Original Research Paper

Phenotypic and genetic differentiation of qualitative traits in sheep ecotype from Cameroon Western Highlands

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Abstract
This study was carried out in the highlands zone, west region of Cameroon to evaluate the distribution and frequency of sheep qualitative traits. Four hundred and three (403) adult sheep were randomly sampled in the study area. The qualitative traits observed were the presence or not of toggles, beard, horns and the sheep coat color (white, black, white-black and white-brown). The main results showed that the traits observed were variable according to the locality and sex of the animal. The sheep from the Bamboutos Division have the highest toggles frequency (21.69%) compared to those of the Noun Division whose frequency was the lowest (11.67%). Toggles were present in both sexes with higher frequency of 18.18% in females compared to the males (9.47%). Beard was almost non-existent in the two localities as well as in the two sexes. Horns were present in sheep of all the investigated localities and in both sexes, with higher frequency in males (90.53%) compared to females (8.12%). The action of the gene responsible for the color of the coat was variable as far as any locality was concerned. The predominant color observed was white. The gene frequencies recorded for the presence of the toggles (Waw), beard (Brb) and horns (HoP) were 0.06%, 0.00% and 0.35%, respectively. These values were far below the expected Mendelian value of 0.75. These low frequencies observed would indicate that the sheep populations of the highlands of the west region of Cameroon were variegated without proper actions of artificial selection, opening ways for genetic improvement.

Keywords: Phenotypes- Sheep – qualitative traits – gene frequencies – West Cameroon

Introduction
Sheep production is considered as an important economic activity for rural and peri urban populations in Sub-Sahara Africa. Sheep populations constitute in a context of low monetization and insecurity, a source of households’ savings and contribute to the diversity of easy income and food resources (Mamadou, 2000; Kamuanga, 2002; Duteurtre et al., 2003; Boye et al., 2005; Gagara, 2008). Sub-Saharan native sheep populations display large adaptability: rusticity, resistance to hunger, thirst and trypanotolerance. They can be raised in all diverse agro-climatic areas (FAO, 2008). Despite the fact that sheep are widely distributed (Devendra and McLeroy, 1982), they are neglected and their key role in tropical agriculture has been misunderstood for some while (Wilson, 1983). In Cameroon, sheep production is found throughout the country with undeniable socio-economic importance (Tchouamo et al., 2005). The Ministry of Livestock, MINEPIA (2012) estimated the sheep flock around 3 million heads. This livestock species is represented by the West Africa dwarf sheep (Djallonké), Peuhl or Pulfulli and Foulbé sheep, the Uda sheep with Balaami variety, the Kirdi sheep or Massa and the humid forest Black Belly sheep (Meka et al., 2019). According to Hall (1999), diversity of the genetic heritage, climatic conditions, free mating and natural selection could give rise to different local populations of sheep and consequently, to the development of differential adaptive behaviors that could be obvious in
the morphology of animals. In the same vein, the findings of Oseni et al. (2006) show that, the diverse expressions of qualitative traits can have certain adaptive mechanisms linked to adaptation and survival in different ecological zones. This was supported by the report of Odubote (1994) on the influence of some qualitative traits on the genetic potential and adaptability of Nigerian goats. Hence, the necessity to keep these unique genes considering the fact that the high-level production of hybrids, does not behave well with low-input management typical of the smallholder production system (Rege and Gibson, 2003). Given that the characterization of a given breed is the first step of a long lasting of its genetic improvement, the aim of the present study was to provide information on the distribution or frequencies of some qualitative traits of West Cameroon highland sheep populations.

Material and methods

Area of study

The study was carried out between October 2014 and January 2015 in the Sudano-guinean zone of the western highlands of Cameroon (LN 3°5′, LE 8°20′). Elevation varies from 1400 to 2700 m (Figure 1). The climate that prevails is characterized as Cameroonian type, modified by the altitude. The temperature varies from 16 to 27°C; the relative humidity ranges from 49 to 97%. The average rainfall is about 2000 mm raging from 1700 to more than 2500 mm/year and divided into two seasons. The rainy season moves from half-March to half-November and the dry season, from half-November to half-March (Feukeng, 2005).

