteurelosis using ovine pasteurelosis and andanthrax using anthrax vaccine before the beginning of the experiment and brought indoors after the pens had been properly washed and disinfected. They were vaccinated against common diseases (anthrax and pasteurelosis, and anthrac) using anthrax vaccine before the quarantine period.

Grass hay harvested from the University campus was used as the basal diet while Noug seed cake (NSC) and Wheat bran (WB) were used as supplement feeds. The proportion of the supplement feeds in the rations was at a ratio of 2:1 on dry matter basis (that is, 2 parts of WB to 1 part of NSC). Supplement feeds were offered to lambs daily in two equal meals at 08:00 and 16:00. Clean drinking water and mineralized salt-licks were made available to individual lamb at all times. The experimental lambs were offered grass hay and the respective supplement feeds for 14 days to acclimatize them to the feeds and they were fed on the same diet for the rest of the experimental period (that is, 90 days).

The experiment was conducted using a completely randomized block design fashion with breed-group used as block. Six lambs of the same breed-group were randomly assigned to one of the two diets (Diet-1 [D1-low level of supplementation]: Hay ad libitum + 150 g/head/day of the concentrate mix and Diet-2 [D2-high level of supplementation]: Hay ad libitum + 350 g/head/day of the concentrate mix).

Methods of skin quality determination

Ordinal logistic regression model: grading of wet-blue chrome-tanned skins

In this study, visual inspection of the skin quality was undertaken by trained panel and grade for skin quality was given according to a 1 to 5 scales with 1 being excellent and 5 being poor. For ordinal response outcomes with more than two response variable levels, one can model functions called cumulative logits by performing ordinal logistic regression using the proportional odds model (McCullagh and Nelder, 1989). The LOGISTIC procedure of (SAS, 2005) is used to model the proportional odds model whenever the response variable has more than two levels. The model used for the analysis was:

$$\ln \left( \frac{p(\text{skin quality})}{1 - p(\text{skin quality})} \right) = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 \times (\text{skin quality})$$

Test $H_0$: No breed effect (that is, $\beta_1 = 0$) vs. $H_a$: significant breed effect ($\beta_1 \neq 0$).

RESULTS AND DISCUSSION

When there is only one effect, its test is equivalent to the likelihood-ratio test for the whole model. The likelihood-ratio Chi-square is 14.25, different from the Wald Chi-square of 10.88, which illustrates the point that Wald tests are to be regarded with some skepticism.

Table 2 indicates that, the parameter “Breed” is significantly different from zero. The small p-value (that is, 0.0026) rejects the hypothesis that the parameter
Table 1. Physical requirements for grading of wet-blue chrome tanned skins by defects and whole appearance.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Visually assessed cutting values (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Excellent)</td>
<td>90 - 100</td>
</tr>
<tr>
<td>2</td>
<td>75 - 89</td>
</tr>
<tr>
<td>3</td>
<td>65 - 74</td>
</tr>
<tr>
<td>4</td>
<td>45 - 64</td>
</tr>
<tr>
<td>5 (Poor)</td>
<td>15 - 44</td>
</tr>
</tbody>
</table>

Grade 1 leather with eventual cutting value of 90 to 100%, grade 2 leather with eventual cutting value of 75 to 89%, grade 3 leather with eventual cutting value of 65 to 74%, grade 4 leather with eventual cutting value of 45 to 64%, and grade 5 leather with eventual cutting value of 15 to 44%.

Table 2. Testing global null hypothesis: BETA = 0.

<table>
<thead>
<tr>
<th>Test</th>
<th>Chi-square</th>
<th>DF</th>
<th>Pr &gt; Chi square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood ratio</td>
<td>14.25</td>
<td>3</td>
<td>0.0026</td>
</tr>
<tr>
<td>Score</td>
<td>11.36</td>
<td>3</td>
<td>0.0099</td>
</tr>
<tr>
<td>Wald</td>
<td>10.88</td>
<td>3</td>
<td>0.0124</td>
</tr>
</tbody>
</table>

DF = Degrees of freedom.

Table 3. Analysis of maximum likelihood estimates.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Estimate</th>
<th>SE</th>
<th>Wald chi-square</th>
<th>Pr&gt; Chi square</th>
<th>Exp (Est)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed B1</td>
<td>1</td>
<td>2.52</td>
<td>1.23</td>
<td>4.20</td>
<td>0.0405</td>
<td>12.48</td>
<td>(1.12, 39.68)</td>
</tr>
<tr>
<td>Breed B2</td>
<td>1</td>
<td>-2.26</td>
<td>1.26</td>
<td>3.20</td>
<td>0.0735</td>
<td>0.11</td>
<td>(0.01, 1.24)</td>
</tr>
<tr>
<td>Breed B3</td>
<td>1</td>
<td>0.51</td>
<td>1.15</td>
<td>0.20</td>
<td>0.6571</td>
<td>1.67</td>
<td>(0.17, 15.9)</td>
</tr>
</tbody>
</table>

DF = degrees of freedom, SE = standard error; 95% CI = 95% confidence intervals.

“Breed” is equal to zero. The score Chi-square for testing the proportional odds assumption is 11.36, which is not significant with respect to a Chi-square distribution with 6 DF (p = 0.0529). This indicates that, the proportional odds assumption is reasonable.

By default, ordered response values are assigned to the sorted response values in ascending order, and PROC LOGISTIC models the probability of the response level that corresponds to the ordered value 1. Result in Table 3 shows that, the probability of 1 (excellent) is modeled. Besides, in the model used by the PROC LOGISTIC analysis, for the CLASS variable “Breed” reference coding was used. As a result, the Estimate, Exp (Est) values along with 95% confidence intervals in Table 3 represent the parameter estimates, odds ratio estimate between the corresponding level (B1, B2, B3) and the reference level (B4) and their respective 95% confidence intervals.

The positive value (2.52) under the parameter estimate for skin-quality-grading of B1 indicates a tendency toward the lower-numbered categories of the skin-quality-grading of B1 relative to that of B4. In other words, the skin-quality-grading of B4 is better than that of B1. Skin-quality-grading of B2 and B3 are both better than that of B1.

To see if a skin quality grading is preferred, look for the most negative values of the parameter estimates (B1 = 2.52, B2 = -2.26, B3 = 0.51, and B4 = -0.78. The value for the effect of B4 is the negative sum of the others). Accordingly, the relative magnitudes of these slope estimates imply the preference ordering of the skin quality grading as B2 > B4 > B3 > B1.

According to the odds ratio results given in Table 3, the “skin quality grading for B1 vs. B4” has an odds ratio of 12.48. These odds ratio says that, the odds of receiving a lower score grade for breed B1 is 12.48 times than that of the odds of receiving a lower score grade for breed B4. The effect of “Diet” or its interaction with “Breed” has not been found significant. As a result only “Breed” effect was considered in this analysis.
Conclusions

The study showed that, skin quality grading of "B2" was found to be better than "B1". However, crossing of “B1" with “Dorper” sheep has brought an improvement in skin quality of the “B3”. This improved leather quality is also expected to bring higher revenue on the export market. However, further studies on similar experiments and evaluation on additional data sets are required to support the above finding.

The introduction of “Dorper” through crossbreeding can improved cutting value of skins of the indigenous breeds with low possible defects and thus, improves the quality of leather products.

REFERENCES


