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Genetic Parameters and Fixed Effects Estimation for Fibre Traits in Alpaca Huacaya (*Lama pacos*)

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Abstract: Alpaca (*Lama pacos*) is one of the two species of South American Camelids being Huacaya the most important breed due to its higher fibre production. Appropriate knowledge of genetic parameters for production traits is important in order to predict the selection response and also to establish selection strategies. The purpose of the present study is to estimate the genetic parameters and the fixed effects for fibre production in a population of Huacaya alpaca breed from the Toccra community (Arequipa region, Peru). The animal population consisted of 286 descendents, 38 sires and 188 dams. The analyses carried out showed that the effects of sex, colour and year of shearing were not significant while the age at shearing was significant on all traits. Fleece weight showed the highest heritability values while diameter and length fibre showed an intermediate value. Genetic and phenotypic correlations were all positive with high values between fibre diameter and length. Therefore, a promising panorama is depicted for a selection program as it will be possible to obtain a good response to the selection.

Key words: Alpaca, fleece, diameter, fibre, age, colour, Peru

INTRODUCTION

Animal production in Peruvian Altiplano is based on the breeding of South American camelids mainly Huacaya alpaca breed. This breeding constitutes the major living activity in this area. The breeding system suffers from several deficiencies like losing of fibre thinness and colour, decrease of the population and the poor managerial techniques. In fact only about 20% of individuals produce thin fibres (<17 μm diameter).

A major difficulty in estimating the genetic parameters is the lack of constancy of their values. Heritability and genetic correlations change as a consequence of selection and consanguinity (Bulmer, 1971). Therefore, it is a mandatory to dispose of estimates of such parameters before selection starts as it is necessarily followed by an increase of consanguinity. The use of mixed model methodology allows obtaining unbiased solutions (Henderson, 1975). On the other hand, these parameters are necessary in order to choice the more suitable traits for selection and to evaluate, afterward the future progenitors on the basis of their additive breeding values (Ponzoni *et al*., 1999).

Concerning wool traits, fibre diameter is the most important factor affecting the balls produced (Antonini and Vinella, 1997). The average diameter value in the alpaca Peruvian population is 23.8 and 24.02 μm for the Suri and the Huacaya breeds, respectively. In the New Zealand alpaca, the value is between 28.0 and 31.9 μm (Mistiri *et al*., 2000). This diameter is affected by factors like breed, age, colour, year and season of production (Frank *et al*., 2006). On the other hand, the sex of the animal specially affects the thinness (Mistiri *et al*., 2000; McGregor and Butler, 2004).

With respect to genetic parameters, different estimates of heritability are shown in Table 1. The highest heritability corresponds to fibre diameter with a value of 0.73±0.19 (Mistiri *et al*., 2000) although much lower values (0.18) were also reported (Leon-Velarde and Guerrero, 2001). On the other hand, fibre diameter as well as fleece

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Table 1: Available estimates of heritability for fibre diameter, fibre length and fleece weight

Traits	Estimates	References
Fibre diameter	0.67±0.30	Ponzoni *et al.* (1999)
	0.73±0.19	Mistiri *et al.* (2000)
	0.18	Leon-Velarde and Guerrero (2001)
Fibre length	0.21±0.01	Roque *et al.* (1985)
	0.43±0.39	Mamani (1991)
	0.31	Leon-Velarde and Guerrero (2001)
Fleece weight	0.35±0.02	Velasco (1980)
	0.22	Bravo and Velasco (1983)
	0.21±0.07	Roque *et al.* (1985)
	0.31±0.17	Ruiz de Castilla *et al.* (1992)

weight show a moderate value of heritability. The estimates vary from 0.21±0.01-0.43±0.39 for fibre length and from 0.21±0.07-0.35±0.02 for fleece weight. The estimated heritability for fibre traits in the Huacaya breed is between 0.25 and 0.41 (Cervantes *et al*., 2010). No estimates for genotypic or phenotypic correlations are available. These estimates are necessary for the fine tuning of a multi-trait selection scheme.

The objective of the present research is to estimate genetic parameters in a population of alpaca from the Huacaya breed in order to know the heritability and the genetic correlations of the most important traits of the alpaca wool.

MATERIALS AND METHODS

Animals corresponded to a population of alpaca from the Toccra community of Arequipa region in the Peru. This population consisted of 286 young animals from 38 sires and 188 dams. The wool traits analysed corresponded to the first shearing during 2005 and 2006. Data relative to fleece weight and fibre length were collected by breeders. Samples for diameter analysis were obtained for the mid flank by the own breeder and analysed in the laboratory of textile fibres of the National Agricultural University of La Molina in Lima (Peru). Best linear unbiased estimates of fixed effect and estimates of variances components were obtained via the following multi-trait linear model:

$$\begin{bmatrix} d \\ l \\ w \end{bmatrix} = \begin{bmatrix} \mu d \\ \mu l \\ \mu w \end{bmatrix} + \begin{bmatrix} Sd_i \\ Sl_i \\ Sw_i \end{bmatrix} + \begin{bmatrix} Yd_j \\ Yl_j \\ Yw_j \end{bmatrix} + \begin{bmatrix} Ad_k \\ Al_k \\ Aw_k \end{bmatrix} + \begin{bmatrix} Cd_m \\ Cl_m \\ Cw_m \end{bmatrix} + \begin{bmatrix} Bd_n \\ Bl_n \\ Bw_n \end{bmatrix} + \begin{bmatrix} Ed_n \\ El_n \\ Ew_n \end{bmatrix}$$

where, d, l and w stand for analysed traits i.e., fibre diameter, fibre length and fleece weight, respectively. S, Y, A and C are fixed effect affecting traits i.e., sex of the animal, year of shearing, age of the animal and the colour of the cape, respectively. B and E are the random effects, namely B the animal effect which variance structure was proportional the additive components according to the numerator relationship matrix and E the residual or the environmental effect which variance structure was proportional to the residual components according to an identity matrix. Where, the additive variance-covariance components are:

$$\begin{bmatrix} a_d^2 & a_{dl} & a_{dw} \\ & a_l^2 & a_{lw} \\ & & a_w^2 \end{bmatrix}$$