Figure 1: Map of study area for Cameroon West highlands Sheep
Data collection

Four hundred and three (403) sheep, including 308 females and 95 males divided in 5 of the 8 divisions that the region has, were sampled. Four qualitative traits (toggle, beard, horn and coat color) were used as variables of the classification of the population. From the presence or absence of the toggles, beard and horns, the sampled animals were observed as follows:

- \((W_a^-)\) for presence and \((W_a^+)\) for absence of toggles
- \((B_r^b)\) for presence and \((B_r^+)\) for absence of beard
- \((H_o^+)\) for presence and \((H_o^p)\) for absence of horns.

Concerning the coat pigmentation, the types of the color of fur observed have been classified in white \((A^{wh})\), black, white and black, white and brown and others (Sponenberg et al., 1988).

Data analysis

Descriptive statistics were used to describe the distribution of qualitative traits: coat color, horns’ presence, toggles and beard. The distribution of the different qualitative traits were labeled in percentages and classified according to their locality and sex.

The frequencies of the recessive alleles \((W_a^+, B_r^+\) and \(H_o^+)\) were estimated using Hardy-Weinberg equilibrium (Falconer and Mackay, 1996) as indicated below:

\[
q = \sqrt{\frac{m}{M}}; \text{ where,}
\]

\[
q = \text{frequency of the recessive gene}
\]

\[
m = \text{Number of animals observed with a particular recessive trait.}
\]

\[
M = \text{Total number of sampled animals}
\]

From \(q\) as mentioned above, the frequencies of the dominant alleles \((W_a^w, B_r^b, \text{ and } H_o^p)\) were calculated as follows:

\[
p = 1-q; \text{ where,}
\]

\[
p = \text{frequency of the particular dominant allele}
\]

The observed frequencies have been tested against the predictions of the Mendelian ratio of 3:1 corresponding to values of 0.75 for the dominant allele and 0.25 for the recessive allele using Pearson chi-square test. The null hypothesis (NH) being the fact that is in the Mendelian proportions while the alternative hypothesis (AH), the population is not included in the Mendelian proportions.

Pearson’s chi-square test for the state of well-being:

\[
X^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}
\]

The significance level of the test was examined at \(\alpha<0.05\).

Results

The phenotypic frequencies of the different variables observed within the sheep population from the locality and sex perspective are indicated in Tables 1 and 2. All the investigated localities had sheep, which carried toggles, while horns were observed in all rams and also in some ewes (Figure 2). Sheep from the Bamboutos
recorded higher frequency (21.69%), whereas those from the Noun had lowest frequency (11.67%). Similarly, toggles were present in both sexes with highest frequency (18.18%) in females compared to males (9.47%). With regard to beard, it was almost non-existent in all the localities and in both sexes. Horns were present in all sheep of the investigated localities. The sheep from the Bamboutos had the highest frequency (77.11%) whereas those of the Nde had the lowest (62.34%). Horns were present in both sexes of the sheep from the highlands of West Cameroon with highest frequency in males (90.53%) compared to females (8.12%). The action of the gene responsible for coat color was variable according to localities. The sheep were mainly white in the Bamboutos, Menoua and Noun localities (67.47%, 45.07% and 52.50%, respectively), whereas, those of the Mifi and Nde were mainly white and black (57.70% and 49.35%, respectively). The dominant color in both sexes was the white color (55.79% and 44.81%, respectively for rams and ewes).

**Figure 2**: Cameroon West Highland sheep bearing horns: (A: Ram and B: Ewe)

<table>
<thead>
<tr>
<th>Traits</th>
<th>Alleles</th>
<th>Divisions (localities)</th>
<th>Bamboutos</th>
<th>Menoua</th>
<th>Mifi</th>
<th>Nde</th>
<th>Noun</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>F(%)</td>
<td>N</td>
<td>F(%)</td>
<td>N</td>
<td>F(%)</td>
</tr>
<tr>
<td>Toggle</td>
<td>W O W</td>
<td>18</td>
<td>21.69</td>
<td>13</td>
<td>18.31</td>
<td>9</td>
<td>17.31</td>
</tr>
<tr>
<td></td>
<td>W O W +</td>
<td>65</td>
<td>78.31</td>
<td>8</td>
<td>81.69</td>
<td>43</td>
<td>82.69</td>
</tr>
<tr>
<td>Beard</td>
<td>B B B</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>B B B +</td>
<td>83</td>
<td>100.00</td>
<td>71</td>
<td>100.00</td>
<td>52</td>
<td>100.00</td>
</tr>
<tr>
<td>Horn</td>
<td>H O H</td>
<td>64</td>
<td>77.11</td>
<td>50</td>
<td>70.42</td>
<td>39</td>
<td>75.00</td>
</tr>
<tr>
<td></td>
<td>H O H +</td>
<td>19</td>
<td>22.89</td>
<td>21</td>
<td>29.58</td>
<td>13</td>
<td>25.00</td>
</tr>
</tbody>
</table>

**Table 1**: Phenotypic frequencies (%) of qualitative traits in Cameroon West highlands sheep

**Coat Colour**

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>A B</td>
<td>56</td>
<td>67.47</td>
<td>32</td>
<td>45.07</td>
<td>11</td>
<td>21.15</td>
<td>29</td>
</tr>
<tr>
<td>Black</td>
<td>- -</td>
<td>2</td>
<td>2.41</td>
<td>6</td>
<td>8.45</td>
<td>1</td>
<td>1.92</td>
<td>1</td>
</tr>
<tr>
<td>White-black</td>
<td>-</td>
<td>15</td>
<td>18.07</td>
<td>31</td>
<td>43.66</td>
<td>30</td>
<td>57.70</td>
<td>38</td>
</tr>
<tr>
<td>Brown</td>
<td>- -</td>
<td>2</td>
<td>2.41</td>
<td>1</td>
<td>1.41</td>
<td>2</td>
<td>3.85</td>
<td>1</td>
</tr>
<tr>
<td>White-brown</td>
<td>-</td>
<td>5</td>
<td>6.02</td>
<td>0</td>
<td>0.00</td>
<td>7</td>
<td>13.46</td>
<td>5</td>
</tr>
<tr>
<td>Others</td>
<td>- -</td>
<td>3</td>
<td>3.61</td>
<td>1</td>
<td>1.41</td>
<td>1</td>
<td>1.92</td>
<td>3</td>
</tr>
</tbody>
</table>

N = Size ; F = Phenotypic frequency
Table 2: Phenotypic frequencies (%) of qualitative traits in Cameroon West highlands sheep

<table>
<thead>
<tr>
<th>Traits</th>
<th>Alleles</th>
<th>Sex</th>
<th>Phenotypic frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ram</td>
<td>Ewe</td>
</tr>
<tr>
<td>Toogle</td>
<td>$W_a^+$</td>
<td>9</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>$W_a^-$</td>
<td>86</td>
<td>252</td>
</tr>
<tr>
<td>Beard</td>
<td>$B_r^+$</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>$B_r^-$</td>
<td>95</td>
<td>308</td>
</tr>
<tr>
<td>Horn</td>
<td>$H_o^P$</td>
<td>9</td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>$H_o^+$</td>
<td>86</td>
<td>25</td>
</tr>
</tbody>
</table>

The genetic frequencies of sampled qualitative traits of the sheep of the highlands of West Cameroon are indicated in Table 3. The frequencies were 0.06%, 0.00% and 0.35%, respectively for the $W_a$, $B_r$, and $H_o$ genes. These values were lower than the expected Mendelian value of 0.75%. These low frequencies observed would indicate that the sheep populations of the highlands of the west region of Cameroon were not purified by artificial selection.