The environmental variance-covariance components are:

$$\begin{bmatrix} e_d^2 & e_{dl} & e_{dw} \\ & e_l^2 & e_{lw} \\ & & e_w^2 \end{bmatrix}$$

The a is the component corresponding to additive variance of each trait (on diagonal) or additive covariance between two traits (above diagonal). The e is the component corresponding to environmental variance of each trait (on diagonal) or environmental covariance between two traits (above diagonal).

The BLUEs and variances components were obtained by using the Wombat software for general linear model and variance components estimation (Meyer, 2006, 2007).

RESULTS AND DISCUSSION

Estimation of fixed effects: The blues of fixed effects are shown in Table 2. It can be seen that neither sex nor years of shearing have shown any significant influence on the analysed traits. Nevertheless, the analysis of coat colour suggests that white animals produce about 14% more wool than the coloured with the same diameter and length of the fibre. On the other hand, age of animals affected significantly all the traits under analysis. Yet age increased the fibre diameter, bearing in mind that a diameter <22 μm is still a good value (McGregor, 2006) and breeder should delay shearing until the animals are 1 year olds to take profit from the increase in fibre length (about 15%) and in fleece weight (about 37%). Lupton *et al.* (2006) have reported that sex, age and colour all affected fibre traits with a significant interaction between sex and age. Similarly, Frank *et al.* (2006) found a clear evidence of the effect of age and colour on fleece weight and fibre diameter.

Estimation of heritability: Values of heritability are shown in Table 3. The highest value of heritability was obtained for fleece weight (0.71). Such a value is much higher than those reported in the literature where the highest value

Table 2: GLS means according to sex, year of shearing, age and coat colour of the analysed wool traits

Factors	Data number	Fibre diameter	Fibre length	Fleece weight
Sex				
Male	113	19.67[a]	10.26[a]	1.476[a]
Female	101	19.81[a]	10.27[a]	1.437[a]
Year				
2005	112	20.09[a]	10.34[a]	1.516[a]
2006	102	19.35[a]	10.19[a]	1.394[a]
Age (months)				
9	17	18.77[a]	9.53[a]	1.275[a]
10	78	19.02[a]	10.06[b]	1.315[b]
11	88	20.19[ab]	10.33[b]	1.518[c]
12	31	20.76[b]	10.98[c]	1.748[d]
Colour				
White	155	19.90[a]	10.18[a]	1.489[a]
Coloured	59	19.30[b]	10.48[a]	1.376[b]

Table 3: Heritabilities (±SE) on diagonal, genetic correlations (±SE) above diagonal and phenotypic correlation (±SE) below diagonal for fibre diameter, fibre length and fleece weight

Traits	Fibre diameter	Fibre length	Fleece weight
Fibre diameter	0.36±0.20	0.60±0.26	0.28±0.16
Fibre length	0.18±0.07	0.28±0.18	0.37±0.17
Fleece weight	0.15±0.07	0.16±0.07	0.71±0.25

(0.35) was reported by Velasco. This is a good finding since fleece weight is the main quantitative component of production and should be included as a selection objective. Fibre length show a moderate heritability smaller than that reported by Leon-Velarde and Guerrero (2001) but higher than the value reported by. Nevertheless, there is no need to change the mean of this trait as it shows an adequate value according to the textile industry in the Peru. Fibre diameter is an important economical trait since it is the scale of wool quality. It should be maintained below 22 μm (McGregor, 2006) to ensure a good quality to wool. Thus, the reduction of this trait should also be included in the selection objectives. However, its heritability is moderate (about 0.30) and therefore selection would not be as efficient as when applied for fleece weight.

Estimation of correlations: The values of additive and phenotypic correlations are also shown in Table 3. All the phenotypic correlations showed lower values (between 0.16 and 0.18). Concerning additive correlations, the highest value (0.60) was obtained between fibre diameter and length. The lowest value (0.28) was obtained between fibre diameter and fleece weight. This is a favourable feature since it suggests that selection in the opposite direction for diameter and weight is possible. Lastly, the correlation between fleece weight and fibre length was moderate with a value of 0.37. A selection criterion could be the increase on fleece weight, keeping fibre diameter at the limit value imposed by the textile industry. However, other genetic tools of improvement should be investigated like QTL affecting wool traits as some QTL of notable effect were already described in sheep (Bidinost *et al*., 2008).

CONCLUSION

In order to improve the economical conditions of habitants of the Toccra community of Arequipa region in the Peru, a selection program for improvement of wool traits of the alpaca in this region should be implemented. Such an improvement could be achieved by selecting animals on the basis of their breeding value for increasing fleece weight keeping constant the fibre diameter. On the other hand, the age at 1st shearing should be applied at least 1 year because of its beneficial drawbacks on production.

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