Table 3: Gene frequencies of qualitative traits in Cameroon West highlands sheep

<table>
<thead>
<tr>
<th>Traits</th>
<th>Alleles</th>
<th>Expected value</th>
<th>Observed value</th>
<th>Gene frequencies</th>
<th>$\chi^2$ test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toogle</td>
<td>$W_a$</td>
<td>302.25</td>
<td>65</td>
<td>0.06</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$W_a^+$</td>
<td>100.75</td>
<td>338</td>
<td>0.94</td>
<td>*</td>
</tr>
<tr>
<td>Beard</td>
<td>$B_r$</td>
<td>302.25</td>
<td>0</td>
<td>0.00</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$B_r^+$</td>
<td>100.75</td>
<td>403</td>
<td>1.00</td>
<td>*</td>
</tr>
<tr>
<td>Horn</td>
<td>$H_o$</td>
<td>302.25</td>
<td>292</td>
<td>0.35</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>$H_o^+$</td>
<td>100.75</td>
<td>111</td>
<td>0.65</td>
<td>*</td>
</tr>
</tbody>
</table>

*Significant at p<0.05

Discussion

In general, genetic frequencies of qualitative traits observed in sheep of the highlands of West Cameroon indicate phenotypic variability. Yakubu et al. (2010) showed higher toggles frequencies in females (36.63%) compared to males (11.45%) for Yankassa sheep breed in Nigeria. However, on Uda and Balami sheep, the same researchers found higher frequencies in males (10.26% and 19.59%) compared to females (1.59% and 13.59%). The total frequency of 16.13% is not in accordance with the 48% and 98.28% reported respectively by Ozoje and Kadri (2001) on West Africa Dwarf sheep and Rodero et al., (1996) on Lebrijan Churro sheep in Andalusia. Salako (2012) obtained toggles frequencies of 4.59% and 82.14%, respectively in the Djallonké sheep and in Yankassa sheep in Nigeria, which is therefore not comparable with our observations. The frequency of 0% observed corroborates with the observations of Yakubu et al. (2010) on Balami, Yankassa and Uda sheep in Nigeria.
Salako (2012) reported that the presence of horns in rams and ewes in the Djallonké and Yankassa sheep in Nigeria with a sexual dimorphism in favor of the males. According to Yakubu et al., (2010), the bearing of horns could be advantageous in the tropics where the temperature can easily reach the extremes due to the fact that they are the only specific areas with a major drainage of blood through the cavernous sinus, which, according to Robertshaw (2006), is involved in the control of the thermal homeostasis mechanisms. Yakubu et al., (2010) observed the predominance of white coat color in both rams and does in Balami sheep in Nigeria. According to Ozoje and Kadri (2001), in addition to relationship between white coloring and environment stress, there is also a morphostructural importance, for it affects the width of shoulders on sheep. Furthermore, Dyrmundsson and Adalsteinsson (1980), reported that allele $A^{wh}$ responsible for the white coat color plays a role in suppressing off-season reproduction; which is an advantage under harsh environmental conditions where the off-season reproduction with lambing in cold season, would lead to the high mortality of kids.

Yakubu et al., (2010) found the $W_a^w$ allele frequencies ranging from 0.08%, 0.02% and 0.09% respectively in Yankassa, Uda and Balami sheep in Nigeria, which are close to observations from this study. On the other hand, Ozoje and Kadri (2001) reported frequency of 0.39% for the $W_a^w$ allele, which is in contradiction with the observations on this sheep populations. According to Yakubu et al. (2010), such low frequency of the gene responsible for the presence of toggles is sign that it is subject to disappearance. Such observations should lead to appropriate decision making in order to ameliorate the understanding of diminishing mechanisms and potential impacts on current and future breeding programs.

**Conclusion**

From this study, the frequencies of toggles, horns and coat color patterns in Cameroon West highlands sheep vary according to locality and sex. Dominant genes for all these traits were present but at very low frequencies. The sheep populations in the region were variegated without a directional selection. To foster sheep larger breeding efforts in the country, further investigations should be intensified both for other qualitative studies and in connection with quantitative aspects that could enable sheep production.

**References**


